A Quintuple Helix Framework for the Implementation of Resilient and Green Road Freight Transportation in South East Europe

By

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Abstract

The unpredictable nature of extreme weather-induced disruptions is posing tremendous pressure on nowadays supply chains. Longer transports, increased fuel consumption, hazardous wastes, unsatisfied clients, social unrest and risks, damage to the environment, infrastructure and assets are only few of the pressuring outcomes. This situation becomes even more critical when it comes to freight transportation which is much closer to societies and to the environment. In order to counteract this, the concept of supply chain resilience is being adopted towards identifying solutions for the supply chains to recover after such a disruption took place. However, institutions tend to leverage (more) cost minimization as the key indicator of resilience efficiency against environmental and social indicators – and this is highly visible especially in the lower income region of South East Europe (SEE). This leverage is slowly becoming obsolete, as the global literature, policy and practice are consistently demanding for the need of resilient and green supply chain management (RGSCM) and implicitly of resilient and green freight transportation (RGFT). This is why, institutions can no longer emphasize economic benefits against societal and environmental value when dealing with resilience and thus, the proper implementation of RGFT/RGSCM strategies becomes critical.

RGSCM and RGFT implementation have often been studied through various theoretical frameworks such as the ecological modernisation theory (EMT) for understanding how eco-innovations emerge, diffusion of innovation theory (DIT) for investigating how eco-innovations diffuse, complex and adaptive systems theory (CAST) for examining how resilience and self-adaptation is being achieved and finally, institutional and stakeholders theory (INT and ST) for reasoning how institutions adopt eco-innovations triggered by stakeholder groups (co-evolution).

However, the key literature gap that this research aims to fill resides in the lack of existence of a converged framework for all the five theories with focus on understanding how institutional level RGFT/RGSCM practices can be implemented and leveraged at the stakeholder (mesosystem) level in order to ensure a wider scale impact. Such theoretical convergence gap becomes tangent with the recently developed quintuple helix model where eco-innovations, institutions, society and the environment are being seen as the key connected pillars of eco-modernisation in nowadays society.

In this context, the aim of this thesis is to propose a quintuple helix framework for the implementation of RGFT/RGSCM during weather induced disruptions in SEE by underpinning how institutional interactions and RGFT/RGSCM eco-innovation implementation can scale-up to stakeholder level. In order to support this convergence and the theoretical framework assumptions, a three-stage mixed-method approach has been adopted at the South East European level (Stage one – qualitative interviews, N=6; Stage two – qualitative and quantitative semi-structured exploratory & confirmatory survey, N=311; Stage three – focus groups only on Greece in order to enable higher specialization of the findings, N=3 and modelling and simulation, N=3).

Overall, the key outcome that has been revealed is that quintuple helix co-creation, goal and key performance indicators (KPI) alignment of all stakeholders and capacity to transform (eco-modernize) of institutions are the key enablers of fast eco-innovation (RGFT/RGSCM) diffusion and implementation. The additional (key) research outcomes are: firstly, disruptive eco-innovators are limited and most of the other institutions are primarily adapting/transforming; secondly, there is high willingness to leverage eco-innovations at the stakeholder level; thirdly, the RGFT/RGSCM eco-innovations will be based on the smart specialization areas of the country/region; fourthly, by having the inner desire to excel, institutions will continue to eco-innovate (mostly through steady transformation) – ensuring thus the sustainable change at the stakeholder level (by putting pressure on the late adopters). Lastly, a concerning element in this area resides in the existence of very isolated stakeholder groups which may not co-evolve.

This research brings academic contribution by exploring each of the five theories and by proposing their convergence built upon the quintuple helix model. Additionally, this research provides advancements in the utilisation of mixed-methods research in RGFT/RGSCM. Similarly, this research provides practical benefits to institutions in terms of offering guidance and solutions for RGFT/RGSCM implementation. Policy-wise, this research enables better policy formulation especially in terms of triggering quintuple helix co-creation towards enhanced societal and environmental outcomes (impacting thus on society as well). Finally, the core limitations of this thesis which should be addressed in future studies consist of the high level approach in terms of converging the five theories as well as in the manner in which the triangulation is being performed (the three stages are not performed integrally and then triangulated – being rather integrated as means of one stage informing another).

Keywords: Resilient and green freight transportation; Supply chain; Quintuple helix; Institution; Stakeholder, Innovation, Adoption, South East Europe.

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Acronyms & List of terms

Acronym	Explanation
CAST	Complex and adaptive systems theory which explains how systems achieve equilibrium through interactions among its entities.
Circular economy	An environmentally sustainable and resource efficient economy where one industry's waste becomes the primary resource of another industry.
CRQ	Converged research question – a research question that has been devised by combining several research questions that point towards the same query.
DIT	Diffusion of innovation theory which explains how innovations are being diffused (either transformative or disruptive) within a system.
Disruption	Any interference that causes substantial negative changes/damages in the operational flow of a system.
Eco-innovation	In this research, any RGFT/RGSCM strategy/practice.
Ecosystem	In this research, an abstraction of the natural/environmental ecosystem which incorporates mesosystems.
EMT	Ecological modernization theory which explains how natural and social systems eco-innovate and co-modernize themselves when dealing with disruptions.
EuP	Standard for energy efficiency.
FT	Freight transportation.
GFT	Green freight transportation (transportation that is considered environmentally sustainable).
GSCM	Green supply chain management (supply chains that are considered green – they also incorporate GFT as a sub-discipline).
INT	Institutional theory which explains how individual institutions evolve and incorporate changes when operating within a stakeholder/system group.
ISO14001 and ISO14031	Environmental regulation standards.
KPI	Key performance indicator.
LCA	Lifecycle assessment (assessment of the CO2 footprint of a product across the entire supply chain required to manufacture and transport the product until (including) disposal).
Mesosystem	An abstraction of societal ecosystems based on the quintuple helix concept. Also referred to as stakeholder level.
Microsystem	An abstraction of RGFT/RGSCM ecosystems which are incorporated within mesosystems.
Quintuple helix	An evolution of the traditional triple helix concept (university/innovation, industry, government towards including society and environment as key drivers of (sustainable) development within mesosystems.
Resilience	Ability of a system to recover from a disruption and return to a better state than the one before the disruption.
RGFT	Resilient and green freight transportation (transportation systems that reach resilience in an environmentally sustainable manner).
RGSCM	Resilient and green supply chain management (supply chain systems that reach resilience in an environmentally sustainable manner – includes RGFT as a sub-discipline).
RH	Research hypothesis (mostly used in this thesis as key driver of the systematic literature review).

RoHS	Standard for managing hazardous substances/materials.
RQ	Research question (mostly used in this thesis as key driver of the organizational theory review).
SC and SCM	Supply chain (SC) (the entire network of enterprises, infrastructures and resources that co-create towards ensuring all the stages involved (from raw material, processing to delivery) in satisfying demand under the most efficient management strategies (SCM)).
SCEnAT	An LCA based tool for supply chain environmental analysis that has been used throughout this thesis (in Stage three of the methodology) in order to provide illustrative examples of how different RGFT/RGSCM strategies could help reduce the CO2 footprint of supply chains during disruptions.
SCRM	Supply chain risk management (a sub-discipline of SCM which focuses on risk management and mitigation).
Smart specialization	Policy instrument/strategy which directs funding and development according to the key strengths of a region.
ST	Stakeholders theory which explains how groups of institutions that form a stakeholders group pose pressures at the ecosystem levels upon individual institutions in order to achieve common standards/practices.
SQ	Search query comprising of formulas and logical operators that have been used to drive the systematic review strategy.
TFT Pillars	The seven main pillars of the proposed theoretical framework of the thesis.
WEEE	Standard for managing the waste of electrical and electronic equipment.

Chapter 1: Introduction

This chapter adopts an introductory nature by providing an overview on the entire research that has been performed in order for the reader to gain an initial understanding of the contextual complexity of the research area. Before proceeding to read this document it is highly advisable that the acronyms and list of terms section is consulted.

1.1 Background of the problem

The unpredictable nature of extreme weather-induced disruptions (heavy rain, blizzards, snow, icy roads, fog, heat waves) is posing tremendous pressure on nowadays supply chains. Longer transports, increased fuel consumption, hazardous wastes, unsatisfied clients, social unrest and risks, damage to the environment, infrastructure and assets are only few of the pressuring outcomes of such disruptions (Keohane & Victor, 2016; Chhetri et al., 2016; Global risks, 2015; GAR, 2015; Walch, 2015; Van der Vegt et al., 2015; Thompson et al., 2014; Surminski, 2013; Contestabile, 2013;Jarvis et al., 2012; Linnenluecke et al., 2012; Natarajarathinam et al., 2009; Hale & Moberg, 2005). As social and environmental concerns are growing in importance through normative and coercive directions, supply chain management (especially transportation) must fastly adapt to such requirements when aiming to achieve resilience in an environmentally and socially aware manner. To this end, resilient and green supply chain management (RGSCM) and its subfield - resilient and green freight transportation (RGFT) act as core enablers of modern growth with tremendously increased social pressures that demand innovative approaches for leveraging institutional level practices to a wider scale (i.e. mesosystem) in order to support eco-modernisation with a greater impact (Wong et al., 2016; Fallah et al., 2015; Torabi et al. 2015; Cardoso et al., 2015; Genovese et al., 2014; Koh et al., 2014; Ketikidis et al., 2013; Govindan et al., 2014; Bell et al., 2012; Shi et al., 2012; Zhu et al., 2012; Sarkis et al, 2011; Baresel-Bofinger et al., 2011; Sarkis et al., 2008). Such actors that pressure RGSCM and RGFT comprise of the key developmental institutions of a low carbon economy: research/eco-innovation, effective environmental policies, industries that innovate or incorporate eco-innovations, and the environment and society which act as core influencers of such an integrated eco & co-evolution framework (the Quintuple Helix Model as described by Carayannis, Barth & Campbell, 2012).

Even more, environmentally sustainable resilience (ability of a supply chain to return to its operational mode in a low carbon manner after a disruption took place) requires true co-creation at the quintuple helix level as institutionally focused solely economic performance (during disruptions) can no longer be accountable for the societal and environmental damage triggered by supply chains in their complex process of re-adaptation towards ensuring resilience. Such co-creation becomes even more critical during weather induced disruptions which due to their unpredictable nature can cause substantial damages to supply chains, societies and environment. Finally, all this context becomes even more critical in South East Europe which lacks the necessary mechanisms, research and infrastructure to properly adopt a quintuple helix level approach when aiming to enable environmentally sustainable resilience within its main transportation mode (road freight). This way, RGFT and RGSCM pose a core challenge for research and practice.

RGSCM and RGFT have often been studied through various theoretical frameworks such as the ecological modernisation theory (EMT) for understanding how eco-innovations emerge, diffusion of innovation theory (DIT) for investigating how eco-innovations diffuse among the RGSCM/RGFT actors, complex and adaptive systems theory (CAST) for examining how resilience and self-adaptation is being achieved and finally, institutional and stakeholders theory (INT and ST) for reasoning how institutions adopt eco-innovations triggered by stakeholder groups (and vice-versa). However, all these theories have been studied in a mere isolation when it comes to RGSCM/RGFT. Even more, a systematic literature review on theoretical foundations related to RGSCM/RGFT practice implementation shows a clear focus solely on institutional level drive of RGSCM/RGFT research, eco-innovation and eco-practice incorporation (and decision making) with very recent relation to proper co-creation and co-evolution at the entire quintuple helix level (in which nowadays supply chains span) with no evidence of quintuple helix co-creation and eco-innovation scale-up for the benefit of the entire ecosystem (Fahimnia et al, 2015; Tajbakhs & Hassini, 2015; Varsei et al., 2014; Bhattacharya et al., 2014; Taticchi et al., 2013; Seuring, 2013; Winter & Knemeyer, 2013; Bjorklund et al., 2012; Banerjee, 2008; Tang et al., 2008; Hervani et al., 2005; Shepherd & Gunter, 2005; Bendell, 2003).

In this context, this research introduces a convergence of existing (but disconnected/isolated) five organizational theories in the field of RGSCM/RGFT in order to trigger the emergence of a binding framework capable to drive and explain research and practical developments in this field. More specifically the proposed framework builds upon the work of Carayannis, Barth & Campbell, (2012) related to the quintuple helix (model) and integrates EMT, DIT, CAST, INT and ST in order to provide a comprehensive and modern framework for RGSCM/RGFT implementation. Such quintuple helix mesosystem is perceived to be integrated in the ecological/environmental ecosystem and accordingly, the mesosystem incorporates RGSCM/RGFT microsystems that co-create by diffusing and adopting eco-innovations towards achieving environmentally sustainable resilience.

1.2 Research questions, aim and objectives

The aim of this research is to propose a quintuple helix framework for the implementation of resilient and green road freight transportation (RGFT/RGSCM) during natural/weather induced disruptions in South East Europe by underpinning how institutional interactions and RGFT/RGSCM (eco-innovation) implementation can scale-up to mesosystem/stakeholder level. As it will be shown in the theoretical foundation and systematic literature reviews, there are several types of inquiries that this research will perform. Firstly, initiated by the theoretical foundation background of the proposed (five) theories, a series of seven converged research questions (CRQs) will drive the elaboration of the specific objectives (OBs) as well as of the Pillars of the proposed theoretical framework. These CRQs have been converged as shown in section 2.1.6 by overlapping common gaps and inquiries of each of the five theories. To this end, the seven CRQs (which will answer mostly academic inquiries) are:

> **CRQ1**: Bottom-up: How can local level institutional EMT driven eco-innovations (either transformative or disruptive) diffuse faster under the DIT behaviour and scale-up (as explained by ST and INT) across the RGFT CAST driven microsystem panarchy during crises towards enabling resilience (Dubey et al., 2015; Govindan et al., 2015; Tian et al., 2014; Gobbo et al., 2014; Zhu et al., 2012; Darnall et al., 2008; Andrews et al., 2003; Hoffman & Ventresca, 2002) (Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Golicic & Smith, 2013; Zhu et al., 2012; Moore & Westley, 2011; Van den Berg, 2011; Chertow, 2009; Atwell et al., 2008; Jacobsson & Brgek, 2008; Walker et al., 2006; Walker et al., 2004)?

CRQ2: Top-down: How can the modernized ecosystem level (explained by the ST) generate eco-innovation exogenous pressures on the individual institutions (explained by INT) in an international ecosystem and what are the institutional level responses to such induced EMT driven modernization (Govindan et al., 2015; Tian et al., 2014; Zhu & Geng, 2013; Dornfield et al., 2013; Sarkis et al., 2011; Rivera, 2004) ?

CRQ3: Transversal: What are the local level institutional controlled processes of the CAST driven RGFT microsystem and how do these institutional controlled processes integrate and co-evolve (INT, ST) with the ones of other quintuple helix stakeholders in order to enable co-creation and fast eco-innovation adoption (EMT, DIT) towards ensuring RGFT at the quintuple helix mesosystem-level (Baumgartner et al., 2015; Piotrowicz, W., & Cuthbertson, 2015; Bhattacharya et al., 2014; Varsei et al., 2014; Ahi & Searcy, 2015a; Ahi & Searcy, 2015b; Gopal & Thakkar, 2012; Ivanov et al., 2012; Van den Berg, 2011; Folke et al., 2010; Bansal & Mcknight, 2009; Chertow, 2009; Pathak et al., 2007; Holling, 2001)?

CRQ4: Transversal: What are the effects of the interconnectedness of the institutional level stakeholders and the location of the disruption within a quintuple helix CAST based mesosystem on the RGFT process in terms of the effectiveness of the emerged eco-innovation (EMT) diffusion (DIT) (Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Zhu & Ruth, 2013; Petit et al., 2010; Gonzalez et al., 2008; Arimura et al., 2008; Hervani et al., 2005; Wagner & Bode, 2006) ?

CRQ5: Methodologies: What CAST systems modelling and simulation, mixed-methods research and behavioural analysis can be performed within an ecosystem (Faisal, 2016; Dubey et al., 2015; Hohenstein et al., 2015; Qazi et al., 2015; Heckmann et al., 2015; Tattichi et al., 2015; Huerta-Barrientos et al., 2015; Chouwdhury & Hossan, 2014; Molina-Azorin & Lopez-Gamero, 2014; O'Rourke, 2014; Seuring, 2013; Golicic & Davis, 2012; Zhu et al., 2012;Pathak et al., 2007) ?

CRQ6: Exogenous: How can stochastic externalities induced disruptions (such as environmental conditions) be better overcame in CAST ecosystems through eco-innovation (EMT, DIT, INT, ST) (Li & Coates, 2016; Chhetri et al., 2016; Snyder et al., 2015; Loh & Thai, 2015; Mattson & Jenelius, 2015; Global risks, 2015; GAR, 2015; Van der Vegt et al., 2015; Zhu & Ruth, 2013; Linnenluecke et al., 2012; Ergun et al., 2010; Natarajarathinam et al., 2009; Stecke & Kumar, 2009; Nakano, 2009; Sanchez-Rodriguez et al., 2008; Holling, 2001) ?

CRQ7: Transversal: How does the DIT properly explain the adoption of EMT by CAST based RGFT institutions (Kamalahmadi & Parast, 2016; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Zhu et al., 2012; Carayannis, Barth & Campbell; 2012; Carayannis & Campbell, 2010; Brugge & Van Raak, 2007; Quist, 2007; Sondejker et al., 2006)?

Derived from the CRQs, the following specific OBs have been established (towards enabling also a more practical/societal/policy result emergence). The role of these OBs are to place the CRQs into a measurable and granular workplan structure.

- **OB1:** Assessment of extreme weather conditions impacts (institutional and ecosystem level, mixed methods):
    - **OB1.1:** Understand which weather conditions cause the most impactful disruptions in road freight transportation from SEE (relates to CRQ6).
- **OB2:** Assessment of business impact and decision making processes against the disruptions caused by such weather conditions (institutional level, mixed methods):
    - **OB2.1**: Understand what negative business outcomes emerge as a result of such disruptions
    - **OB2.2:** Understand what (green) key performance indicators do business use and to what extend when dealing with disruptions
    - **OB2.3:** Understand to which extent do businesses implement green practices during their decision making processes

    - **OB2.4:** Understand what drivers and barriers do businesses face when aiming to adopt/implement green practices
    - **OB2.5:** Understand what resilience mechanisms do businesses implement and to what extent these mechanisms include environmentally sustainable practices
    - **OB2.6:** Understand how (to what extent) businesses interact with the RGFT/RGSCM stakeholders.
- **OB3:** Develop a framework for stakeholders to implement resilient and green road freight transportation practices (mesosystem level):
    - **OB3.1:** Investigate how can the resilience mechanisms of businesses be supported/fostered faster by other stakeholders from the ecosystem (relates to CRQ1, CRQ7).
    - **OB3.2:** Investigate to what extent do businesses respond to ecosystem pressures in order to implement RGFT practices (relates to CRQ2).
    - **OB3.3:** Compare the RGFT KPIs of businesses with the ones of the involved mesosystem's stakeholders (relates to CRQ3).
    - **OB3.4:** Establish the importance of business partnerships interconnectedness in terms of enabling fast RGFT (relates to CRQ4).
    - **OB3.5:** Use modelling tools (SCEnAT) to show practical underpinnings of implementing suitable RGFT (relates to CRQ5)

OB4: Develop several simulations to test the proposed framework with RGFT/RGSCM mesosystem stakeholders (modelling & simulation)

Overall, based on the seven CRQs and on the granular targets set by the four main OBs, the following seven Theoretical Framework of the Thesis (TFT) Pillars denote the key concepts of the proposed theoretical framework by this research which binds the five main theories. The following pillars are being sustained/extended during the primary research phase by answering the CRQs via the OBs.

Pillar 1: The RGFT microsystem is CAST based and must emphasise the following core elements: adaptability, flexibility, capacity to foster resilience and well defined key controlled processes at the (supply chain) microsystem level.

Pillar 2: Having these elements with core fundamental infusions from the EMT, during a disruption, the RGFT microsystem will eco-innovate and based on the well defined key controlled processes (with core support from flexibility, adaptability) a green resilience strategy will emerge.

Pillar 3: However, in the best case, this green resilience strategy will be implemented at the institutional (INT) or RGFT microsystem level without any direct impact measurement and implementation oversight at the wider ecosystem level (quintuple helix mesosystem) which has wider implications for the environment (ST).

Pillar 4: To this end, based on the CAST and DIT, the propagation of the green resilience strategy and the necessary quintuple helix co-creation processes should be devised in order to leverage the impact of the green resilience strategy from microsystem, to mesosystem and finally to the ecosystem (INT, ST).

Pillar 5: Thus, the DIT propagates eco-innovations from institutions to ecosystem inducing thus change at the ecosystem/stakeholder level (ST) which will later on put more exogenous pressure to institutions (INT) to induce further modernization (cycle).

Pillar 6: This way, green resilience propagation is not isolated in a remote microsystem location of the environment and it will impact and induce modernization and transformation throughout all social systems by relying on EMT, CAST and DIT.

Pillar 7: The meaning of green resilience in this case is the capacity of the RGFT microsystem to recover in an environmentally sustainable (resource efficient and negative impact reduction) manner after an environmentally induced disruption took place by properly propagating the recover throughout all social systems that are involved.

As it can be seen, all CRQs, OBs and Pillars are related and used throughout the thesis in order to properly drive the research. In order to provide a better overview on how these items relate with all the concepts overarching this research, Table 1 provides a descriptive overview.

Table 1: Key researchers, main theories, CRQs, TFT Pillars and OBs

Concept	Key researchers that drive this thesis	CRQs	TFT Pillars	OBs
Quintuple helix theory	Carayannis, Barth & Campbell 2012; Carayannis & Campbell, 2010;	CRQ1, CRQ2, CRQ3	Pillars 1,2,3,4,5,6	OB3.1, OB2.2, OB2.3, OB3.2, OB2.6, OB3.3
EMT	Zhu et al., 2012; Berger et al., 2001; Mol, 2000; Mol, 1995	CRQ1, CRQ2, CRQ4, CRQ6, CRQ7	Pillars 1,2,3,4,5,6	OB3.1, OB2.2, OB2.3, OB3.2, OB3.4, OB2.5, OB3.1
DIT	Zhu et al., 2012; Hervani et al., 2005; Rodgers, 1962	CRQ1, CRQ2, CRQ6, CRQ7	Pillars 1,2,3,4,5,6	OB3.1, OB2.2, OB2.3, OB3.2, OB2.5, OB3.1
CAST	Dubey et al., 2015; Govindan et al., 2015; Tian et al., 2014; Zhu & Ruth, 2013; Folke et al., 2010; Walker et al., 2006; Holling, 1973	CRQ1, CRQ3, CRQ4, CRQ5, CRQ6, CRQ7	Pillars 2,3,4,5,6	OB3.1, OB2.2, OB2.6, OB3.3, OB3.4, OB2.5, OB3.5, OB2.5, OB3.1
INT	Dubey et al., 2015; Govindan et al., 2015; Tian et al., 2014;	CRQ1, CRQ2, CRQ6	Pillars 1, 3,4,5,6	OB3.1, OB2.2, OB2.3, OB3.2, OB2.5
ST	Ivanaj et al., 2015; Sarkis et al., 2011; Delmas & Toffel, 2004	CRQ1, CRQ2, CRQ6	Pillars 1, 3,4,5,6	OB3.1, OB2.2, OB2.3, OB3.2, OB2.5
Quintuple helix co-creation	Dubey et al., 2015; Govindan et al., 2015; Ivanaj et al., 2015; Fahimnia et al., 2015; Diabat et al., 2014; Holling, 2001	CRQ3, CRQ7	Pillars 2,3,4,5,6	OB2.6, OB3.3, OB3.1
Resilience as CAST based quintuple helix co-creation	Kamalahmadi & Parast, 2016; Carvalho et al., 2012; Craighead et al., 2007; Christopher & Peck, 2004	All	All	All
Weather induced disruptions as drivers of inner eco-innovation engine of co-creation at the quintuple helix level	Bahadur & Doczi, 2016	All	All	All
RGFT/RGSCM	Dubey et al., 2015; Govindan et al., 2015; Tian et al., 2014; Acquaye et al., 2014; Koh, 2014; Zhu et al., 2012; Walker et al., 2008; Hervani et al., 2005	All	All	All

1.3 The proposed scientific methodology of this research

The chosen methodology (critical realism and post-positivism vision) resides in a three stage mixed-method approach that responds to the methodological gaps in the area of RGFT/RGSCM: Firstly, there is a need for mixed methods research in GSCM/GFT (Faisal, 2016; Dubey et al., 2015; Chouwdhury & Hossan, 2014; Molina-Azorin & Lopez-Gamero, 2014; O'Rourke, 2014; Golicic & Davis, 2012; Zhu et al., 2012; Seuring, 2011; Psychogios and Priporas, 2007; Mangan et al., 2004; Creswell, 2003; Christy and Wood, 1999; Goodman, 1999); Secondly, there is a need of mixed methods research in relation to analysing resiliency performance in supply chains with tangency to RGFT/RGSCM (Hohenstein et al., 2015; Qazi et al., 2015; Kilubi et al., 2015; Tabrizi & Razmi, 2013; Pettit et al., 2013; Cadden et al., 2013); Thirdly, the literature claims for the development of frameworks that make use of quantitative based modelling & decision support in RGSCM/RGFT (Heckmann et al., 2015; Qazi et al., 2015; Tattichi et al., 2015; Huerta-Barrientos et al., 2015; Seuring, 2013; Wu & Olson, 2008; Craighead et al., 2007; Srivastava et al., 2007; Chan & Chan, 2006; Fleisch & Tellkamp, 2003; Lee et al., 2002; Simchi-Levi, 2000); Fourhtly, the related literature stipulates the need of mixed methods when analysing systems that include environment, society and cross-system innovation/practice diffusion – quintuple helix (Soosay & Hyland, 2015; Smith & Rupp, 2015; Sounders et al., 2015; Power & Gruner, 2015; Deacon et al., 2014; Storer et al., 2014; Soundararajan & Brown, 2014; Iofrida et al., 2014).

In this context, the following research approach is being adopted by this thesis:

> **Stage one**: Qualitative exploratory interviews at the institutional level (N=6, one in each different country from SEE) to consolidate the scarce literature findings (from SEE) and to enable a more targeted approach for Stage two.
>
> **Stage two:** Qualitative (exploratory) and quantitative (confirmatory) semi-structured survey across the six SEE countries (N=311) at the institutional level (test and explore: RGFT/RGSCM practices and their implementation status, drivers & barriers to RGFT/RGSCM implementation, KPIs used to monitor RGFT/RGSCM and wilingness to implement RGFT/RGSCM).

Stage three

– **Part one** Exploratory and confirmatory qualitative focus groups (N=3) to provide more insight into Stage two in Greece only and to leverage the institutional level findings to a stakeholder/quintuple helix mesosystem level.

– **Part two** Modelling and simulation of institutional level supply chains towards proposing a quintuple helix framework (as confirmed/explored in Stage three Part one) for the implementation of RGFT/RGSCM during weather-induced disruptions.

1.4 Research findings and implications

The findings emerged after the three methodological stages provide good incentives to extend the academic literature in this related field (within the quintuple helix mesosystem from South East Europe). The overall consensus that emerged is that RGFT/RGSCM during weather-induced disruptions can be indeed achieved only through co-creation and goal alignment at the quintuple helix mesosystem level (as such disruptions affect the entire quintuple helix mesosystem, not only the supply chains). The following academic inquiries and theories have been explored and informed:

- Arguing for the convergence of EMT, CAST, DIT, INT and ST towards providing an integrated research framework for RGFT/RGSCM implementation within quintuple helix mesosystems. This is the core novelty of this research and has been achieved by building upon the work of Carayannis, Barth & Campbell (2012) in a manner in which it also responds to the RGFT/RGSCM methodological approach gap mentioned in section 1.3.

- Exploration of the EMT by filling the research gaps in terms of the need for multi-stakeholder co-creation, transformation/modernization, and impact among institutions and stakeholders in relation to RGFT/RGSCM implementation (Kamalahmadi & Parast, 2016; Nooraie & Parast, 2016; Francis & White, 2016; Choudhury et al., 2015; Mari et al., 2015; Rajesh & Ravi, 2015; Kim et al., 2015; Durach et al., 2015; Barosso et al., 2015; Perera et al., 2015; Mensah et al, 2015; Gilly et al., 2014; Kristianto et al., 2014;

Scholten et al., 2014; Carvalho et al., 2012; Zhu et al., 2012; Lengnick-Hall et al., 2011; Burnard & Bharma, 2011; Christopher & Peck, 2004).

- Exploration of the DIT by confirming the need for (fast) RGFT/RGSCM eco-innovation scale-up from the institutional level to the mesosystem/stakeholder level as well as by reasoning the adoption pressures/drivers and choices – transformative against disruptive (Zhu et al., 2012; Moore & Westley, 2011; Atwell et al., 2008; Jacobsson & Brgek, 2008; Walker et al., 2006).

- Exploration of CAST by confirming/explaining the concept of institutional interconnectedness within mesosystems/stakeholder groups towards enabling better eco-innovation adoption under specific KPIs (Kamalahmadi & Parast, 2016; de Siqueira et al., 2015; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Blackhurst et al., 2011; Petit et al., 2010; Falasca et al., 2008; Craighead et al., 2007; Tang, 2006, Christopher, 2004).

- Exploration of the INT and ST by confirming and exploring top-down and bottom-up pressures to RGFT/RGSCM eco-innovation adoption/implementation (Ivanaj et al., 2015; Hsu et al., 2013; Hu & Hsu, 2010; Ninlawani et al., 2010; Mont & Leire, 2009; Seuring & Muller, 2008; Walker et al., 2008; Srivastava, 2007; Chien & Shih, 2007; Wright & Elcock, 2006; Tsoulfas & Pappis, 2006; Yalabik et al., 2005; Evans & Johnson, 2005; Eveloy et al., 2005; Handfield et al., 2005; Widmer et al., 2005; WEEE, 2003).

- Finally, exploring how RGFT/RGSCM can be implemented institutionally and at the mesosystem level (in SEE with the main focus on Greece) under a quintuple helix approach –where the key message that has been revealed is that quintuple helix co-creation, goal and KPI alignment of all stakeholders and capacity to transform (eco-modernize) of institutions are the key enablers of fast eco-innovation (RGFT/RGSCM) diffusion and implementation.

Secondly, this research provides industry with a quintuple helix framework for the implementation of RGFT/RGSCM by revealing SEE level explorations (with an ultimate focus on Greece) of: RGFT/RGSCM practices that can be used, drivers, barriers and guidelines for the use of modelling and simulation tools (all these for confirmed weather-induced disruptions). This will ensure proper standard compliance, public/environmental acceptance and financial efficiency.

Thirdly, through the focus groups (targeting Greece), quintuple helix co-creations have been triggered, enabling a better mutual understanding and goal alignment – in full coherence with the policy-makers' visions (ensuring thus that policy makers can also have a more targeted area for devising suitable policies and allocating resources - primarily centred around the smart specialization areas).

Finally, societal/environmental organizations will be integrated more in the quintuple helix decision making (especially following industry's requests) leading to an enhanced quality of life, fewer environmental damages and a long term motivated and actively involved society that will co-create their environmentally sustainable surroundings.

1.6 Limitations and further research

The main limitations of this research consist, primarily, of the flexible rigorousness regarding the triangulation process (which is pertinent to most research in this area) in the sense that full triangulation implies the implementation of fully integral and separate investigations which are then compared (Faisal, 2016; Dubey et al., 2015; Chouwdhury & Hossan, 2014; Molina-Azorin & Lopez-Gamero, 2014; O'Rourke, 2014; Golicic & Davis, 2012; Greene, 2008; Bergman, 2008; Bazeley et al., 2004). However, the current research used the mixed-method approach to compensate the limited research in this area by adopting a widely exploratory strategy (with partial quantitative and qualitative confirmations). Secondly, expert sampling in Stage one and Stage three is pertinent to a certain bias and isolated clustering of the research findings. Thirdly, the qualitative analysis part in Stage one and Stage three (following inductive content analysis) is highly biased on the transcript interpretation capacity of the primary researcher and may also have led to certain inaccuracies (Heckmann et al., 2015; Qazi et al., 2015; Tattichi et al., 2015;

Huerta-Barrientos et al., 2015; Seuring, 2013; Wu & Olson, 2008; Craighead et al., 2007; Srivastava et al., 2007; Chan & Chan, 2006; Fleisch & Tellkamp, 2003; Lee et al., 2002; Simchi-Levi, 2000). Furthermore, the overall assumptions of the proposed theoretical framework are high level and have been developed widely through an exploratory strategy with very limited confirmation. Still, the findings of Stage two confirm core parts that overcome these limitations. Finally, regardless of the confirmatory nature of Stage two and of the second part of Stage three, the findings may be subjected to validity claims due to the lack of information/knowledge on these concepts by the targeted sample (which may reduce the validity of the findings). Overall, these limitations have been mitigated through the partial triangulation and through the representative nature of the expert samples.

In this context, further research required to extend and further investigate the findings of this research could comprise of:

Replicate the methodology utilized by this research on other (or similar) quintuple helix mesosystems in order to cross-validate the findings and build up scientific value for this approach at a higher granularity level in order to properly assess (via integrally performed mixed-methods) the validity and influence of each of the five theories (EMT, DIT, CAST, INT, ST) when it comes to explaining RGFT/RGSCM implementation within quintuple helix mesosystems.

Provide an answer for the remaining problematic gaps in the field of EMT, DIT, CAST, DIT, INT and ST such as: differentiation between strong and weak EMT and its impact on dematerialization vs supramaterialization in a circular economy context, the role of the environmental flows ideology, the role of localized interactions, the role of panarchy governance.

1.7 Academic, practical, policy and societal impact of this research

The impact (up-to-date) of this research consists of:

- one article pre-selected for publication in the Journal of Cleaner Production (Impact factor: 3.844);

- the acquisition of two new EU funded projects (TrainERGY – Energy efficient operations and REINVEST – Sustainable freight transportation in EU & India with total value of 700 000 EUR);
- the establishment of the Triple Helix Association Chapter of Greece as local chapter of the global Triple Helix Association initiated by Prof Henry Etzkowitz at the University of Stanford (USA);
- the establishment of the local branch of the UK based Advanced Resource Efficiency Centre (AREC) (quintuple helix co-creation for resource efficiency);
- Indirect impact through dissemination and multiplication of the results:
    - Integration of the research findings in the teaching curriculum of the University of Sheffield international Faculty, CITY College (BSc and MSc level);
    - Participation (with full submissions) to 13 related conferences (during 2012-2016) – details can be found in Appendix E.

1.8 Thesis structure

The chapters of this thesis will follow such as:

- Chapter 2 presents the systematic literature review. The chapter is initiated with a review of theoretical foundations related to RGFT/RGSCM under the influence of EMT, DIT, CAST, ST and INT. The purpose of this initial review is to properly explain the foundations of the five main theories (EMT, DIT, CAST, INT, ST) and to show how the CRQs and TFT Pillars have been derived. Furthermore, a systematic literature review is being performed on a wide range of academic resources in the area of RGFT/RGSCM in order to understand how such literature relates to the five main theories (as well as to refine/focus the CRQs, OBs and TFT Pillars of the thesis). In order to perform the systematic review, a series of research hypotheses (RH) related to the CRQs, TFT Pillars and OBs have been devised.
- Chapter 3 and Chapter 4 present the methodological explanations required to perform the primary research. Firstly, the research philosophy and design of the three main stages is presented, followed by a critical analysis of the findings of each stage in relation to the CRQs, Pillars and OBs.

- Chapter 5 provides the critical analysis and discussion part by bridging the outcomes of the three research stages in a critical integrative manner towards retrieving the final outcomes of the primary research outcomes in relation to the CRQs, Pillars and OBs.
- Chapter 6 (conclusion) provides the final remarks of this research together with the key limitations, further research and impact discussion.
- Finally, the thesis continues with the enumeration of the references utilised throughout the entire analysis as well as with key appendices that provide additional supporting materials to be used in order to gain a better understanding of the presented facts.

Additionally, the graphical aids included in this thesis provide a good reference for visualizing the research and knowledge elaboration process in a step by step manner. For example, all the figures are used to explain the following facts:

- Providing insights into the theoretical assumptions of this thesis' framework: Figure 1, Figure 5 and Figure 7.
- Showing how all the five theories interact, overlap and converge: Figure 2, Figure 3, Figure 4, and Figure 6.
- Explaining the systematic literature review approach and relating all the concepts used in the thesis to drive the research (OBs, CRQs, TFT Pillars, RHs): Figure 8, Figure 9, Figure 10 and Figure 11.
- Depicting the key outcomes of the systematic literature review: Figure 12, Figure 13, Figure 14, Figure 16, Figure 18 and Figure 20.
- Showing how the systematic literature review responds (and to what extent) to the CRQs, OBs and TFT Pillars: Figure 15, Figure 17 and Figure 19.
- Explaining the key stages of the methodology: Figure 21, Figure 22, Figure 23 and Figure 33.
- Displaying the outcomes of the modelling and simulation stage: Figure 24, Figure 25, Figure 26, Figure 27, Figure 28, Figure 29, Figure 30, Figure 31, Figure 32, Figure 34 and Figure 35.

Similarly, the findings boxes are used only in the systematic literature review part of the report in order to better emphasize the key outcomes of the review in terms of their connection with the five theories (EMT, DIT, CAST, INT and ST). Finally, the tables provided in this thesis provide key aggregated data and are used primarily in the data analysis sections to report key results and findings.

1.9 Summary

The key points that need to be acknowledged before proceeding to the thesis are:

- Before proceeding to read this thesis it is highly advisable that the acronyms and list of terms section is consulted.
- The understanding of the research background and aim is highly importnat: weather induced disruptions must be overcome via the adoption of RGFT/RGSCM for which this research proposes a framework based on the convergence of EMT, DIT, CAST, INT and ST under the quintuple helix model via a three stage mixed-method research.
- The already (partially) confirmed impacts of this thesis support the relevance of this research.
- The role of the graphical aids is highly important as all diagrams, tables and boxes are connected towards providing abstractions of the key findings at various points in the thesis development.

This chapter adopted an introductory nature by providing an overview on the entire research that has been performed in order for the reader to gain an initial understanding of the contextual complexity of the research area – as well as to provide a guidance of how to approach the thesis.

Chapter 2: Literature Review

2.1 Introduction to the literature review and to the social science epistemology

Resilient and green freight transportation (RGFT) as sub-discipline of resilient and green supply chain management (RGSCM) is a recent field of research and practice that extends the traditional work of parallel disciplines focusing solely on green supply chains management (GSCM) or supply chain risk management and resilience or even core operations research with applications in supply chain management (i.e. lean operations). For this purpose, a pioneering work performed by Ahi & Searcy (2013) positions nowadays supply chain management in the context of its mandatory environmental sustainability within the triple bottom line with core emphasize on the need for (resilience and) responsibility towards the entire stakeholders impacted by the supply chain (Zhu & Ruth, 2013; Azevedo et al., 2013; Koh et al., 2013; Shi et al., 2012; Bai et al., 2012; Carvalho et al., 2011; Stonebraker et al., 2009; Koh et al., 2007). The same view is strengthened later on by Govindan et al. (2014) which take this work further and analyses supply chain management from the point of view of the lean, green and resilience paradigms and demonstrate how these three paradigms have a positive impact. The entire debate on RGFT and RGSCM takes place under the framework of the two core drivers (resource efficiency and environmental impact) of environmental sustainability outcomes (Wong et al., 2016; Fallah et al., 2015; Torabi et al. 2015; Cardoso et al., 2015; Genovese et al., 2014; Koh et al., 2014; Ketikidis et al., 2013; Govindan et al., 2014; Bell et al., 2012; Shi et al., 2012; Sarkis et al, 2011; Baresel-Bofinger et al., 2011; Sarkis et al., 2008) – which provide thus a core direction for pursuing resilience outcomes solutions: resource efficiency in closed loop supply chains and environmental footprint reduction.

Furthermore, recent studies show that resilience (in green freight transportation and green supply chain management) is increasingly become related to: its impact and synergy with ecosystem stakeholders - industry, policy, society, environment (Govindan er al, 2016; Diabat et al., 2015; Zhu & Ruth, 2013; Carayannis, Barth & Campbell, 2012; Carayannis & Campbel, 2010) and that, innovation propagation from institutional (local stakeholder) to the entire ecosystem becomes the key to ensuring the intended environmental outcomes - besides resilience (Zhu et al., 2012; Ivanon et al., 2012; Van den Berg, 2011; Folke et al., 2010)

It is thus of core importance that all the research on RGFT and RGSCM is focused along the strands identified by the literature and practice. These research directions for RGFT and RGSCM are indeed beneficial, however, in order to properly grasp the theoretical underpinnings that drive and explain advancements in this field, it is critical to identify social science theoretical frameworks (organizational theories/epistemologies) that explain these events.

Organisational theories (social science theoretical frameworks) are statements of relations among concepts within a set of boundary assumptions and constraints (Bacharach, 1989). Basically, organisational theories are used to enable researchers to focus on concrete and guided aspects rather than being diverted by the complexity of any system.

The literature provides significant number of such theories that could be used to explain the behaviour of facts (such as RGFT) – however the most emblematic review of the application of such theories in GSCM (including thus RGFT/RGSCM) was performed by Sarkis et al. (2011). According to the author, the theoretical contribution of the supply chain management is very limited with several tangent research strands in operations management (Shi et al., 2012; Ketchen & Hult, 2007; Etzion, 2007) and with most of the remaining research residing in the social science areas not related to organizational behaviour (Tang, 2010) – leading to a severe research gap in the field of GSCM (and implicitly RGFT/RGSCM). Some of the theories identified by Sarkis et al. (2011) as applicable to RGSCM/RGFT research are: complexity theory, ecological modernization, information theory, institutional theory, resource based view, resource dependency, social network, stakeholder and transaction cost economics. However, as it will be shown, the core of the literature seems to point towards towards the use of EMT, DIT, CAST, INT and ST in relation to researching RGFT/RGSCM.

Nevertheless, RGFT implies much more than GSCM especially if the context mentioned in the beginning of this section is to be considered (the impact on society and stakeholders, scalability of the solutions from institutions to ecosystems, and thus, additional theoretical foundations apply. For this purpose, theories such as complex adaptive systems (which encompass resilience) and the diffusion of innovation theory have been identified as core fundaments that drive this search (as it will be shown in the upcoming sections). The core of this research resides in the ecological modernization theory (EMT) with support of further understanding from the diffusion of innovation theory (DIT), the complex and adaptive systems theory (CAST), institutional theory (INT) and stakeholder theory (ST).

The literature review chapter is structured as the following (two main parts – section 2.1 – organizational theories (social science epistemology) and section 2.3 - systematic literature review):

- Section 2.1.1 provides an overview on the organizational theories that influence this research (EMT, DIT, CAST, INT and ST) in order to provide an overarching approach to these matters. Then, the upcoming section discuss each, in details, the five theories: 2.1.2 (EMT), 2.1.3 (DIT), 2.1.4 (CAST), 2.1.5 (INT and ST).
- Section 2.1.6 presents how the five theories overalp in terms of gaps, research questions and general inquiries – and how the converged research questions (CRQs) of this thesis have been derived. Specifically, each of the five theories has individual research questions (RQs) – which, when converged, become CRQs.
- Section 2.1.7 presents the theoretical framework of this thesis (TFT) and its assumptions.
- Section 2.1.8 presents the summary of the organizational theory (epistemology) part which triggers the CRQs and the TFT Pillars of the thesis.
- Section 2.2 presents the systematic literature review methodology that has been adopted by this research.
- Section 2.3 presents the actual outcomes of the systematic literature review that has been developed along the CRQ (from which specific research hypotheses – RHs have been derived) towards providing sufficient literature background to enhance the necessity and validity of the proposed CRQs and TFT Pillars.
- Section 2.4 provides concluding remarks for the entire review process.

2.1.1 Overview

The ecological modernisation theory (EMT) underpins a core new ideology towards sustaining growth in simultaneous awareness of environmental protection and is deemed to be the core influencing theoretical fundament of this thesis. This chapter of the thesis discusses in depths the EMT by focusing on its primary theoretical fundaments and research debates. The EMT is the main theory influencing this research under the following assumptions which will be scientifically explored towards providing contribution to the existing research:

The EMT is a core driver for industrial and societal growth and the resilient and green freight transportation (RGFT) social ecosystem (which is a quintuple helix ecosystem: industry, research, policy, society, environment) which points towards an environmentally sustainable growth with clearly perceived benefits.

The EMT within the RGFT/RGSCM social ecosystem is highly influenced by the diffusion of innovation theory (DIT) - by relying on the DIT to explain how EMT induced behaviour is being adopted within the RGFT social ecosystem.

The RGFT social ecosystem requires the complex (and adaptive) systems theory (CAST) to explain how resilience is being achieved. However, as the RGFT social ecosystem is integrated within the EMT underpinnings, the socio-ecological reorganization explained by the CAST towards achieving resilience, becomes thus, highly influenced by the EMT principles. At this point, the co-reorganization/transformation/resilience scale-up from institutional level to ecosystem level will be explained through the institutional theory (INT) and stakeholder theory (ST). Figure 1 displays these facts by putting into scene all the five theories.

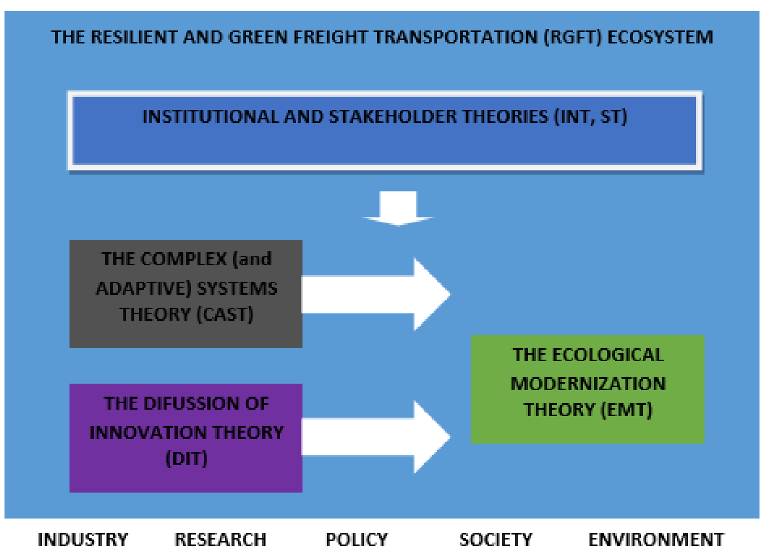

Figure 1: High level overview on the theoretical foundation assumptions

One of the core influencing studies that combines EMT and DIT (in transition economies) was performed by Zhu, Sarkis and Lai (2012) in relation to green supply chain management (GSCM) and innovation diffusion in an ecological manner for improved organizational performance. The study adopts and tests two core propositions:

> Proposition one: "*GSCM innovation adoption can be categorized into varying levels of adoption among various manufacturers*."
>
> Proposition two: "*Manufacturers with higher levels of adopting GSCM attain better performance*" (Zhu et al., 2012, p173)

This approach provides, thus, a core opportunity to further extend the theoretical contribution towards EMT and DIT in the transition region of South East Europe (which is the target of this research) with the core focus on RGFT social ecosystem as a subset of GSCM.

Another key series of studies that drive this research reside in the highly cited work of Folke et al. (2010) and Walker et al. (2006) which combine CAST with EMT in order to explain DIT and reason how crises (such as disruptions in freight transportation) could serve as opportunities to innovate in an environmentally sustainable manner:

> "*Transformational change at smaller scales enables resilience at larger scales. The capacity to transform at smaller scales draws on resilience from multiple scales, making use of crises as windows of opportunity for novelty and innovation, and recombining sources of experience and knowledge to navigate social–ecological transitions.*" (Folke et al., 2010)

Taking this CAST-based transformation from institutional level to larger scales (ecosystem) will be performed through know-how and theoretical direction infused by the INT and ST. Generally, ST and INT deal with how individual institutions react at stakeholder's exogenous pressures and this is why these theories become critical at this point towards informing on how such drivers/pressures lead to the scale-up of institutional transformation (Sarkis et al., 2011; Ball & Craig, 2010; Matos & Hall, 2008; Hirsch, 1975). These aspects are discussed in a practical approach by (Dubey et al., 2015; Govindan et al., 2015; Tian et al., 2014; Gobbo et al., 2014; Zhu et al., 2012; Darnall et al., 2008; Andrews et al., 2003; Hoffman & Ventresca, 2002) (Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Golicic & Smith, 2013; Zhu et al., 2010; Testa & Iraldo, 2010; Nawroka, 2008; Walker et al., 2008; Chien & Shih, 2007; Hervani et al., 2005;

Ginsberg & Bloom, 2004; Delmas & Toffel, 2004; Gupta & Pierro, 2003; Rao, 2002; Chan & Lau, 2001; Hoffman, 2000),

Finally, the work of Carayannis, Barth & Campbell (2012) is of core relevance towards understanding the behaviour of RGFT frameworks by integrating EMT and DIT, INT and ST into a properly explained CAST based ecosystem where knowledge (innovation), practice, society, policy and the environment (the quintuple helix) are the key decision making factors and drivers of theoretical advancements:

> "*The Quintuple Helix finally frames knowledge and innovation in the context of the environment (natural environments). Therefore, the Quintuple Helix can be interpreted as an approach in line with sustainable development and social ecology. "Eco-innovation" and "eco-entrepreneurship" should be processed in such a broader understanding of knowledge and innovation*" (Carayannis & Campbell, 2010; Carayannis, Barth & Campbell, 2012).

The upcoming theoretical insights into the EMT, DIT and CAST will highly relate to the work of the previously mentioned authors as their core findings and approaches provide the main developmental axes for this research.

2.1.2 The EMT and its influence in understanding RGFT

2.1.2.1 A social science theory view of ecological modernization

The ecological modernisation theory (EMT) is much more than just an environmental policy – it is the core ideology and theoretical fundament of modern development. The EMT is generally used as a social science framework to analyze and understand changes and transformation requirements throughout ecological crises with immediate influence on ecological policy making and growth stakeholder management (Berger et al., 2001).

Initiated in mid-1980s primarily by Joseph Huber (Lundqvist, 2000; Mol, 1995), it managed to transcend by the 90s in developmental stakeholders' agendas (policy makers, research, industry). The core vision of the EMT resides not in the mitigation of the environmental damage itself, but rather, on the transformation of the entire ecosystem of growth and development towards a more sustainable operational behaviour from all points of view (also in line with CAST, INT and ST).

For achieving this, all stakeholders (including society) become thus involved in EMT's approach through a direct co-creation and mutual transformation (Lundqvist, 2000).

Nonetheless, it is of core importance to analyse the motivation of the growth ecosystem towards their engagement in the EMT induced-transformation. For this, the quintuple helix ecosystem will be considered (Carayannis, Barth & Campbell, 2012).

Policy makers target: Job creation opportunities, less societal pressure, compliance to regulations, economic growth.

Industry targets: New markets/business opportunities, governmental support for such opportunities, innovation capacity and potential from the target markets.

University: Industry funded research and a fostering policy enabled entrepreneurial context.

Society: Access to jobs, prosperity, good living conditions.

Environment: Sustainability and responsibility.

In today's context of a quintuple helix growth and development, the EMT becomes a core source of change and innovation through transformation which leads to growth for all stakeholders.

Following such vision, it is important to understand the underpinning social theory related to EMT in order to further build on it. For this purpose, emblematic researches performed by Buttel (2000) and Berger et al. (2001) provide four different social science perspectives of EMT which according to Revel and Rootherfood (2003) are the core pillars of transformation:

- EMT as a school of thought or belief system (ideology, governance, social cohesion).
- EMT as a policy discourse (policy & society) .
- EMT as strategic management (industry).
- EMT as innovation or technological adjustment (research, transformation).

Having the four perspectives of the EMT as described by Buttel (2000), it is crucial to emphasize (as shown in the previous bullet point list) how each EMT perspective relates to stakeholders from the quintuple helix of Carayannis & Campbell (2000). Nonetheless, similarly as Lundquist (2000), Buttel (2000) stress the role of "transformation" when it comes to the EMT. Starting from a transformation of governmental environmental policies towards more preventive (rather than reactive behaviours) which will multilaterally spread within the society and industry, the environmental policies will finally transgress under the patronage of the market which is much more rapid and flexible towards changes rather than the government. This is intended to lead to a different relationship between the state and the society (with more empowered roles for the society).

Such transformation and "handover" role which depict the social theory foundation of the EMT is thoroughly explained by Mol (1995) and Spaargaren (1996) specifically in relation to Schumpeterian theories of long cycles and innovation as well as in relation to Giddens' (1994) work on the four dimensions of modernity – but with core emphasis on the work of Beck (1994) related to the risk society (as mentioned in Buttel, 2000). Overall, these authors adopt the view that issues induced by modernization (i.e. environmental) can only be solved through transformation and through more modernization. More specifically, to achieve this, ecological practices should be institutionalized within the quintuple helix's practices of production/consumption, process in which the leading actors should constantly learn, transform and enable change (Berger et al., 2000).

Furthering this debate, Berger et al (2001) focuses more on the second perspective of EMT (policy discourse) and emphasize the outbreak of sustainable development movements that transgress national boundaries and diffuse towards regionally, transnational and globally coordinated efforts in this field. The authors argue that such discourse has significantly influenced the other three perspectives of the EMT towards becoming a globally (informally) recognized developmental theory, which recently has become more formalized and institutionalized. However, the core element conceived by the authors resides in the process of ideological transformation (Buttel (2000), Lundquist (2000), Mol (1995)).

Besides the above mentioned supporters, the EMT faces certain critiques. One such critique challenges the theoretical framework of the EMT with core underpinning in social science fundamentals. Specifically, Connelly and Smith (1999) argue that the EMT is an emblematic image of capitalism and of western civilization which aims to induce global development at their own pace (rather than enabling other ecological mechanisms). In a similar approach in an earlier study, Christoff (1996) triggers the problem of regional policy making related to EMT which leads to – the so called – “weak” EMT in industrialized nations with a more monopolistic industrial and governmental approach (this relates to the third and fourth pillar).

Furthermore, focusing on the policy discourse of the EMT, Berger et al (2001) identify additional critiques and weaknesses of the EMT. Such critiques have to do with modernity and rationality of the EMT discourse in the sense that the conflict between economic gains and environmental sustainability are rarely mentioned which often leads to segregated efforts towards EMT implementation and development. Similar EMT discourse and school of thought critiques (first perspective) are also discussed by Reitan (1998) which focuses on the social contradictions fostered by EMT communication and interpretation.

To identify even more critiques of EMT – the highly cited research of Fisher and Freudenburg (2001) identifies research clusters that focus on EMT limitations. The core pillar of the EMT resides in (technological) innovation as a source of solving ecological crises. Such an approach had a considerable number of critiques in the early days of capitalism and technological outburst, however nowadays, technology and innovation are linearly linked and thus the EMT does not encounter such downsides. Secondly, EMT infused governance will lead indeed to a modernized governance as well, however, increased pressures from nongovernmental and environmental associations will burden policy makers in this process (Mol, 2000). Similarly, Buttel (2000) strengthens these critiques by arguing that the EMT lacks a well defined set of pillars – being rather adapted/interpreted in different ways by different actors.

Finally, in order for the EMT to be implemented, research (Pellow et al., 2000; Mol, 1995) shows that transformations will take place at each institutional sphere related to growth:

- Policy making (based on industry-government collaboration)
- Market and economic networks
- Social networks

This view is consistent with Carayannis & Campbell (2010) and Carayannis, Barth & Campbell (2012) which adds value to the claim that the quintuple helix ecosystem for EMT requires quintuple tier transformation and co-creation in order to underpin the social science theoretical advancements of the EMT (however, in this case – the research/scientific pillar is not mentioned).

Furthering this claim, a more recent advancement of the EMT from a social science theory was performed by Horlings and Marsden (2011). The authors show that for the application of EMT with real capitalized outcomes (in this case – in the field of agriculture) – a constant co-creation and transformation of society, policy, market/spatial and culture are required. The core innovation in the authors model resides in the proposal of another perspective (science/research) of the EMT framework. This is totally in line with Carayannis, Barth & Campbell (2012) quintuple helix mode which fosters EMT theoretical frameworks. There are other core recent researches that also support the social science framework of the EMT in the direction promoted by Carayannis & Campbell (2010), such as Bai et al. (2012), Shi et al. (2012), Kitchen and Marsden (2009), Frissen (2007), Marsden et al. (2010), Zhu et al. (2012), Bayraktar et al. (2009).

Finally, York and Rosa (2003) underpin key research challenges for the EMT from a social science perspective. Firstly, a core research limitation of the EMT resides in the lack of sufficient explanation related to the modernity of stakeholders and their impact on ecological modernity (co-growth). Secondly, most of the existing EMT case studies are not based on core stochastic processes and also do not provide sufficient evidence of the frequency of the observed outcomes. Thirdly, the analysis of the research related to deepening the EMT should be done on the entire ecosystem and not on individual actors (i.e. only on government or industry). Lastly, specific theoretical contribution must explore the EMT by analysing the balance between supermaterialization and dematerialization.

2.1.2.2 The EMT in the context of RGFT

Resilient and green freight transportation (RGFT) is an emerging field and lacks any unilateral explanation within the vision of one single social science theory. This is the reason why, this thesis will assert to investigate how RGFT/RGSCM can be explained through five social science theories (EMT, DIT, CAST, INT and ST). For the purpose of the EMT, it is notable to mention that RGFT is a subset of the larger group of green/sustainable supply chain management which has indeed, significant work from a social science point of view (specifically related to EMT).

Thus, from an EMT point of view, the challenge of RGFT is a subset of environmental (or green) supply chain management (RGSCM). According to the core work performed by Berger et al. (2001):

> “..., *one important issue for (EMT) research is to add a social science perspective to the processes and dynamics of environmental supply chain management*.”

This is highly approved by other research as well since in most of the cases, ecological practices within supply chain management have usually been assessed under the lenses of economic benefits and often lacks a social science perspective (Berger et al., 2001; Hall, 2000; Zhu et al., 2012).

To begin with, according to (Berger et al., 2001) the EMT influences GSCM in three main ways:

- Diffusion of environmental practices within the integrated chains (INT, ST)
- Diffusion of technological innovations within the integrated chains (INT, ST)
- Inclusion of a wider range of supply chain actors in the decision making processes (INT, ST)

Nevertheless, one pioneering work in the field of EMT influenced GSCM resides in the work of Sarkis (1999) in terms of its circular movement of resources philosophy – which nowadays became one of the core topics of transnational EMT governance – the circular economy concept in which the EMT philosophy is implemented through at its full potential (EU, 2015).

Finally, following the pioneering work of Sarkis (1999) but with more recent studies, Zhu et al (2012) provide an in-depth analysis on the levels in which EMT influences GSCM.

Firstly, the authors are in the same line with the previous research in relation to EMT by believing that environmental issues can be tacked by ensuring resource efficiency through soft (optimizations, co-creation) and hard (equipment) technological innovations. What should be noted in this case is that this is the core research where technological innovation is mentioned as a solution (as compared to the previous work in which such measures were related to “transformation”. Secondly, Zhu et al. (2012) view EMT & technological innovations as opportunities and not as solutions for GSCM – aspect which is also consistent with related research (Berger et al., 2001; Revell, 2007). Finally, the authors provide the first attempt to link and demonstrate how the DIT influences the EMT by testing related hypotheses specifically related to the Chinese market. Their research provides core fundament for the current thesis which will adopt such approach for South East Europe.

2.1.2.3 Current status of EMT in RGFT and research questions for the EMT social theory advancement

Overall, the literature on EMT as a social science theory has emerged from its main idea underpinned in the 80s by Huber, Simonis & Janicke, then transcended towards the 90s as a policy implication tool (Mol 1995; Spaargaren, 1996). Furthermore, around 2000, the EMT became recognized as a multilateral framework to some extent related to GSCM (as a school of thought, policy discourse, strategic management and innovation/technological adjustment (Buttel, 2000; Berger et al., 2001; Lumdquist, 2000; Hall, 2000; Sarkis, 1999)). However, the actual in-depth analysis of the EMT and its relation to innovation (as an inner source and opportunity of crisis resolution through soft & hard innovation) took place later on through two phases: transformation of (quintuple helix) stakeholders (and the way they interact) and only then the actual innovation stage (Rootherford, 2003; Yotk & Rosa, 2003; Horlings & Marsden, 2011 Frissen (2007); Kitchen and Marsden (2009), Carayannis, Barth & Campbell (2012), Marsden et al. (2010), Zhu et al. (2012)).

Following this analysis, the literature gaps which drive the research questions in relation to EMT as a foundation for RGFT towards providing social science perspectives as a framework, are:

RQ1.1: How do the consolidated EMT pillars apply to and explain RGFT ? (Berger et al., 2001; Zhu et al., 2012): EMT as a school of thought or belief system (ideology, governance, social cohesion); EMT as a policy discourse (policy & society); EMT as strategic management (industry); EMT as innovation or technological adjustment (research, transformation).

RQ1.2: How can the quintuple helix ecosystem for growth (including RGFT) foster more "strong" EMT implementation rather than "weak" (Horlings & Marsden, 2011; Carayannis, Barth & Campbell, 2012).

RQ1.3: What transformations and co-creation are required to help stakeholders overcome EMT implementation for RGFT (Ivanaj et al., 2015; Hsu et al., 2013; Horlings & Marsden, 2011; Carayannis, Barth & Campbell, 2012) ?

RQ1.4: To what extent do stakeholders modernize & transform themselves (is there a correlation between ecological modernization implementation and institutional modernization) ? (Dubey et al., 2015; Govindan et al., 2015; Zhu et al., 2012; York & Rosa, 2003)

RQ1.5: What is the effect of EMT implementation on the entire ecosystem, rather than on individual stakeholders ? (Dubey et al., 2015; Govindan et al., 2015; Tian et al., 2014; Gobbo et al., 2014; Zhu et al., 2012; Carayannis, Barth & Campbell, 2012; York & Rosa, 2003)

RQ1.6: Does the EMT implementation lead to dematerialization or supermaterialization ? (York & Rosa, 2003)

RQ1.7: How does the DIT properly explains the adoption of EMT by RGFT stakeholders ? (Zhu et al., 2012; Carayannis, Barth & Campbell, 2012).

2.1.3 The DIT and its influence in understanding RGFT

2.1.3.1 A social science theory view of the DIT

The diffusion of innovation theory (DIT) was firstly introduced by Rodgers (1962) in order to explain how innovation communication and adoption takes places over time within a social ecosystem based on four main elements (the innovation, the diffusion channels, human capital and the characteristics of the ecosystem). This theory provided significant influence over the years towards understanding how innovation propagates and enables growth, stability and prosperity of ecosystems. For example, a highly cited systematic review over 25 years of research publications in related journals performed by Meade & Islam (2006) proves once more the interest and the strong research clusters on the DIT advancements across various domains. The innovation adopters within an ecosystem have been categorized by Rodgers (1963) and by a similar pioneering structure (related to GSCM ecosystems) which was adopted more recently by Zhu et al. (2012) into four categories: innovators, laggards, early adopters, early majority and late majority. This categorisation plays a crucial role in understanding innovation flows specifically in relation to researching RGFT in which the need for resilience is solved by an eco-innovation (either performed by an innovator or adopted from an innovator).

The DIT & EMT (under the keyword of eco-innovation) have been studied in-depth by the pioneering work of Rennings (2000) which provides an overview of EMT-influenced innovations and how do they affect ecosystems. The author defines eco-innovation as the measures performed by stakeholders (in line with Carayannis, Barth & Campbell, 2012, 2010) in terms of developing new ideas, products, behaviours which respond to environmental sustainability targets. Such innovations can be organizational, social, institutional, and technological. This approach is highly in line with the EMT view in terms of multi-stakeholder modernization and eco co-evolution.

Thus, it is important to understand the role of ecosystem stakeholders towards providing an insight into how the DIT and EMT influence GSCM and RGFT. For this purpose, the work of Carayannis, Barth & Campbell (2012, 2010) becomes critical:

> *The Quintuple Helix finally frames knowledge and innovation in the context of the environment (natural environments). Therefore, the Quintuple Helix can be interpreted as an approach in line with sustainable development and social ecology. "Eco-innovation" and "eco-entrepreneurship" should be processed in such a broader understanding of knowledge and innovation*" (Carayannis & Campbell, 2010; Carayannis, Barth & Campbell, 2012).

In the above mentioned quintuple helix ecosystem of Carayannis, Barth & Campbell (2012, 2010), the EMT and DIT intersect towards providing eco-innovation solutions for sustainable development. Thus, the EMT and DIT provide a co-creation framework for eco-innovation support for any societal subsystem/microsystem (i.e. GSCM, RGFT) in the following manner:

- Diffusion of research, knowledge, innovation by building up human capacity through academic institutions
- Utilization of the human capital, knowledge and innovation for market purposes (industry)
- The natural environment provides humanity with natural capital and acts as a key decision making factor which drives knowledge, innovation and human capital for market purposes

- The social capital (same as the environment) influences the knowledge and innovation through cultural specificities and information movement (media).
- The political system influences and is influenced by all the above-mentioned factors in order to enable a sustainable co-creation among them.

This DIT & EMT ecosystem model proposed by Carayannis, Barth & Campbell (2012, 2010) is a social ecosystem in which, generally, resilience in any activity will resemble in a CAST influenced manner (more elaborations are provided in section 2.1.4). Furthermore, the diffusion of innovation theory plays a critical role in understanding CAST based resilience aspects also. Another core work that binds CAST and DIT performed by Moore & Westley (2011) aims to identify whether scaling up (from institutional level to ecosystem level) of innovation can enable better resilience mechanisms. In such a process, the transition of innovations and resilience mechanisms across disciplines seems to be inherently necessary. It this thus of core relevance to strengthen the argument that EMT based innovations can transform to provide better resilience mechanisms in CAST based systems (Holling, 1973) – more details about the interrelationship of EMT, CAST and DIT are provided in section 2.1.4. To this end, the authors (Moore & Westley, 2011) clearly differentiate two types of innovation: transformative innovation (intervention) that scales up within the CAST based ecosystem panarchy as a response to a crisis/opportunity (usually undertaken by innovation adopters) and disruptive innovation (usually performed by innovators) that takes place within the boundaries of DIT (Atwell et al., 2008; Walker et al., 2006).

However, for the purpose of RGFT, from a social science point of view, both types of innovations are applicable (transformative & disruptive) as the RGFT is inherently CAST influenced as well as DIT and as it will be explained later on, both crises that lead to transformative innovation (also discussed in INT and ST) as well as unforeseen (technological) breakthroughs that lead to disruptive innovation can take place.

Finally, the research performed by (Jacobsson & Brgek, 2008) summarizes various gaps related to the DIT in tangency with EMT and CAS from which the core one pertinent to this thesis is the one related to the limited understanding of innovation scale-up across ecosystem levels.

2.1.3.2 The DIT in the context of RGFT

The DIT plays a critical role in understanding resilience in GSCM (and implicitly in RGFT) especially in the moment of disruptions where innovative EMT based practices should be adopted within ecosystems in order to self-adapt. For this purpose, one of the core articles that relate DIT with GSCM is provided by Hervani et al. (2005) which argue that the ability & resources (financial, staff, knowledge, monitoring) of an organization as well as exogenous ecosystem related pressures to foster EMT based innovations are critical for a proper diffusion of innovation across the ecosystem (Florida et al., 2000; Sharma, 2000). This is highly consistent with the localized interactions that scale-up in the CAST-based panarchy concepts that will be discussed in section 2.1.4.

To the same extent, a more recent pioneering study performed by Zhu et al. (2012) positions EMT-based innovation as key opportunities for GSCM challenges (i.e. RGFT) and identifies, based on the DIT (Rogers, 1995) factors that influence innovation diffusion across GSCM ecosystems with heterogeneous panarchy actors under the CAST framework. Specifically, the authors argue that GSCM ecosystems are highly consistent with the core five innovation pillars (Zhu et al., 2010): Relative advantage (thus, EMT explained-crises within RGFT microsystems as drivers of innovation can bring competitive advantage); Compatibility (replicability and scalability of practices across a CAST ecosystem); Complexity (analysed under CAST); Trialability (consistent with the cycle based nature of CAST ecosystems); Observability (outcome monitoring and performance measurement at the ecosystem level).

Furthermore, (Zhu et al., 2012) argue that internal and external factors (market, society, institutions, - thus tangent with INT and ST) put pressure on GSCM towards adopting and diffusing ecological innovation across the entire ecosystem. Such factors are basically related to the other actors of the ecosystem with total alignment with the quintuple helix model proposed by Carayannis, Barth & Campbell (2010, 2012). To this end, the authors propose a framework for diffusion of innovation within GSCM ecosystems through the Bass model which builds up the DIT by arguing that innovation diffuses through two channels (Akinola 1986, Kalish and Lilien 1996, Henderson and Lentz 1996, Firth *et al.* 2006; Horbach 2008; Albuquerque *et al.* 2007): Imitation innovation (consistent with the transformative innovation); Independent (internal) innovation (consistent with the disruptive innovation)

Generally, there is limited research in terms of identifying the direct influence of the DIT within GSCM (and RGFT) – and especially in the field of eco-innovation (as this is a relatively new field). However, Zhu et al. (2012) have provided significant research directions that should guide the advancement of EMT and DIT in relation to GSCM (and implicitly RGFT) and the following two are core to this thesis: how can eco-innovations in GSCM be diffused faster from innovators and early adopters to laggards; how can eco-innovations be diffused within the ecosystem by relying on the environmental flows ideology (Moland & Spaargaren, 2005).

2.1.3.3 Current status of DIT in RGFT and research questions for the DIT social theory advancement

To sum up, the diffusion of innovation theory (DIT) introduced by Rodgers (1962) in order to explain how innovation communication and adoption takes within a social ecosystem provides core insights into how EMT-influenced eco-innovations are infused within GSCM (and implicitly RGFT) ecosystems as well as how the eco-innovation (either initiated or replicated) required during a disruption/crisis propagates into the CAST based RGFT ecosystem. Overall, it is important to understand the core flows of thought related to DIT influence on RGFT with complements from EMT, CAST, INT and ST. For this purpose, Figure 2 provides an overview on the influence of DIT in RGFT by showing how the environment and the other quintuple helix institutions rely on DIT and co-creation for eco-innovation diffusion:

Figure 2: Impact of DIT on RGFT

Finally, there is generally significant research gap in the application of DIT (with EMT and CAST influences) in GSCM and the systematic literature review has identified the following research questions provided by the key leaders in this field:

RQ2.1: How can eco-innovation (either disruptive or transformative) scale-up across the ecosystem levels/panarchy (Govindan et al., 2015; Tian et al., 2014; Zhu & Geng, 2013; Dornfield et al., 2013; Zhu et al., 2012; Jacobsson & Brgek, 2008)?

RQ2.2: How can transformative (eco)-innovation driven by the EMT (to solve resilience crises) diffuse faster based on core controlled processes at the institutional level (Bhattacharya et al., 2014; Green et al., 2014; Moore & Westley, 2011)?

RQ2.3: How can disruptive (eco) innovation (to solve resilience crises) respond better to the need of the entire ecosystem (Moore & Westley, 2011; Atwell et al., 2008; Walker et al., 2006)?

RQ2.4: How can eco-innovations in GSCM be diffused faster from innovators and early adopters (INT, ST) to laggards (Zhu et al., 2012)?

RQ2.5: How can eco-innovations be diffused within the ecosystem by relying on the environmental flows ideology (Moland & Spaargaren, 2005)?

2.1.4 The CAST and its influence in understanding RGFT

2.1.4.1 A social science theory view of CAST

For the purpose of this thesis, ecological modernisation is the key social science theory which drives the research. However, EMT as up to now has limited application in the field of RGFT, although it is a core influencer of GSCM. Hence, explaining resilience in conjunction with GSCM (and green freight transportation as its subset) becomes highly relevant. The ability to grasp resilience (as recover mechanism for pre/during/post disruption scenarios) is a dynamic process as the RGFT ecosystem is highly multilateral as presented in the previous section which focused on the EMT. Operating in a quintuple helix environment where ecological innovation is the key opportunity triggered by crises/disruptions it is of core importance to understanding how such ecosystem reacts in such scenarios as well as what mechanisms for recovery exist. To this end, as this section will show, the relevance of complex and adaptive systems theory (CAST) in relation to EMT is highly relevant to solve the challenge of RGFT.

Resilience itself, has been highly linked with social and ecological systems (having roots in ecology) within the boundaries of CAST and presents considerable challenges for researchers to underpin its complexity and to measure the effect of the proposed models due to the uncertainty and uniqueness of each crisis emerged within the specific ecosystem (Carpenter et al., 2005; Holling, 1973). From the CAST point of view, RGFT is indeed a social & ecological system and there is considerable research on this topic (Gunderson & Holling, 2002; Berkes et al., 2003; Scheffer et al., 2003). Achieving and measuring resilience is indeed a considerable challenge and according to Carpenter (2003) and Carpenter et al. (2005), the effectiveness of the resilience framework resides in the proper understanding of the complex adaptive system in which the crisis takes place. To this end, understating such system from the CAST point of view is critical for the purpose of RGFT.

In its initial analysis, Holling (1973) – the core researcher to underpin resilience in ecological ecosystems has initially viewed resilience as the extent to which a system could be disrupted without changing its state. However, over the years, researchers have bind resilience theory and systems theory more closer in order to answer even deeper research questions related to social ecosystems. Social ecosystems (where human are involved) became more complex than the traditional ecological ecosystems, and thus, resilience started by being viewed as the pace to which a system returns to its initial (or better) state after a disruption took place (Walker et al., 2006; Pimm, 1991). For this purpose, the resilience theory became closely linked to CAST. Furthering this process, and aligning to the sustainable development challenges, resilience in the context of social ecosystems has been linked to ecological ecosystems in order to enable recovery in an environmentally sustainable manner of disruptions taking place in social ecosystems and to this end, the EMT becomes a necessity (Walker et al., 2006; Berkes et al., 2003; Dasgupta & Maller, 2004; Hughes et al., 2005; Folke et al., 2010; Van den Berg et al.. 2011).

One revolutionary research (highest number of citations) that binds CAST, EMT, INT and ST was performed by Holling (2001) which views cooperation settlements (either political, social, ecological, industrial) as complex systems which self-regulate based on a number of controlling processes. Such self-regulation (i.e. transformation, resilience) is being done based on historical knowledge (i.e. events, past crises) and in this process, heterogeneous actors (i.e. the quintuple helix actors) perform localized interactions towards achieving the goal - self-regulation/resilience (Levin, 1999). This view of CAST is different than another strong research cluster strengthened by Roe (1998) which argues that self-regulation in CAST is governed by rather random processes (due to increased complexity and uncertainty) rather than by controlled processes. However, this thesis adopts the first view (resilience in CAST can be governed through controlled processes) and the following review will explain in more details this decision. More specifically, the CAST-based context of RGFT resides in the quintuple helix ecosystem where institutional (localized) interactions take place towards ensuring resilience (and from the institutionalized interactions – the actual controlled processes can be derived). Through controlled processes, ensuring EMT – infused outcomes can also be performed.

Furthermore, Holling (2001) relies on the concept of "Panarchy" in which CAST undertake growth, renewal and restructuring cycles. The challenge at this point is to understand these adaptive cycles towards identifying their vulnerability points and resilience strategies (Folke et al., 1998). As identified by Holling (2001), one of the first work that investigated the role of structures and hierarchies (within the concept of autonomous agents that co-creation based on policies – not necessarily top-down approach) was performed by Simon (1974) which argues that CAST can self-regulate and achieve resilience if the proper communication among these agents takes place (thus, proper co-creation among quintuple helix stakeholders could enable RGFT). Based on this work, Holling (2001) and Walker et al. (2004) explained the characteristics that the adaptive cycles of CAST should have towards ensuring resilience: Adaptability/flexibility of a system (learning capacity / knowledge management); Inner controllability (key controlled processes/indicators); and Inner vulnerability control (capacity to integrate resilience).

Folke et al., (2010) take even further these three characteristics and argue that the inner controllability should be highly related to transformability and transition towards adaptation (despite system's resistance to change) in order to ensure CAST resilience with EMT influences:

> "*Social–ecological resilience is about people and nature as interdependent systems*"
> "*Preventing such an undesired critical transition will require innovation and novelty*"

These three main characteristics are critical for CAST to ensure the intended self-regulation (resilience) which leads to the next key point for CAST related to the work of Schumpeter (1950). More specifically, the adaptive cycles self-regulate (in the view of CAST) through the "creative destruction" process which provides the opportunity for transformation/innovation and here is where the EMT and DIT intervene (EMT for guiding the outcome towards ecological modernization/transformation and DIT for ensuring the proper diffusion of the creative solution/innovation towards the entire ecosystem).

The same view is also shared by Folke et al. (2010) and Walker et al. (2006) which combine CAST with EMT in order to explain DIT and reason how crises could serve as opportunities to innovate in an environmentally sustainable manner:

> "*Transformational change at smaller scales enables resilience at larger scales. The capacity to transform at smaller scales draws on resilience from multiple scales,*

making use of crises as windows of opportunity for novelty and innovation, and recombining sources of experience and knowledge to navigate social–ecological transitions." (Folke et al., 2010). This view is also in line with Holling (2001)'s view of the localized/institutionalized interactions towards diffusion resilience across the ecosystem.

To this end, it seems promising to derive the fact that the quintuple helix ecosystem of RGFT which resembles a CAST reacts towards disruptions/crises in similar ways as the adaptive cycles of CAST – however based on controlled processes which are driven by the EMT and diffused/implemented by the DIT under INT and ST.

Despite the promising solutions for creative destruction / ecological innovation / self-adaptation, enabled by CAST, EMT, DIT, INT and ST, it is fundamental for this thesis to denote the stochastic factors and events which may induce crises to complex and adaptive systems leading to severe disorder or complete termination of the adaptive cycles. Such as scenario is not imaginable and acceptable in the context of freight transportation which is vital for its ecosystem. However, Holling (2001) has reviewed to a significant extent such factors which completely undermine CAST based ecosystems. Specifically, the author reveals how such major cataclysms (i.e. biological, environmental) caused severe damage to the natural ecosystem on Earth million years ago. Similar factors have resided within history in the context of social disruptions, politics, religion. Still, authors such as Berkes (1999) and Folke et al. (1998) claim that modern ecosystems (based indeed on CAST) can (more easily) overcome such stochastic factors and that rather, disruptions in nowadays governance (either social, political, environmental, industrial) are an outcome of rigidity and stress accumulated through long cycles of success. Nevertheless, as Holling (2001) argues, even in such modern scenarios, stochastic externalities such as weather/natural disruptions/crises can bring ungraspable outcomes in which the self-adaptation/resilience will take significant amount of time – despairing thus the involved ecosystem.

Such stochastic externalities (weather/natural disasters) are the core of this thesis which analyzes RGFT in relation to weather/natural disasters-induced disruptions, and thus, proposing a model in which the CAST-based RGFT ecosystem self-regulates in an innovative ecological manner driven by the EMT and enabled by the DIT – is of critical novelty.

Finally, a pioneering articled authored by Van den Berg et al. (2011) introduces a systematic review of articles published in the “Environmental Innovation and Societal Transitions” journal specifically in relation to CAST, INT, ST and DIT influences to EMT research. Some of the key research gaps pertinent to this thesis identified by this review include: limited research on CAST and DIT related ecological & technological innovation research, limited research on innovation propagation and its impact within ecosystems and limited research on analysing the transition of socio-ecosystems to environmentally sustainable practices.

2.1.4.2 The CAST in the context of RGFT

For the purpose of the CAST, it is notable to mention that RGFT is a subset of the larger group of supply chain management systems which have indeed, significant work from a social science point of view (specifically related to EMT).

Supply chain management (SCM) has in-depth research and analysis in the framework of CAST mostly in terms of cost optimization, however less work has been done towards the analysis of resilience and environmental sustainability within the CAST framework for SCM in order to properly understand RGFT. Before proceeding with the core findings of this section, it is of core importance to reiterate the three main pillars of CAST based resilience discussed in the previous section: adaptability, inner controllability and inner vulnerability control (capacity to foster resilience).

In order to focus specifically on supply chains, Pathak et al (2007), as a core representative work in this field, provide an in-depth analysis of SCM from the CAST point of view, however, focusing only on the first pillar of CAST-based resilience defined by the core work of Holling (2001), Walker et al. (2004) and Folke et al. (2010) – adaptability (and learning). The authors argue that adaptability of supply chains is highly influences by the interconnectedness of the supply chain network (microsystem) as well as by the capacity of the supply chains to learn. Furthermore, the authors argue that within the CAST framework, supply chains are highly influenced by the outer ecosystem in which they co-exist and co-evolve and thus, it is of core importance to include such exogenous constructs in any theoretical proposal related to CAST. This aspect provides thus an opportunity to include the EMT as a core exogenous driver of the wider (quintuple helix) ecosystem in which the supply chain microsystems operate. Finally, the authors argue several limitations of the CAST in relation to SCM adaptability and opens the lead for further research: how can the exogenous ecosystem foster better co-creation for the CAST-based SCM microsystem; what are the key SCM decision making factor at the institutional level and how do they match with the decision making factors at the ecosystem level in order to ensure prosperity and stability within a CAST framework; how do various cross-tier supply chain microsystems interaction among each-other within the wider ecosystem; what are the long term strategies and policy implication for CAST based SCM. In terms of research methodology limitations, the authors have identified gaps in the following areas: systems modelling and simulation, mixed-methods research and behavioural experiments.

On the other hand, Ivanov et al. (2012) focus on the second pillar of CAST based resilience (inner control and decision making processes/variables) in the context of uncertainty and vulnerability of supply chains microsystems and argue that in relation to disturbance and uncertainty analysis as well as in the real time adaptation control (which are core for CAST based resilience) there are significant research gaps such as: limited frameworks that connect high level strategic planning controls (such as inter-organizational – and even higher at the ecosystem level) with lower level (institutional) control models.

Focusing on the third pillar (inner vulnerability control to foster resilience), the representative work of Zhu & Ruth (2013) position resilient and GSCM within the context of EMT and CAST. The authors argue that EMT based resilience serves as basis for nowadays resilient and sustainable supply chain management (including RGFT) within an CAST operational framework (Christopher & Peck, 2004; Petit et al., 2010; Ashton, 2009; Ehrenfeld, 2007). Furthermore, the authors claim that the resilience of micro-level actors (institutional) as well of as high level ecosystem overall needs to be significantly improved in order to cope with the pressuring challenges. What is pertinent to mention though is the authors overlap the CAST based adaptive cycles and resilience with industrial ecosystems while arguing that supply chains are not strictly based on such cycles. However, there is consistent literature that points towards the fact that nowadays supply chains are definitely cycle-based as the discussion on circular economy, and closed loop supply chains is more and more frequently evolving as an emblematic image of GSCM (Wong et al., 2016, Fallah et al., 2015, Torabi et al. 2015, Cardoso et al., 2015). Thus, Zhu & Ruth (2013)'s claims on resilient and eco-efficient industrial ecosystems (which encompass resilient GSCM and RGFT) are of high relevance towards the social science contribution of RGFT in relation to CAST and EMT. Even more, the authors, as well as (Chertow, 2009) view adaptability as the "*intentionally management of resilience of industrial ecosystems*" which is in total alignment with Holling (2001)'s view on resilience in terms of being done on internal controlled processes (rather than on random elements) and thus resilience and eco-efficient industrial ecosystems as well as in green freight transportation can be achieved through:

- Increasing the environmental benefit (efficiency and reuse under the framework of EMT in innovative ways through the DIT, INT and ST)
- Enabling more co-creation & partnerships among multi-level stakeholders/actors (as described in CAST, INT and ST)

In a similar manner related to the third pillar (inner vulnerability control to foster resilience), it is of core importance to understand how the disruptions that industrial ecosystems (GSCM, RGFT) face propagate in order to investigate how can the CAST influence RGFT and how can DIT and EMT influence this process of achieving resilience. According to Bansal and Mcknight (2009), the core influencer of disruption propagation resides in the lack of proper symbiosis (or co-creation) among the multi-tier stakeholders both with the supply chain microsystem as well as in the CAST based exogenous systems (INT, ST) in which it integrates. This is even more worrisome, as according to Zhu & Ruth (2013), the core and most catastrophic disruption propagations in supply chains are due to catastrophic and unforeseen events (i.e. weather conditions, natural disasters) rather than the usual ones (partner failure, economic fluctuations).

Furthermore, research evidence shows that the extent of a disruption in a CAST based environment linearizes with two endogenous variables: the location of the disruption within the ecosystem and the degree of the interconnectedness of the ecosystem actors (Zhu & Ruth, 2013; Petit et al., 2010; Wagner & Bode, 2006). This fact implies that the three CAST pillars of resilience vary according to these two variables in the sense that a well internally connected ecosystem will better produce an ecological innovation to self-adapt during a disruption – critical aspect for RGFT (Craighead et al., 2007; Janssen et al., 2006). Thus decision-making in the self-adaptation process becomes critical for supply chains. To the same extent, with a core focus on decision making during disruptions, a core literature review performed by Alexander et al.

(2014) positions decision making as core element in GSCM especially in case of crises/disruptions within CAST based environments where innovative solutions/decision are required.

2.1.4.3 Current status of CAST in RGFT and research questions for the CAST social theory advancement

Resilience has initially been studied in the context of ecology and has been officially coined by Holling (1973) in the context of complex adaptive systems (CAST) and later on resilience and CAST have been linked to EMT (Holling, 2001) and DIT (Folke et al., 2010) with strong literature support. Summarizing the literature trend of the CAST and of the CAST application for GSCM (and implicitly for RGFT) with EMT, ST, INT and DIT support, the following research questions have been identified:

RQ3.1: How can localized interactions (symbiosis) based on controlled processes scale-up and co-create to enable self-adaptation of a CAST based system at the mesosystem/microsystem level (Kamalahmadi & Parast, 2016; de Siqueira et al., 2015; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Van den Berg et al., 2011; Folke et al., 2010; Bansal and Mcknight, 2009; Holling, 2001) ?

RQ3.2: How can the concept of "Panarchy" (Holling, 2001) be applied based on the three CAST pillars and explain how co-creation within the mesosystem/microsystem takes place (Walker et al., 2004; Van den Berg et al., 2011; Chertow, 2009) ?

RQ3.3: How can the EMT infuse the ecological modernisation view and how can the DIT explain the innovation outburst during crisis (disruption) resolution (resilience) which provide a novel opportunity for self-adaptation of a CAST mesosystem/microsystem (Francis & White, 2016; Choudhury et al., 2015; Akgun & Keskin, 2014; Gogelci & Ponomarov, 2013; Demmer et al., 2011; Folke et al., 2010)?

RQ3.4: How can stochastic externalities (such as environmental conditions) induced crises (disasters) be better/faster overcome (Zhu & Ruth, 2013; Holling , 2001) ?

RQ3.5: How can the exogenous ecosystem influence and foster better co-creation for the CAST-based RGFT microsystem (Kamalahmadi & Parast, 2016; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Folke et al., 2010; Pathak et al., 2007) ?

RQ3.6: What are the key SCM decision making factor at the institutional level and how do they match with the decision making factors at the ecosystem level in order to ensure prosperity and stability within a CAST framework under uncertainty (Ivanov et al., 2012; Chertow, 2009; Pathak et al., 2007) ?

RQ3.7: How do various cross-tier supply chain microsystems interaction among each-other within the wider ecosystem (Ivanov, 2012; Pathak et al., 2007) ?

RQ3.8: What systems modelling and simulation, mixed-methods research and behavioural experiments can be performed within a CAST mesosystem/microsystem for resilient supply chains (Pathak et al., 2007) ?

RQ3.9: Strengthen the claim that resilient GSCM (and implicitly RFGT) are cycle based industrial ecosystems based on CAST in the context on the most recent trends in this document (Wong et al., 2016, Fallah et al., 2015, Torabi et al. 2015, Cardoso et al., 2015).

RQ3.10: What are the effects of the interconnectedness of the actors and the location of the disruption within a CAST mesosystem/microsystem on the self-adaptation(resilience) process as well as on the ecological innovation capacity (Kamalahmadi & Parast, 2016; de Siqueira et al., 2015; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Zhu & Ruth, 2013; Petit et al., 2010; Wagner & Bode, 2006)?

Overall, it is important to understand the evolutionary trend of CAST ecosystems in order to properly gasp the role of this social science theory in explaining RGFT. For this purpose, Figure 3 summarizes the CAST framework for RGFT by showing the adaptive cycles of CAST (and for GSCM in general).

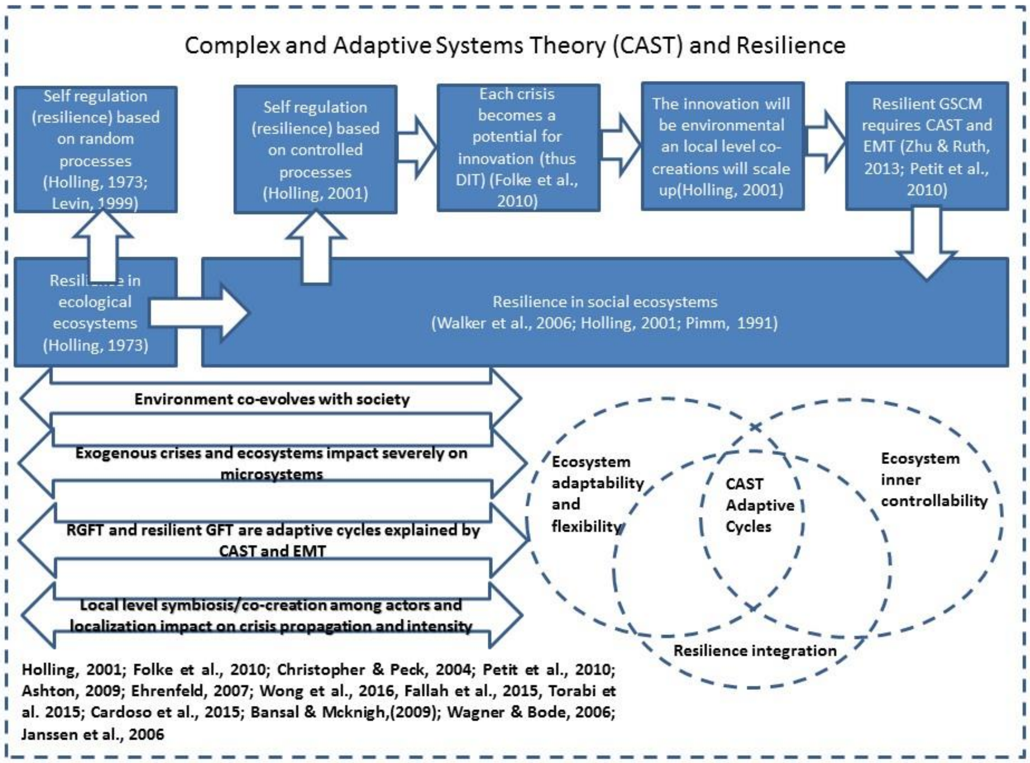

Figure 3: CAST and Resilience

2.1.5 The INT and ST and their influence in understanding RGFT

The institutional theory (INT) positions its social science fundament by denoting how an organisation incorporates organizational behaviour/practice based on exogenous pressures (Dubey et al., 2015; Govindan et al., 2015; Tian et al., 2014; Gobbo et al., 2014; Zhu et al., 2012; Lai et al., 2006; Hirsch, 1975). Such pressures/drivers can be coercive, mimetic and normative and in the view of (Zhu et al., 2012; Clemens & Douglas, 2006; Yu et al., 2006; Kilbourne et al., 2002;), the INT has been constantly used as a framework to understand green practice adoption, providing thus a core potential for explaining the behaviour of RGFT practice adoption within the social/quintuple helix ecosystem (Zhu & Liu, 2010; Ball & Craig, 2010; Harris, 2006; Carter et al., 2000). Some of the key research gaps/questions related to RGFT from the INT point of view are:

RQ4.1: How both exogenous and endogenous pressures promote the adoption of GSCM (RGFT) practices (Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Sarkis et al., 2011; Hall, 2001) ?

RQ4.2: Which stakeholders are the drivers of GSCM (RGFT) implementation within a mesosystem (Govindan et al., 2015; Drohomeretsk et al., 2014; Sarkis et al., 2011; Lee & Kim, 2011; Rivera, 2004) ?

RQ4.3: What is the organizational response to environmental issues (Zhu et al., 2012; Ball & Craig, 2010) ?

In a related manner, the stakeholder theory (ST) (Freeman, 1984) proposes that within an ecosystem (i.e. quintuple helix), stakeholders propagate externalities which diffuse later-on both internally and externally (influencing thus the other stakeholders of the ecosystem), leading to mutual growth at the ecosystem level (Sarkis et al., 2011; Delmas & Toffel, 2004). There is a core implication thus of the ST which explains the production of externalities and of the INT which explains the adoption of externalities within an ecosystem with multiple stakeholders. In the view of Sarkis (2011) and Brito et al. (2008), the ST is highly used in supply chain management, however it has certain criticism on GSCM (and implicitly RGFT) due to the fact that environmentalism is not seen by all stakeholders (yet) as an economic benefit and thus, such exogenous pressures do not always impact on the ecosystem overall, however, efforts towards overcoming this gap are being performed (Sarkis et al., 2010; Tate et al., 2010; Brito, 2008; Chien & Shih, 2007). The identified research gaps of the ST in relation to GSCM (and implicitly RGFT) are:

RQ5.1: How does the innovation diffusion theory explain the adoption of GSCM practices at the mesosystem level based on the ST's emerged exogenous pressures (Ivanaj et al., 2015; Hsu et al., 2013; Sarkis et al., 2011; Vachon, 2007) ?

RQ5.2: How can the ST be implemented at an international/multicultural setting (Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Sarkis et al., 2011)?

Figure 4 provides an overview on the impact/role of INT and ST for RGFT across all the systems proposed by this thesis.

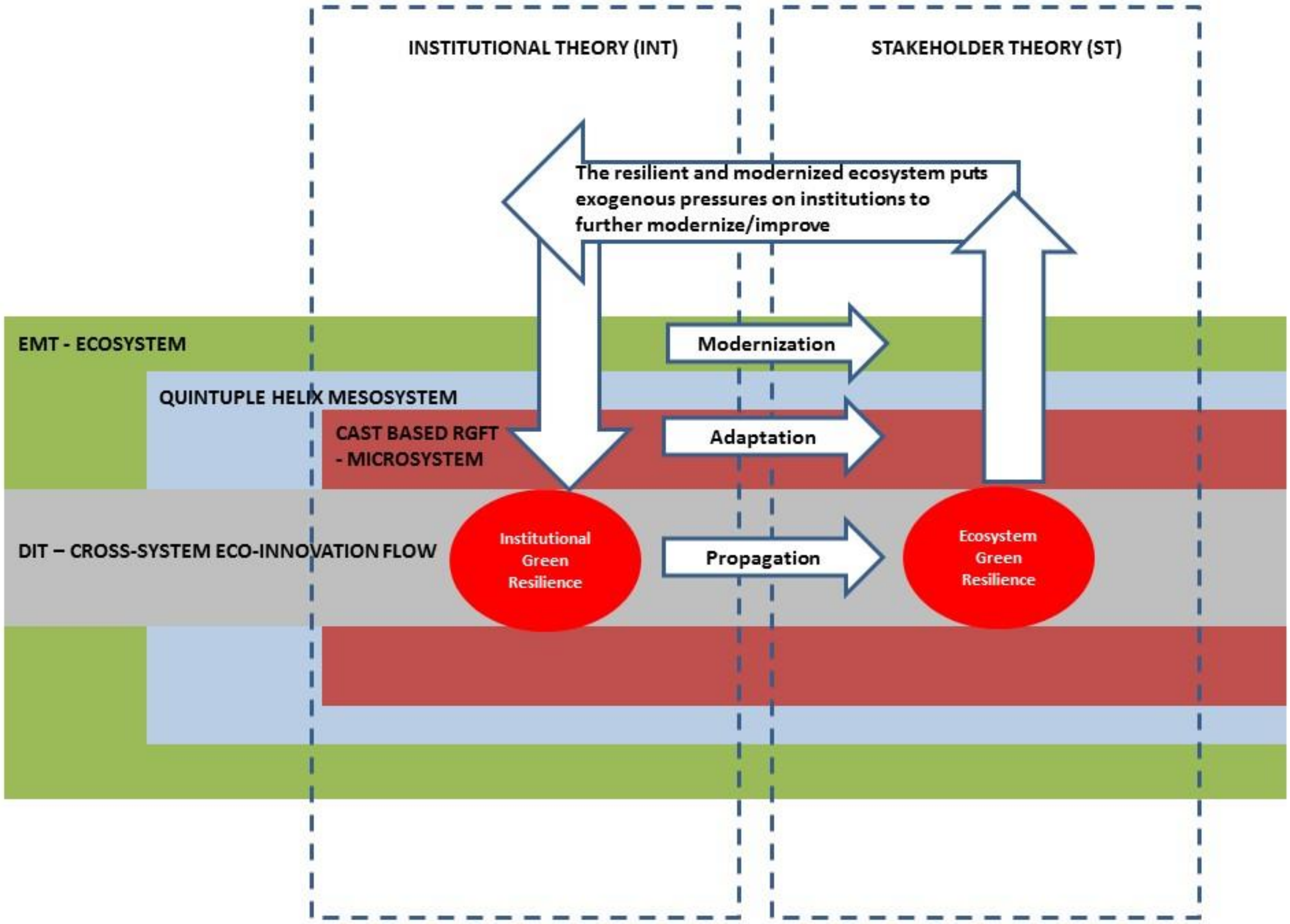

Figure 4: The role of INT and ST within the cross-system environment

2.1.6 Conclusion – Converging EMT, DIT, CAST, INT and ST

2.1.6.1 Discussion on the convergence of EMT, DIT, CAST, INT and ST

The previous sections analysed in details the EMT, DIT, CAST, INT and ST in relation to GSCM and implicitly RGFT/RGSCM. The analysis shows that there are various convergence points among these five theories in which their theoretical fundaments can be utilized to analyse RGFT/RGSCM. A note needs to be provided regarding this convergence in the sense that for example, disruptive innovation would point towards divergence of such theories. Still as it will be shown in the methodology and data analysis section, the preferred innovations in the targeted sample are transformative rather than disruptive which leads to the need of such convergence. However, with many occasions the terminology adopted by each theoretical framework to describe specific concepts was different (regardless of whether the described concept was the same). To this end, the Table 2 provides an overview on the different terminology utilized by each theory for the same concept – as well as the final terminology that will be utilized through this entire thesis in order to maintain consistency.

Table 2: Cross-theoretical definitions

Concept	EMT	CAST (similar with INT and ST)	DIT	Final RGFT terminology
Trigger	**Crises**	**Disruptions / Uncertainty**	**A need/gap**	**Environmentally Induced Disruption (EID)**
Solution	**Transformation**	**Adaptation/ Recovery/ Self-regulation/Transition**	**Diffusion**	**Innovative ecological adaptation (IEA)**
Perception of the trigger	**Opportunity**	**Solution**	**Innovation**	**Innovation**
Location	**Ecosystem**	**System**	**Multi-stakeholder system**	**RGFT Microsystem, Quintuple helix mesosystem and Ecological ecosystem**
Institutional & Social Outcome	**(Ecological) modernization**	**Resilience**	**Innovation adoption**	**Green resilience (GR)**
Who governs the crisis management ?	**Internal & External factors**	**Self regulation driven by small number of controlling processes**	**Different patterns of innovation adopters**	**Resilience based on cross-tier decision making factors**
General status of the medium	**In constant need to modernize**	**In constant need to self-adapt**	**In constant need to innovate**	**Constant need to co-create towards resilience**
Enablers	**Technology, homogenous modernization**	**Technology, communication**	**Technology, high adopters will drive low and medium adopters**	**Environmental technological solutions**

Outcome	**Renewal**	**Optimized order**	**Growth**	**Improved environmentally sustainable, economic and social economic status**

Figure 5 shows the actual interactions across the three main systems (ecosystem, mesosystem and microsystem) in order to strengthen their relevance for this thesis in terms of converging the five theories.

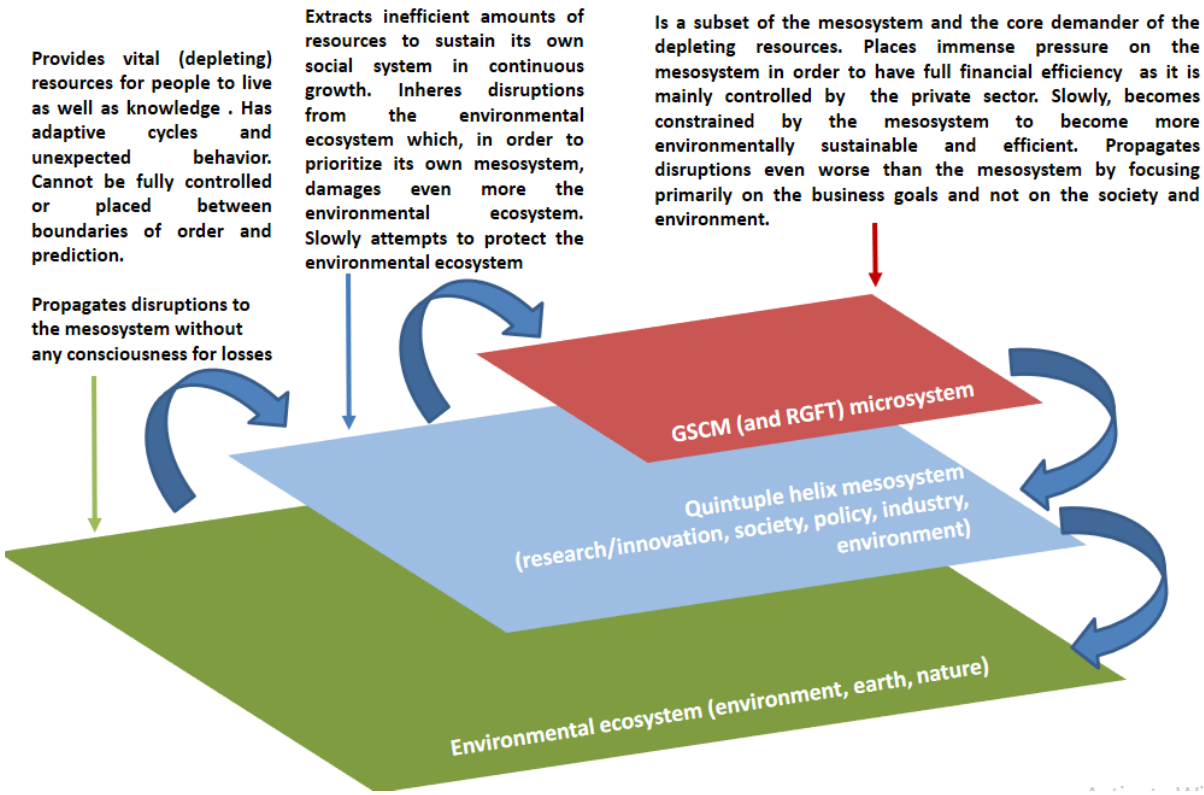

Figure 5: The proposed cross-system integration of the theoretical framework of the thesis

Convergence points among the five theories:

- **EMT** is pervasive in **quintuple helix** stakeholders' agendas (Dubey et al., 2015; Govindan et al., 2015; Ivanaj et al., 2015; Tian et al., 2014; Chakrabarty & Wang, 2013;

Carayannis, Barth & Campbell, 2012; Carayannis & Campbell, 2010; Lundqvist, 2000; Mol, 1995;).

- The core vision of the **EMT** resides not in the mitigation of the environmental damage itself, but rather, on the **proactive transformation of the entire (quintuple helix)** mesosystem of growth and development towards a more sustainable operational behaviour from all points of view. (Lundqvist, 2000).
- **EMT** in the **quintuple helix** (Carayannis, Barth & Campbell, 2012; Revel and Rootherfood, 2003; Berger et al., 2001; Buttel, 2000) is seen as, and as well, must induce transformation in (Pellow et al., 2000; Mol, 1995): EMT as a school of thought or belief system (ideology, governance, social cohesion); EMT as a policy discourse (policy & society); EMT as strategic management (industry); EMT as innovation or technological adjustment (research, transformation).
- **EMT** suggests that lower-level transformations will propagate across the entire ecosystem which is highly in line with the **DIT** view on innovation diffusion as well as with the resilience resolution mechanisms within **CAST** environments (Gobbo et al., 2014; Zhu et al., 2012; ol, 1995; Spaargaren, 1996).
- Thus, innovation diffusion from institutions to ecosystem/stakeholders is explained by **EMT, DIT and CAST**, while the reverse (a modernized ecosystem will pose pressures to institutions to further modernize) is explained by **INT** and **ST** (Zhu et al., 2011; Lai et al., 2006; Delmas & Toffel, 2004; Freeman, 1984; Hirsch, 1975).
- **EMT** – Ecological modernization can take place through more modernization and innovation (amalahmadi & Parast, 2016; Nooraie & Parast, 2016; Mari et al., 2015; Rajesh & Ravi, 2015; Kim et al., 2015; Durach et al., 2015; Barosso et al., 2015; Perera et al., 2015; Mensah et al., 2015; Gilly et al., 2014; Kristianto et al., 2014; Buttel, 2000; Beck, 1994; Giddens, 1994) – in line with **DIT**.
- **EMT** influences GSCM (and implicitly RGFT) in the following ways (Berger et al., 2001): Diffusion of environmental practices within the integrated chains (**EMT**); Diffusion of technological innovations within the integrated chains (**DIT**); Inclusion of a wider range of supply chain actors in the decision making processes (**quintuple helix**)

- **DIT and EMT** leaded to coining the term eco-innovation (Zhu et al., 2012) with core integration within the quintuple helix mesosystem (Caryannis & Campbell, 2012; Carayannis & Campbell, 2010).
- Transformative innovation (intervention) – (**DIT**) - that scales up within the **CAST** based ecosystem panarchy as a response to a crisis/opportunity (usually undertaken by innovation adopters as response to resilience (Kamalahmadi & Parast, 2016; Rajesh & Ravi, 2015; Kim et al., 2015; Durach et al., 2015; Gilly et al., 2014; Kristianto et al., 2014;Moore & Westley, 2011; Folke et al., 2010).
- Disruptive innovation (usually performed by innovators) that takes place within the boundaries of **DIT** (Zhu et al., 2012; Atwell et al., 2008; Walker et al., 2006) and often leads to eco-innovation (**EMT**) if performed within the quintuple helix (Hervani et al., 2005; Florida et al., 2000; Sharma, 2000) – where institutional innovation capacity and exogenous pressures are core enablers (**INT, ST**).
- **Resilience** has roots in ecological systems (preserved by **EMT**) and integrates within **CAST**-influenced systems under uncertainty and vulnerability (Perera et al., 2015; Mensah et al., 2015; Gilly et al., 2014; Kristianto et al., 2014; Scholten et al., 2014; Carvalho et al., 2012; Carpenter et al., 2005; Holling, 1973).
- From the **CAST** point of view, **RGFT** is indeed a social & ecological system and there is considerable research on this topic (Dubey et al., 2015; Govindan et al., 2015; Zhu et al., 2012; Carpenter et al., 2005; Gunderson & Holling, 2002; Berkes et al., 2003; Scheffer et al., 2003).
- Social ecosystems (where human are involved) became more complex than the traditional ecological ecosystems, and thus**, environmentally friendly resilience** started by be viewed as the pace to which a system returns to its initial (or environmentally better) state after a **disruption** took place (Dubey et al., 2015; Govindan et al., 2015; Zhu et al., 2012;; Walker et al., 2006; Berkes et al., 2003; Dasgupta & Maller, 2004; Hughes et al., 2005; Folke et al., 2010; Van den Berg et al.. 2011; Pimm, 1991).
- Environmentally friendly **resilience** is based on an eco-innovation as a response to crisis (**EMT**) and is managed based on a number of controlling processes (B hattacharya et al., 2014; Green et al., 2014; Shen et al., 2013; Hsu et al., 2013; Taticchi et al., 2013; Hitchcock, 2012; Dei & Shefi, 2012; Bai et al., 2012; Walker et al., 2006; Holling et al.,

2001) under the patronage of the following characteristics that the adaptive cycles of **CAST** systems should have towards ensuring resilience: Adaptability/flexibility of a system (learning capacity / knowledge management); Inner controllability (key controlled processes/indicators); Inner vulnerability control (capacity to integrate resilience)

- Folke et al., (2010) take even further these three characteristics and argue that the inner controllability should be highly related to transformability and transition towards adaptation (despite system's resistance to change) in order to ensure **CAST resilience** with **EMT** influences.
- Stochastic externalities such as weather/natural disruptions/crises can bring ungraspable outcomes in which the self-adaptation/resilience will take significant amount of time within a **CAST** based system – thus the effectiveness of the eco-innovation (**EMT**) propagation (**DIT**) becomes critical (Li & Coates, 2016; Chhetri et al., 2016; Snyder et al., 2015; Loh & Thai, 2015; Mattson & Jenelius, 2015; Global risks, 2015; GAR, 2015; Van der Vegt et al., 2015; Linnenluecke et al., 2012; Ergun et al., 2010; Natarajarathinam et al., 2009; Stecke & Kumar, 2009; Nakano, 2009; Sanchez-Rodriguez et al., 2008; Linnenluecke et al., 2012; Ross, 2003; Hale & Moberg, 2005 Monahan et al., 2003).
- Chertow (2009) views adaptability as the "*intentionally management of resilience of industrial ecosystems*" which is in total alignment with Holling (2001)'s view on resilience in terms of being done on internal controlled processes and thus resilience in eco-efficient industrial ecosystems as well as in green freight transportation can be achieved through: Increasing the environmental benefit (efficiency and reuse under the framework of EMT in innovative ways through the **DIT**); Enabling more **co-creation** & partnerships among multi-level **quintuple helix** stakeholders/actors (as described in **CAST, INT, ST**).

Having this convergence and overlapping among EMT, DIT, CAST, INT and ST under the framework of resilient GSCM and RGFT, the research questions specific to each social science theory also lead to a certain convergence. Thus, Figure 6 shows the convergence points among the research questions of the five theories (described in the previous subsections) towards enabling the identification of new research questions for furthering the theoretical fundaments of RGSCM and RGFT based on EMT, DIT, CAST, INT and ST.

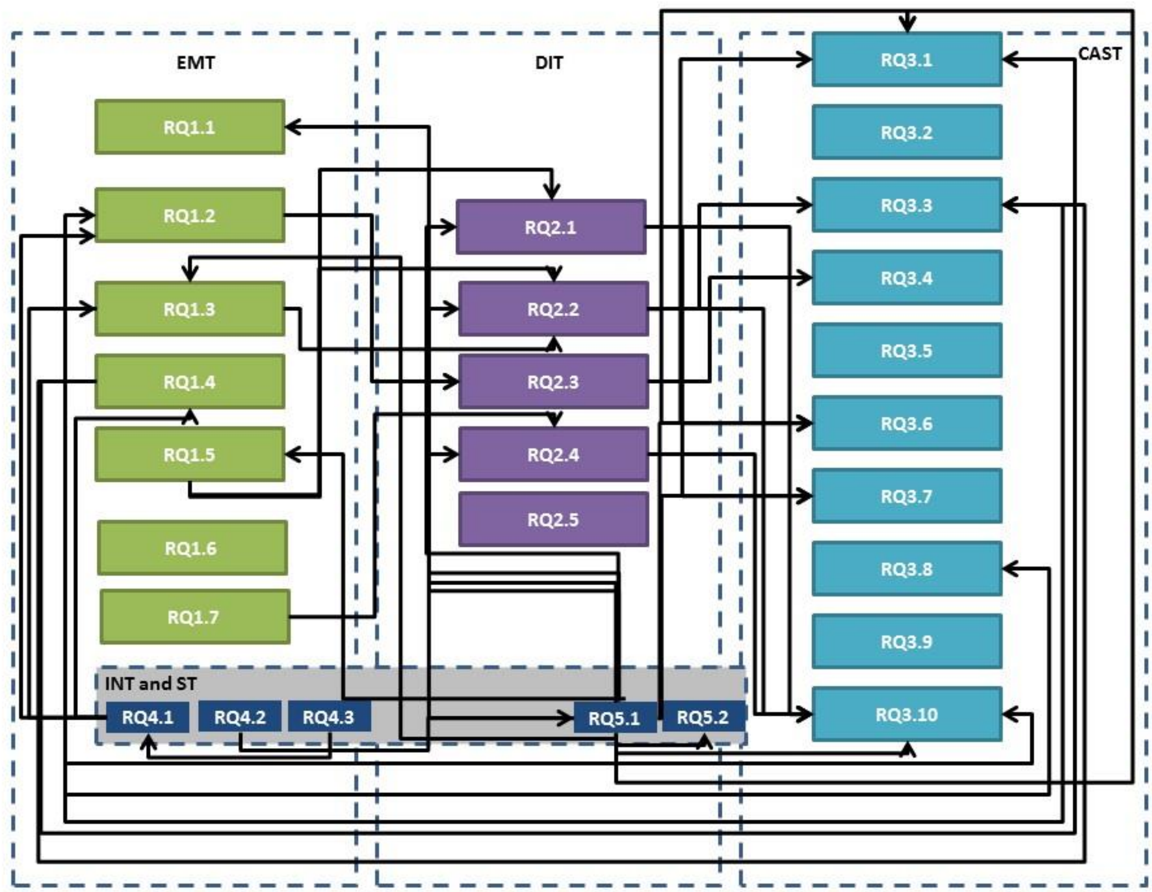

Figure 6: Overlapping the research questions of each theory

2.1.6.2 Final research questions towards boosting the knowledge of EMT, DIT, CAST, INT and ST in relation to RGFT

Building upon the individual research questions identified for each of the five theories as well as on their convergence presented in the previous subsection, the following converged research questions (CRQ) that add theoretical contribution to social science research will be undertaken in this thesis (the meaning of convergence in this case resides in overlapping common gaps, goals and individual research questions of each theory – EMT, DIT, CAST, ST and INT and deriving common/converged research questions (CRQs) that would fit all theories simultaneously):

CRQ1: Bottom-up: How can local level institutional EMT driven eco-innovations (either transformative or disruptive) diffuse faster under the DIT behaviour and scale-up (as explained by ST and INT) across the RGFT CAST driven microsystem panarchy during crises towards enabling resilience (Dubey et al., 2015; Govindan et al., 2015; Tian et al., 2014; Gobbo et al., 2014; Zhu et al., 2012; Darnall et al., 2008; Andrews et al., 2003; Hoffman & Ventresca, 2002) (Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Golicic & Smith, 2013; Zhu et al., 2012; Moore & Westley, 2011; Van den Berg, 2011; Chertow, 2009; Atwell et al., 2008; Jacobsson & Brgek, 2008; Walker et al., 2006; Walker et al., 2004)?

CRQ2: Top-down: How can the modernized ecosystem level (explained by the ST) generate eco-innovation exogenous pressures on the individual institutions (explained by INT) in an international ecosystem and what are the institutional level responses to such induced EMT driven modernization (Govindan et al., 2015; Tian et al., 2014; Zhu & Geng, 2013; Dornfield et al., 2013; Sarkis et al., 2011; Rivera, 2004) ?

CRQ3: Transversal: What are the local level institutional controlled processes of the CAST driven RGFT microsystem and how do these institutional controlled processes integrate and co-evolve (INT, ST) with the ones of other quintuple helix stakeholders in order to enable co-creation and fast eco-innovation adoption (EMT, DIT) towards ensuring RGFT at the quintuple helix mesosystem-level (Baumgartner et al., 2015; Piotrowicz, W., & Cuthbertson, 2015; Bhattacharya et al., 2014; Varsei et al., 2014; Ahi & Searcy, 2015a; Ahi & Searcy, 2015b; Gopal & Thakkar, 2012; Ivanov et al., 2012; Van den Berg, 2011; Folke et al., 2010; Bansal & Mcknight, 2009; Chertow, 2009; Pathak et al., 2007; Holling, 2001)?

CRQ4: Transversal: What are the effects of the interconnectedness of the institutional level stakeholders and the location of the disruption within a quintuple helix CAST based mesosystem on the RGFT process in terms of the effectiveness of the emerged eco-innovation (EMT) diffusion (DIT) (Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Zhu & Ruth, 2013; Petit et al., 2010; Gonzalez et al., 2008; Arimura et al., 2008; Hervani et al., 2005; Wagner & Bode, 2006) ?

CRQ5: Methodologies: What CAST systems modelling and simulation, mixed-methods research and behavioural analysis can be performed within an ecosystem (Faisal, 2016; Dubey et al., 2015; Hohenstein et al., 2015; Qazi et al., 2015; Heckmann et al., 2015; Tattichi et al., 2015; Huerta-Barrientos et al., 2015; Chouwdhury & Hossan, 2014; Molina-Azorin & Lopez-Gamero, 2014; O'Rourke, 2014; Seuring, 2013; Golicic & Davis, 2012; Zhu et al., 2012;Pathak et al., 2007) ?

CRQ6: Exogenous: How can stochastic externalities induced disruptions (such as environmental conditions) be better overcame in CAST ecosystems through eco-innovation (EMT, DIT, INT, ST) (Li & Coates, 2016; Chhetri et al., 2016; Snyder et al., 2015; Loh & Thai, 2015; Mattson & Jenelius, 2015; Global risks, 2015; GAR, 2015; Van der Vegt et al., 2015; Zhu & Ruth, 2013; Linnenluecke et al., 2012; Ergun et al., 2010; Natarajarathinam et al., 2009; Stecke & Kumar, 2009; Nakano, 2009; Sanchez-Rodriguez et al., 2008; Holling, 2001) ?

CRQ7: Transversal: How does the DIT properly explain the adoption of EMT by CAST based RGFT institutions (Kamalahmadi & Parast, 2016; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Zhu et al., 2012; Carayannis, Barth & Campbell; 2012; Carayannis & Campbell, 2010; Brugge & Van Raak, 2007; Quist, 2007; Sondejker et al., 2006)?

2.1.7 The proposed theoretical framework of the thesis (TFT)

Overall, the theoretical framework of this thesis resides in the convergence of EMT, DIT, CAST, INT and ST in relation to explaining RGFT/RGSCM as shown in Figure 7. The proposed TFT has been derived from the organizational theory review (social science epistemology from section 2.1) to serve as key theoretical gap mitigation. This TFT is consolidated via the systematic literature review from section 2.3 as well as through the primary research stages that this thesis undertook.

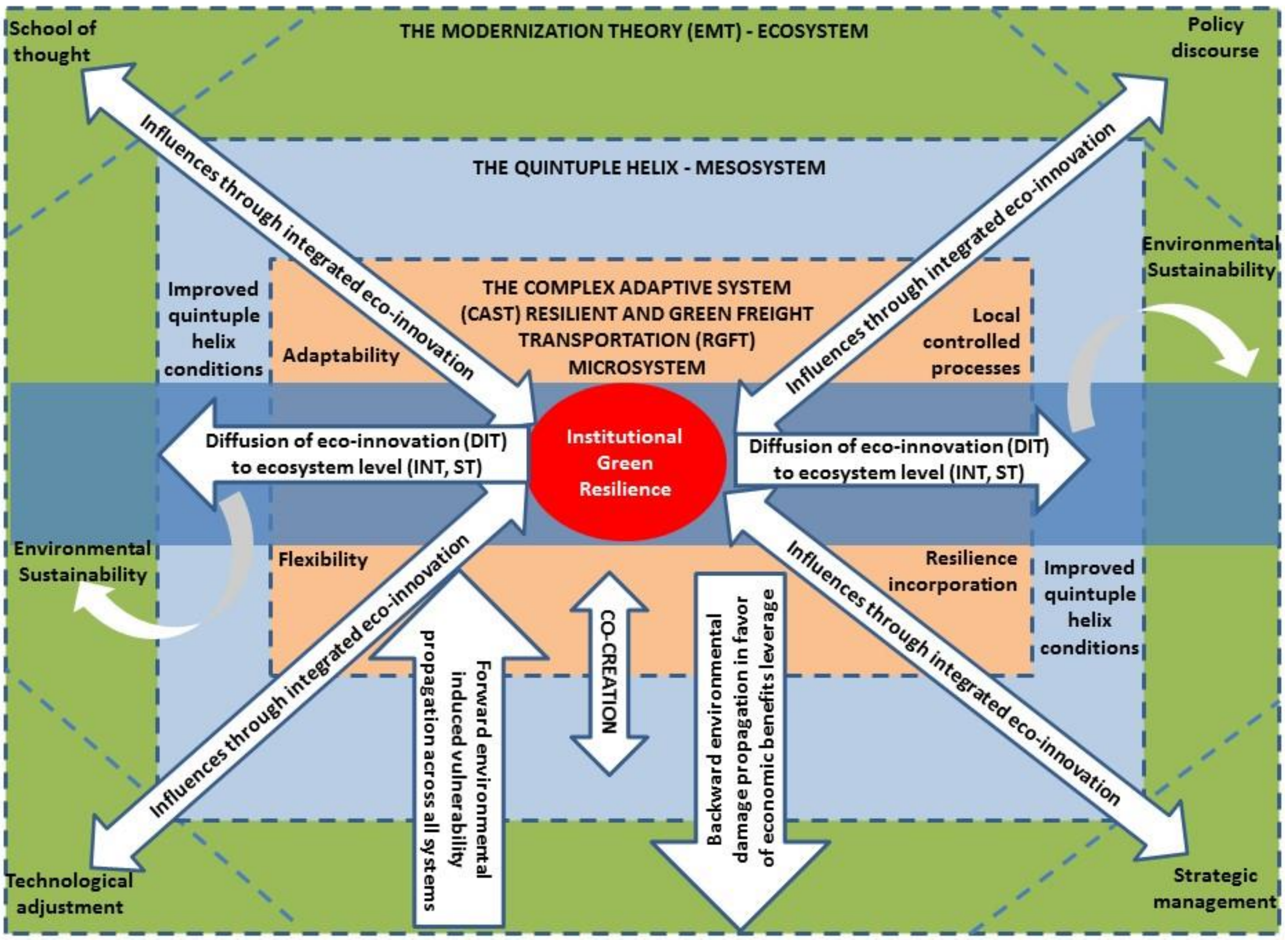

Figure 7: The proposed theoretical framework (TFT) of the thesis

As Figure 7 describes, the theoretical framework of this research is based on the following assumptions (which derive from the research questions) that are presented below. The role of these assumptions are to take the findings and gaps converged into the CRQs and propose a framework based on several pillars that can explain how all the five theories converge towards explaining how RGFT is implemented at the institutional and quintuple helix mesosystem level (achieving thus the aim and objectives of this thesis). The TFT has the following pre-conditions/background and pillars:

The pre-conditions/background of the TFT:

The environment is considered as the main ecosystem layer which integrates within the quintuple helix mesosystem (which, accordingly integrates the RGFT microsystem). The environment, through the EMT, imposes ecological modernization (ideology, discourse, technological adjustment and strategic management) throughout all its subsystems (thus throughout quintuple helix mesosystem and RGFT microsystem)

Furthermore, the environment generates environmental risks and vulnerabilities that cause disruptions that impact directly the RGFT microsystem, which, in order to preserve itself, leverages economic and business oriented goals, propagating the disruption damages to the outer system (quintuple helix mesosystem) and finally to the environmental ecosystem by causing severe environmental damage. When an environmental disruption takes place – at least one RGFT microsystem institution is affected.

The TFT Pillars:

Pillar 1: The RGFT microsystem is CAST based and must emphasise the following core elements: adaptability, flexibility, capacity to foster resilience and well defined key controlled processes at the (supply chain) microsystem level.

Pillar 2: Having these elements with core fundamental infusions from the EMT, during a disruption, the RGFT microsystem will eco-innovate and based on the well defined key controlled processes (with core support from flexibility, adaptability) a green resilience strategy will emerge.

Pillar 3: However, in the best case, this green resilience strategy will be implemented at the institutional (INT) or RGFT microsystem level without any direct impact measurement and implementation oversight at the wider ecosystem level (quintuple helix mesosystem) which has wider implications for the environment (ST).

Pillar 4: To this end, based on the CAST and DIT, the propagation of the green resilience (EMT) strategy and the necessary quintuple helix co-creation processes should be devised in order to leverage the impact of the green resilience strategy from microsystem, to mesosystem and finally to the ecosystem (INT, ST).

Pillar 5: Thus, the DIT propagates eco-innovations from institutions to ecosystem inducing thus change at the ecosystem/stakeholder level (ST) which will later on put more exogenous pressure to institutions (INT) to induce further modernization (cycle).

Pillar 6: This way, green resilience propagation is not isolated in a remote microsystem location of the environment and it will impact and induce modernization and transformation throughout all social systems by relying on EMT, CAST and DIT.

Pillar 7: The meaning of green resilience in this case is the capacity of the RGFT microsystem to recover in an environmentally sustainable (resource efficient and negative impact reduction) manner after an environmentally induced disruption took place by properly propagating the recover throughout all social systems that are involved.

In order to thoroughly support the CRQs and TFT pillars, a systematic literature review is performed (in section 2.3) based on the methodology defined in section 2.2.

2.2 Systematic literature review methodology

The previous section introduced the theoretical fundament development for sustaining the model proposed by this thesis. More specifically, the previous section performed an in-depth analysis of organization theories and social science foundation that underpin the philosophical issue and basis required to analyse and properly guide the research related to understanding RGFT/RGSCM with all the involved complexities and systems/events that interfere. Figure 8 below shows the logical flow of this initial part of the thesis in the sense that it shows how the previous subsections (comprising STEP 1 from the diagram below) are consolidated and extended by STEP 2 and STEP 3.

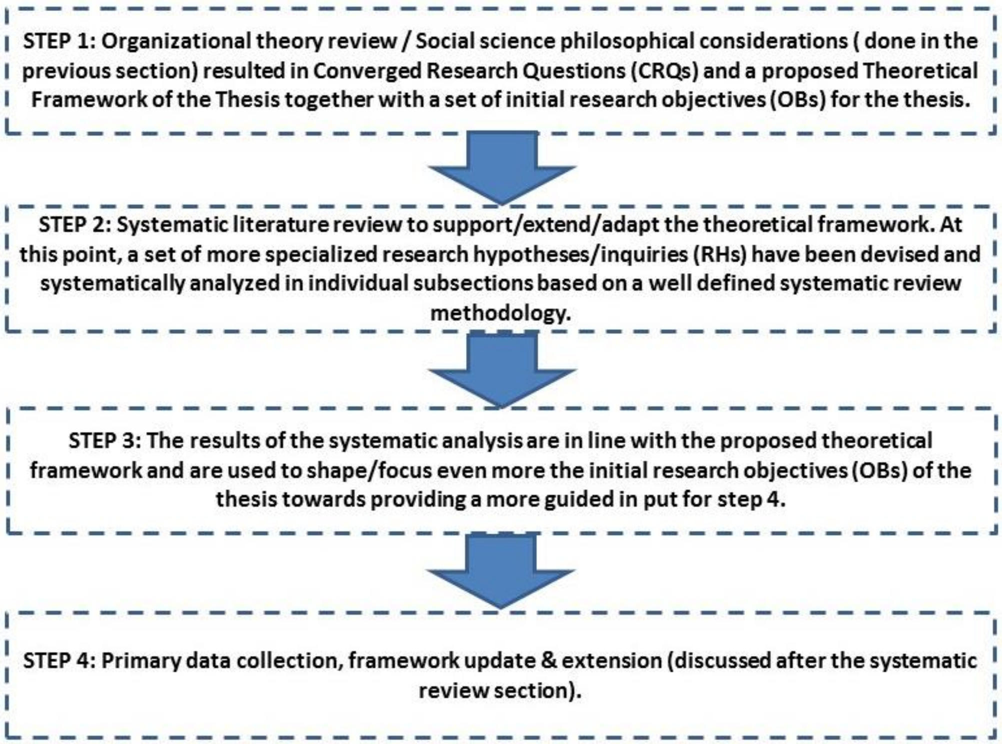

Figure 8: Methodological insight into the secondary research part

A systematic literature review (Figure 9) enables a more accurate identification of research directions and gaps towards conceptualizing a research challenge. In order to ensure its validity and usefulness of results, a specific and discipline-related approach must be undertaken. To this end, one pivotal paper (highest number of citations) which performs a systematic literature review for GSCM is provided by Srivastava (2007). The author motivates the need for this review in order to provide insights for businesses (institutional level), economic growth (ecosystem level) as well as to identify societal and ecological implications (quintuple helix). This paper becomes thus pivotal for this thesis in terms of guiding the systematic literature review as it has core relation to the theoretical framework proposed by the thesis in which EMT, CAST, DIT, INT and ST are interrelated in order to explain the synergies among the environmental ecosystem, the quintuple helix mesosystem and the RGFT microsystem.

The systematic literature review methodology proposed by Srivastava (2007) consists of the following stages (Searcy & Mentzer, 2003; Easterby-Smith et al., 2002) which is in line also with Delbufalo (2012) and Trainfield et al. (2003) – which is are core research for systematic literature reviews related to supply chain management (Golicic & Smith, 2013; Seuring & Gold, 2012): Unit analysis definition (in this case the unit analysis will be a research article and/or book); Definition of the problem context and methodology context to classify the resources; Material filtering (according to the problem and methodology context) and Material collection according to field boundaries (and summary/findings).

Srivastava (2007) provides a good insight into the field boundaries of GSCM to be used for performing a systematic literature review, however for the purpose of this thesis the field boundaries will be defined at the institutional (organizational) and cross-system level in order to grasp the complexity of RGFT and its positioning within the theoretical framework that was proposed. To this end, the literature review context and field boundaries will reside at the intersection of various disciplines as it will be explained in the diagram below. The definition of the field boundaries and context is highly related to the theoretical framework as well as to the research questions/objectives of this thesis in order to properly guide the review towards strengthening/tailoring the research questions as well as the final outcomes that will be achieved through the primary research discussed later-on.

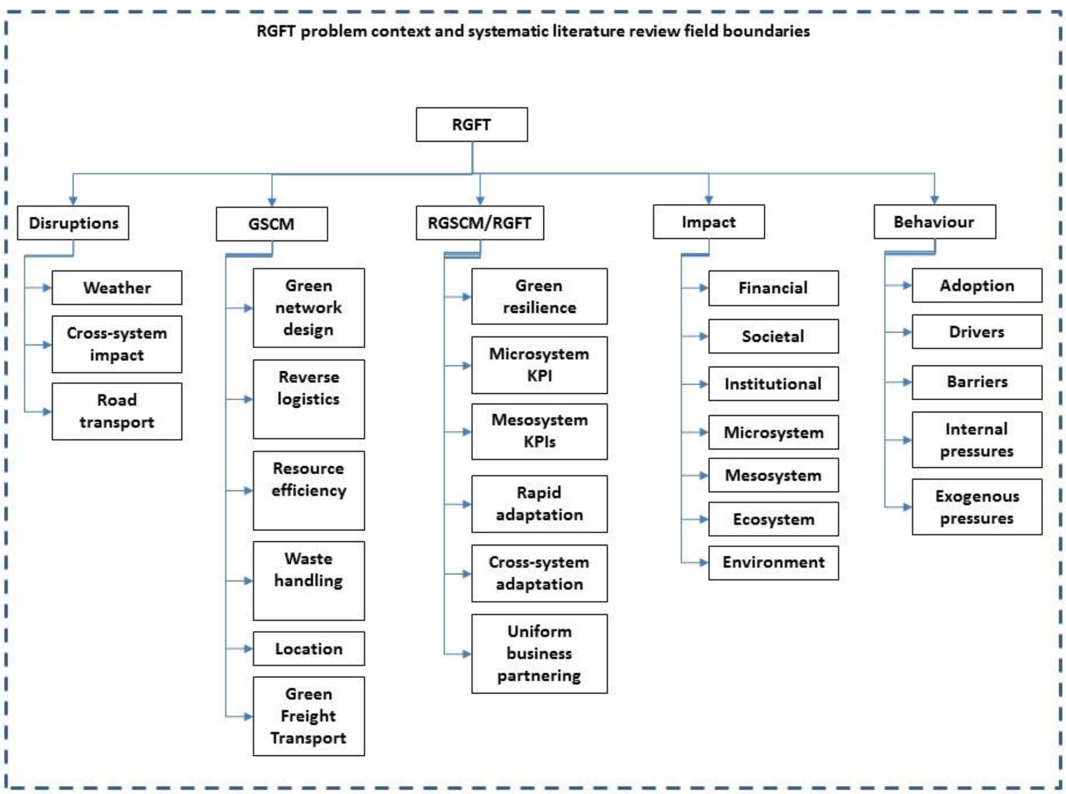

Figure 9: Systematic literature review boundaries & terminology

The research on the individual topics (boundaries) depicted in the above image has underpinnings in the early 90s (Srivastava, 2007), however in order to adopt a systemic approach, only research that is contemporary across all boundaries will be considered. Even more, considering the research debate sustaining the theoretical framework of this research (the core researches positioning RGFT within the mentioned social science theories) the actual resource span range for addressing in a systematic manner the RGFT concept is considered between the years 2000-2016 in order to ensure compatibility and timeliness of the research materials for each element in particular.

Furthermore, considering the field boundaries delimiting this research, it is of core importance to denote the multi-disciplinarily and cross-sectoral character of the involved concepts. This aspect played a crucial role on the resource search process, as currently, there is not focused cluster of academic journal to provide insight into RGFT from a cross-systems point of view. Thus, in order to address this limitation, the resource search process took place within the following academic databases which include the key related journals mentioned in Figure 10):

- Emerald Insight
- Scopus
- StarPlus
- ISTOR
- OECD iLibrary
- EBSCO
- Google Scholar

In order to provide a brief insight into the search process, it is of core importance to mention that a number of 3452 articles have been identified as related to the topic of this thesis (from which a number of 212 have been selected as highly relevant (with another 67 tangent to the scope of the research). The core search methodology and cases is based on the one adopted by (Delbufalo, 2012; Thorpe et al., 2005) and consists of the following (with variations and academic synonymy – the following queries (SQ) contain acronyms – however the actual search include full word spellings):

- **Year range**: 2000-2016

- **Article language**: English

- **Same-criteria equivalent articles selection decision**: the one with higher number of citations

- **First stage** – resource identification (3452 resources):

    - **SQ1:** (RGFT **OR** RGSCM) **AND** DISRUPTION **AND** (WEATHER **OR** IMPACT **OR** ROAD) **AND** (EMT **OR** DIT **OR** CAST **OR** INT **OR** ST)
    - **SQ2:** (RGFT **OR** RGSCM) **AND** (NETWORK DESIGN **OR** REVERSE LOGISTICS **OR** RESOURCE EFFICIENCY **OR** WASTE HANDLING **OR** LOCATION) **AND** (EMT **OR** DIT **OR** CAST **OR** INT **OR** ST)
    - **SQ3:** (RGFT **OR** RGSCM) **AND** (KPI **OR** RAPID ADAPTATION **OR** SYSTEM IMPACT **OR** CROSS SYSTEM PARTNERSHIPS) **AND** (EMT **OR** DIT **OR** CAST **OR** INT **OR** ST)
    - **SQ4:** (RGFT **OR** RGSCM) **AND** IMPACT **AND** (FINANCIAL **OR** SOCIAL **OR** ENVIRONMENTAL **OR** INSTITUTIONAL **OR** ECOSYSTEM) **AND** (EMT **OR** DIT **OR** CAST **OR** INT **OR** ST)
    - **SQ5:** (RGFT **OR** RGSCM) **AND** (INTENTIONS **OR** BEHAVIOUR **OR** ADOPTION **OR** DRIVERS **OR** BARRIERS **OR** INTERNAL PRESSURES **OR** EXOGENOUS PRESSURES) **AND** (EMT **OR** DIT **OR** CAST **OR** INT **OR** ST)

- **Second stage**: Further filtering based on individual resource-based keywords, title and abstract (867 resources selected). This stage has been done in a heuristic manner and thus potential article omissions could comprise one of the core limitation.

- **Third stage**: an ABC analysis has been performed on the second stage articles through fast-skim and in-depth key word identification mechanisms (a special software was used to analyse the 867 articles and perform the desired keyword (the keywords used in stage one) count segmentation for each article. The results of this stage showed high aggregation of keyword counts among two groups of articles (that were segmented as group A – a highly relevant number of 212 articles with highest keyword count; group B – a number of 67 articles tangent to the research however with lower keyword count; and group C – the remaining articles with low keyword count which were discarded).

- **Fourth stage**: an in-depth reading of group A articles (212) has been performed in order to identify empirical evidence related to the problem context and field boundaries adopted by this thesis. The articles have been analysed from the point of view of their hypotheses, employed methodology and its scientific validity, relation to building theoretical contribution (besides practical), findings and finally, research limitations/gaps and proposals for further research.

During the systematic review guided by the problem context and field boundaries, the actual aim was to sustain the theoretical framework of this research which positions the RGFT microsystem within the quintuple helix mesosystem under the wrapping of the environmental ecosystem (with social science explanations provided by the EMT, CAST, DIT, INT and ST) as well as to identify practical underpinnings reasoned by the afore mentioned theories that will show how green resilience at the institutional level is propagated to the ecosystem level and to identify what contextual factors are necessary for this process to take place. To this end, following this contextual aim and the field boundaries, the following research hypotheses defined by the theoretical framework of this thesis have been inquired through the systematic literature review:

- **RH1:** Understand which weather conditions cause the most impactful disruptions in road freight transportation from SEE
- **RH2:** Understand what negative business outcomes emerge as a result of such disruptions
- **RH3:** Understand what key performance indicators do business use and to what extend when dealing with disruptions
- **RH4:** Understand to which extend do businesses implement green practices during their decision making processes

- **RH5:** Understand what drivers and barriers do businesses face when aiming to adopt/implement green practices
- **RH6:** Understand what resilience mechanisms do businesses implement and to what extent these mechanisms include environmentally sustainable practices
- **RH7:** Understand how (to what extent) businesses interact with the RGFT/RGSCM stakeholders.
- **RH8:** Understand how can the resilience mechanisms of businesses be supported/fostered faster by other stakeholders from the ecosystem
- **RH9:** Understand to what extent do businesses respond to ecosystem pressures in order to implement GSCM/RGFT practices.
- **RH10:** Understand how do the RGSCM/RGFT KPIs of businesses match with the ones of the involved mesosystem's stakeholders
- **RH11:** Understand the importance of business partnerships interconnectedness in terms of enabling fast RGFT/RGSCM.
- **RH12:** Understand what modelling tools and research methods are employed to show practical underpinnings of implementing suitable RGFT/RGSCM strategies.

These research hypotheses (inquiries) will be grouped and tested across the following research clusters that have been identified after the systematic review: (individual sections will be provided for each cluster/theme).

- From SCM to GSCM
- From supply chain uncertainty and vulnerability to RGFT
- Weather induced disruptions within supply chains
- Thinking glocal: RGFT and the region of South East Europe

Overall, the systematic review shows convergence and capitalization of the publications across the following journals (shown in Figure 10), fields and research methods which will be use later on to denote the pillars for consolidating the theoretical framework in the field of RGFT/RGSCM from a cross-systems point of view. Finally, Figure 11 shows the link among all the key concepts that drive the consistent research direction of this thesis (how the CRQs relate to the literature review RHs. TFT Pillars and OBs.

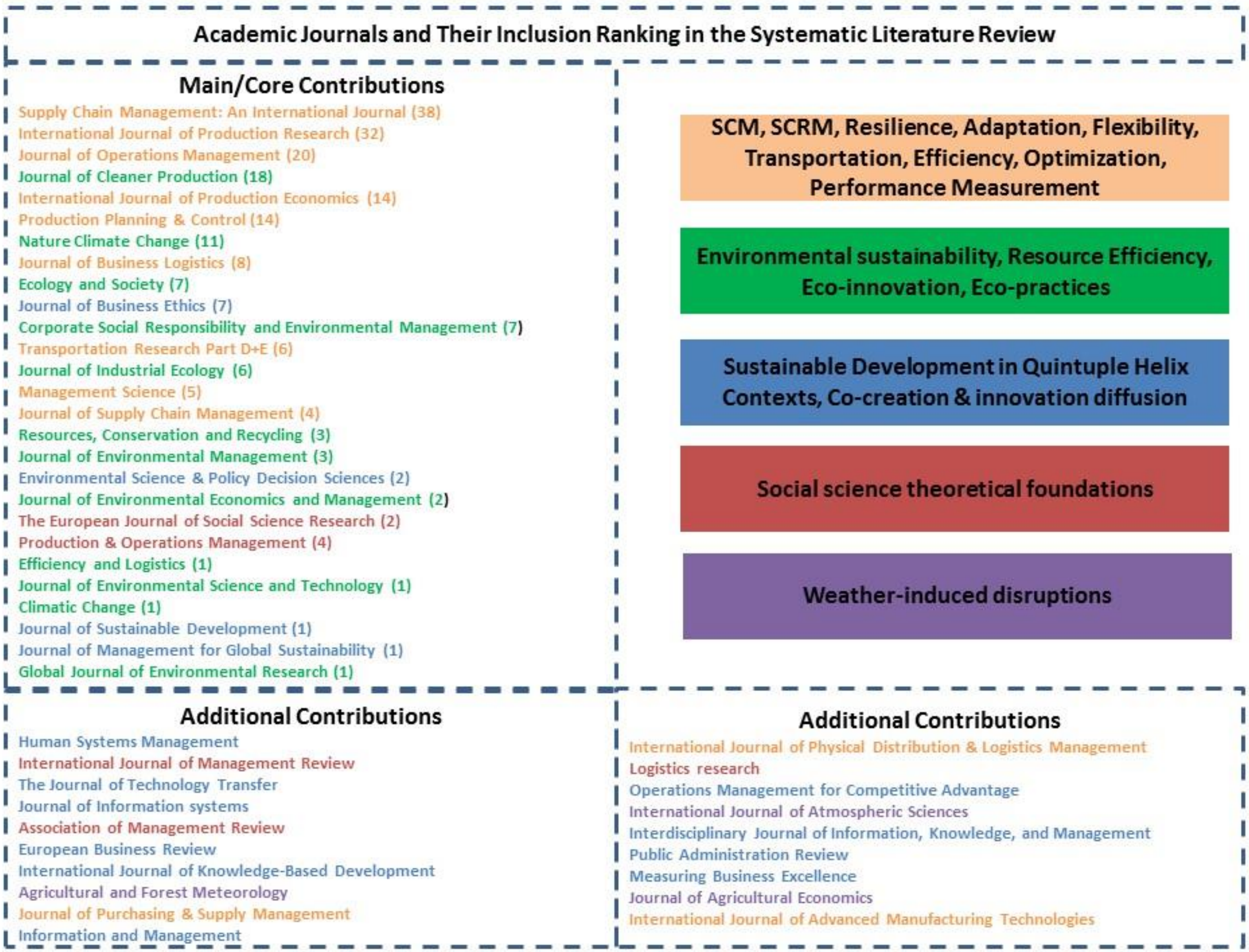

Figure 10: Academic journals included in the systematic review

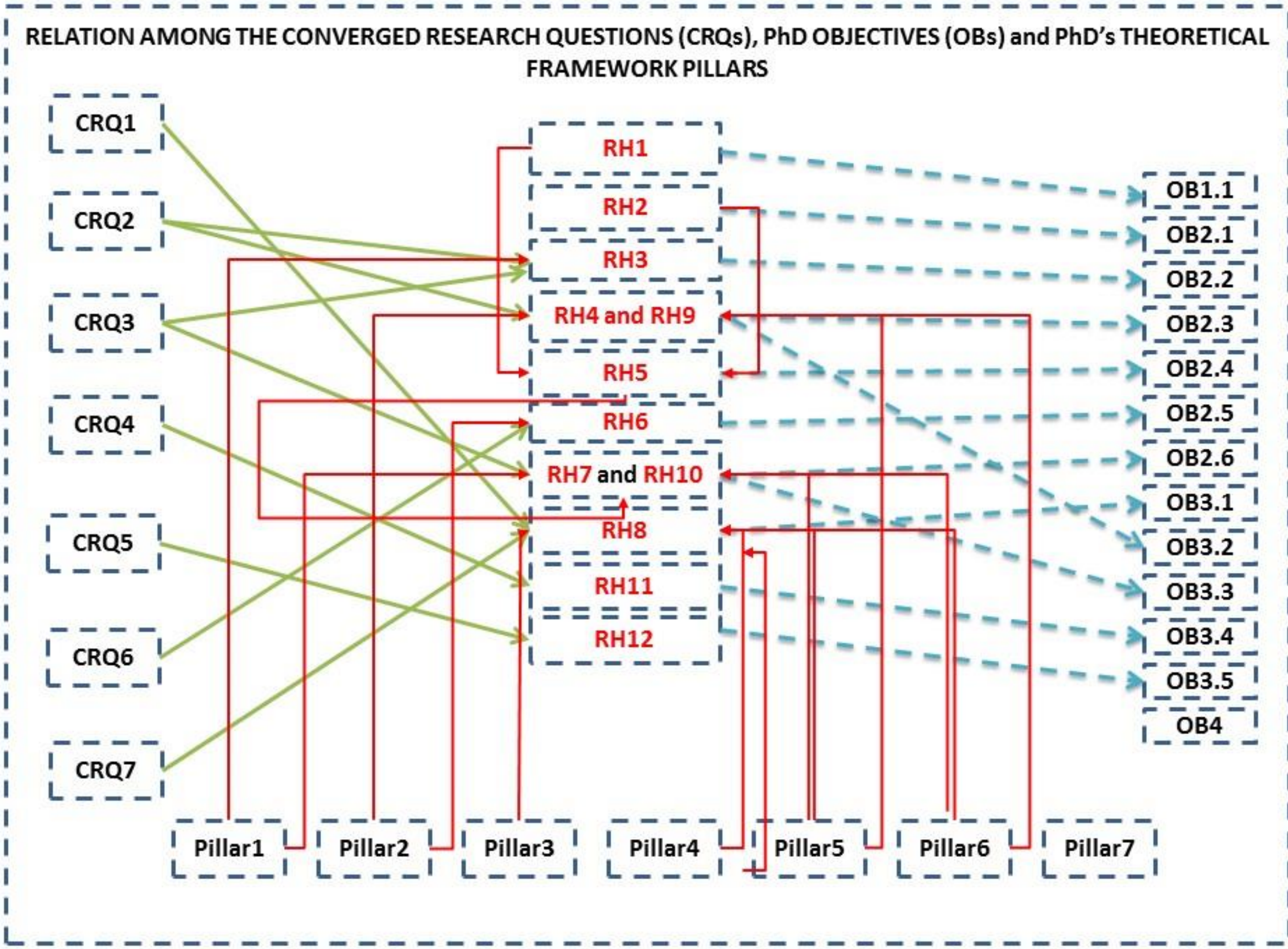

Figure 11: Relation among the CRQs, RHs, OBs and TFT Pillars

2.3 Systematic literature review outcomes

2.3.1 From supply chain management to green supply chain management

This section provides an overview on contemporary insights from the logistics and supply chain management transition to GSCM (with focus on GFT) in order to create the basis for understanding the context that drives the research questions of this study as well as to better reason the theoretical framework previously proposed. In order to better distinguish these concepts, the following definitions start from positioning supply chain management as a discipline:

- Supply Chain Management (SCM) deals with the provision of synchronized decisions and activities used to efficiently integrate all supply chain actors in order for the right product to emerge at the right location, time, price, quantity and condition, while minimizing overall costs and increasing customer's satisfaction. To the same extent, SCM focuses on the sourcing of raw materials, production, product development, commercialization, sales and marketing, reverse logistics and customer relationship management (Govindan et al., 2015; Dubey et al., 2015; Bhattacharya et al., 2014; Loke et al., 2011; Talib et al., 2011; Lockamy & McCormack, 2004; Mills et al., 2004; Chen & Paulraj, 2004).
- Logistics management (i.e. freight transportation) aims to get the right goods/services in the proper condition, at the right place, in the right time and with minimum cost. However, according to Morabito et al. (2000), logistics management focuses more on physical distribution, materials management/transportation. Logistics management became a sub-division of SCM, however they are often discussed in the literature together.
- Freight transportation (FT) as part of SCM: the process of moving goods from raw materials to finished ones as well as waste, by relying on the public transportation infrastructures and involving multiple transportation means (Transport Research, 2009).

- **SCM (FT) integrates many stakeholders: clients (society), businesses (institutions), infrastructures (natural resources and governmental ecosystems (i.e. roads)) → Quintuple helix mesosystem**
- **Logistics (FT) is more related to the physical infrastructure - closer to the society and environment and directly impacted by governmental premises → Quintuple helix mesosystem**

Findings box 1: Supply chain management versus logistics

The main origin of supply chain management (SCM) has been identified by (Locke et al., 2011) as being derived from logistics management (Bhattacharya et al., 2014; Lee & Kincade, 2003; Tan et al., 2002 and Romano & Vinelli, 2001). SCM is also an effort to achieve coordination (Simatupang & Sridharan, 2002 and Kanda & Deshmukh, 2008). Apart from these aspects, nowadays supply chains deal, though, with critical issues such as: demand planning, environmental and social considerations, globalization, increased competition and price pressures, outsourcing, shorter and more complex product life cycles, and increased collaboration among stakeholders (Dubey et al., 2015; Govindan et al., 2015; Hitachi Consulting, 2009). Thus supply chains become global, more complex, more intensive in volume, thus more demanding for the logistical infrastructure and implicitly for the environment.

Furthermore, within nowadays supply chains, the focus is being set on enterprise level SCM rather than on factory level SCM (Dubey et al., 2015; Govindan et al., 2015; Wu et al., 2015; Kistruck et al., 2015; Bhattacharya et al., 2014; Pathak et al., 2014; Sanders, 2007; Cousins & Menguc, 2006; Gunasekaran et al., 2005). Similarly, Akyuz & Erkan, (2010) reviewed that the shift from linked organizations to networked organizations, globalisation and changes of operational means (such as outsourcing) is constantly changing the definition of SCM (Meixell & Gargeya, 2005), by making the supply chain actors more and more interdependent (Janvier-James, 2012). Also, due to complexity, both of the supply chain itself as well as of the consumer demand, companies are forced to coordinate operations that cross their organisational boundaries (Jayarama et al., 2010) – through their collaboration partners/network (Handfield & Nichols, 2002). These aspects lead to increased vulnerability to disruptions especially of the logistical sector from the supply chain through increased distance and risk propagation inter-dependency among the supply chain partners.

- SCM (FT) aims to achieve coordination in a complex context → CAST
- SCM (FT) requires collaboration among stakeholders → CAST
- SCM (FT) is done at an enterprise level, thus it can consist of an self-coordinated microsystem → CAST based microsystem
- SCM (FT) involved high interdependencies within the microsystem (enterprise) with increased risk towards disruptions → CAST based microsystem

Findings box 2: Supply chain management, transportation and CAST

On top of this, today's era of globalisation stipulates for more innovative business models of evolving supply chain every day (Hitt et al., 2015; Bhattacharya et al., 2014; Liu et al., 2014). Tremendous progress and researches have been carried towards developing frameworks and standards for green supply chain and logistics. Despite of all the researches, organisations and ecosysyems are failing to meet the stakeholder's expectations to meet the regulatory standards from social, economic and most importantly ecological point of view. Still industries are struggling to search for best practices within the green logistics. Due to their global expansion, enterprises are critical actors in climate change mitigation and in environmental sustainability promotion (Dubey et al., 2015; Govindan et al., 2015; Melville, 2010), especially since the environment brings both risks and opportunities for businesses. Furthermore, the European Commission is targeting a 20% reduction of GHG emissions by 2020 (EU2020 , 2013). However, with this expansion, enterprises have implicitly increased their risk encounter vulnerability which can have severe impact on the environment.

- SCM (FT) pushes for more innovative green business models (GSCM) → EMT, DIT
- Institutions and ecosystems fail to properly adopt GSCM → EMT, INT, ST, DIT, CAST, INT, ST
- Enterprises (microsystems) become key leaders in GSCM adoption by perceiving environmental induced disruptions as innovative opportunities → EMT, DIT, INT, ST, CAST (with focus on green resilience)

Findings box 3: SCM, FT and their relation with, EMT, INT, DIT, CAST and ST

With such increasing environmental and societal pressure, Beske et al. (2008) argues that companies operate between two opposing poles: the risks and liabilities related to their business activities and the active involvement in the society (Dubey et al., 2015; Govindan et al., 2015; Zhu et al., 2012; Delmas & Toffel, 2004; Holt, 2004 and Teuscher et al., 2006). The relevance of sustainability policies has significantly grown to span the entire supply chain network rather than each individual partner (Bask & Kuula, 2011; Andersen & Skjoett-Larsen, 2009 and Spence & Bourlakis, 2009), thus, the competitive advantage of supply chains relies in the effective sustainability policies which encompass environmental practices.

Institutions should become thus motivated by green sustainability and they incorporate it into their business strategy (Wilhelm et al., 2016; Dubey et al., 2015; Govindan et al., 2015; Fullerton et al., 2014; Lee & Kim, 2011 and Porter & Reinhardt, 2007). Sivakumar et al. (2012) argue that if a network of companies (i.e. microsystem) share resources in a sustainable manner, then their high-level operational management resembles green logistics and green supply chain management.

In order to better differentiate the focus of this paper which is on the logistical part (freight transportation) of the supply chain, the following two concepts must be defined:

- Green/Sustainable logistics (i.e. green freight transport - GFT) refers to the process of minimisation of the environmental impact of transportation either at the physical or the operational level (Demir et al., 2011) and deals with: fuel efficiency, technological innovations in terms of mobility efficiency, technology based operational efficiency (Geldermann et al., 2007), modal shift, logistical flexibility with reduced environmental impacts (Shukla et al., 2010).

- Green supply chain management (GSCM) incorporates green logistics and refers to the strategic, transparent integration and accomplishment of an organization's social, environmental and economic goals (Dubey et al., 2015; Govindan et al., 2015; Sivakumar et al., 2012; Carter & Rogers, 2008, Srivastava, 2007). According to (Sarkis et al., 2010), GSCM deals with: sustainable supply network/chain management (Dubey et al., 2015; Govindan et al., 2015; Cruz & Matsypura, 2009 and Linton et al., 2007; Fleischman et al., 2001; Jayaraman et al., 2003), green/sustainable logistics (Zhu et al., 2012; Wolf, 2011; Sarkis et al., 2010 and González-Benito & González-Benito, 2006), supply/demand sustainability (Cruz & Matsypura, 2009 and Kovács, 2004), supply chain environmental management (Sarkis et al., 2010), product carbon management (McKinnon, 2010), green/environmental procurement (Gunther & Scheibe, 2005 and Chen, 2005), green product development and operations (Kleindorfer et al., 2005), ethical sourcing (Roberts, 2003) and green management and reporting (Keating et al., 2008 and Tate et al., 2010).

- **GFT is highly influenced by the quintuple helix stakeholders towards constant eco-modernization and impact mitigation → EMT, DIT**
- **The quintuple helix stakeholders imposes that green practices should be leveraged from institutional level to (micro/meso/eco)-system level → EMT, DIT, CAST, INT, ST**
- **GFT aims at resource efficiency and environmental impact mitigation through innovative technological practices and flexibility/adaptation → EMT, DIT, INT, DIT, CAST**

Findings box 4: GFT, GSCM and their relation with EMT, DIT, INT, ST and CAST

Having this context, it can be stated that GFT and GSCM are highly influenced by the EMT, DIT, CAST, INT and ST in consistent compatibility with the theoretical framework proposed by this thesis. GFT, is a subdivision of GSCM (the core subdivision which serves all GSCM purposes) and becomes thus influenced by most of the GSCM challenges). However, it is of core importance to understand the contextual factors that reason this influence. For this purpose, this section is tailored to provide a systematic insight into the following research hypotheses (inquiries) which will be presented, each, in the upcoming subsections:

RH4: Understand to which extent do businesses implement green practices during their decision making processes

RH5: Understand what drivers and barriers do businesses face when aiming to adopt/implement green practices

RH7: Understand how (to what extent) businesses interact with the GSCM/RGFT stakeholders.

RH9: Understand to what extent do businesses respond to ecosystem pressures in order to implement GSCM/RGFT practices.

RH10: Understand how do the GSCM/GFT KPIs of businesses match with the ones of the involved mesosystem's stakeholders

2.3.1.1 Answering RH4 and RH9: Green practice implementation during decision making processes under internal and exogenous pressures

The purpose of this section is to reason RH4 and RH9 in terms of understanding how the GSCM practices are being implemented at the institutional level and then diffused at the microsystem (GSCM/RGFT) and mesosystem level (quintuple helix). The literature debate in relation to GSCM practices is generally sound, however most of the categorizations of such practices are, generally, central to the institutional level (more specifically to the operations management of a specific institution. Thus, in order to properly address RH4 and RH9 from the theoretical framework of this thesis' point of view, the GSCM practices will be categorized according to the coercive influencer typology which drives the implementation of the practice at the institutional level and its transgression at the microsystem and mesosystem level.

Internal/Institutional initiated practices: Environmental management systems (EMS) – set of policies and activities utilized in decision making towards promoting an environmentally friendly operational manger within an institution. It involves: internal policies, staff training, auditing, monitoring, senior staff commitment, TQM, JIT (Dubey et al., 2015; Zhu et al., 2010; Darnall et al., 2008; Hu et al., 2008; Walker et al., 2008; Gonzales et al., 2008; Harland et al., 2007; Handfield et al., 2005; Bansal & Hunter, 2003, Sarkis, 2003). EMS promote legitimate businesses, eases the implementation of GSCM (Darnall et al., 2008; Potoski & Prakash, 2005; King et al., 2005). The limitations of EMS reside in the lack of research towards proving practice diffusion from institutional (INT) to ecosystem (ST) level (Tian et al., 2014; Gobbo et al., 2014; Testa & Iraldo, 2010; Darnall et al., 2008; Handfield et al., 2004) especially in relation to freight transportation mitigation practices (Testa & Iraldo, 2010).

Having such operational standards, Hervani et al. (2005) sustain the need for GSCM practice implementation and provide a GSCM performance measurement framework at the institutional level based on external reporting (to the GSCM microsystem & quintuple helix ecosystem), internal control (based on institutional processes/KPIs) and continuous modernization (similar with Drohomeretsk et al. (2014), Gunasekaran (2004) and Zhu et al. (2008)).

The core limitations of such a performance measurement system for GSCM consist of: mistrust, heterogeneity across the microsystem, lack of control/coordination, lack of mediator/leader (Brewer & Speh, 2001) – in high cohesion with the CAST based part of this thesis' model where eco-innovation diffusion (EMT, DIT) is being aimed from the institutional level (INT) to medosystem level (ST). However, the core element of such ISO14031 performance measurement systems for GSCM provided by Hervani et al. (2005) resides in involving the quintuple helix ecosystem stakeholders in validating the true environmental impact of an institution's actions, enabling thus co-creation between the GSCM microsystem and the quintuple helix ecosystem which leads to the ultimate transgression of the environmental innovation from the institutional level to the microsystem and then ecosystem level (having such co-creation knowledge flows established).

- **GSCM/GFT practices are implemented at the institutional level based on EMS, however, performance reporting is being done at the Quintuple Helix Mesosystem level → EMT.**
- **Internal GSCM/GFT practice implementation monitoring is done on key controlled processes with stakeholder heterogeneity and lack of coordination issues → EMT, CAST, DIT.**
- **Regulation (i.e. ISO14031) and performance measurements frameworks for GSCM/GFT practice diffusion imply co-creation and diffusion of practices at the ecosystem level → EMT, DIT, CAST, INT, ST.**

Findings box 5: GSCM, GFT and their stakeholder level leverage

Quintuple helix induced practices: Environmental standard/best practice adhesion (Dubey et al., 2015; Govindan et al., 2015; Ivanaj et al., 2015; Tian et al., 2014; Chakrabarty & Wang, 2013; Lee, 2008; Chien & Shih, 2007; Papadopoulos & Giama, 2007) are core legislative directions emerged as pressure response from various societal organizations and have a coercive impact on institutions towards implementing green practices. For example, ISO14001 (Arimura et al., 2011; Testa & Iraldo, 2010) is a key GSCM practice adopted by institutions. Even more, further specialized standards such as ISO14031 is utilized towards ensuring proper performance measurement for the implementation of EMSs (Hervani et al., 2005).

Similarly, two core directives (related to the European Union primarily however they affect all stakeholders collaborating with EU registered institutions) consists of the Waste Electrical and Electronic Equipment (WEEE) and the Restriction of Hazardous Substances (RoHS) and are core practices that GSCM adopts (Hu & Hsu, 2010; Zhu & Sarkis, 2006; Widmer et al., 2005; Huang, 2005). Additionally, the energy usage products (EuP) regulation is the first regulatory framework (in the European Union) to support LCA based GSCM practices in terms of acknowledging the overall environmental impact of a specific unit of product (Hu & Hsu, 2010; Yung et al., 2008; Grote et al., 2007; Hansen et al., 2005). Further work on LCA as a GSCM practice is debated by (Srivastava, 2007; Sanchez et al., 2004; Tibben-Lembke, 2002). Finally, Testa & Iraldo (2010) perform an in-depth study on assessing how institutional related behaviour and resources are impacted by exogenous contexts.

The findings show that the position of the institution within the microsystem affects the adoption of GSCM practices as well as institutional factors such as: number of employees, stock exchange listing, and the existence of an environmental management unit (Gonzalez et al., 2008; Arimura et al., 2008; Hervani et al., 2005; Florida et al., 2000). Finally, (Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Testa & Iraldo, 2010;Arimura et al., 2008; Zhu et al., 2005; Sheu et al., 2005; Christman & Tailor, 2001) argue that cross-border cooperation with more developed markets poses exogenous pressures on institutions towards adopting GSCM.

- **Quintuple helix mesosystem directives (→ ST) impact on GSCM/GFT microsystem institutions (→ INT)**
- **The position of an institution (→INT) within the GSCM/GFT microsystem as well as inner resource capacities influence the adoption of quintuple helix mesosystem (→ ST) imposed eco-practices. This links with the CAST concepts where the position of an institution plays a key role in the self-adaptation/eco-resilience process.**

Findings box 6: GSCM, GFT and the Quintuple Helix under ST, INT and CAST

Co-creation and co-evolution/co-modernization within the mesosystem: Collaboration with stakeholders within the GSCM/GFT microsystem becomes critical to achieve the common goal. Such co-creation can be related to eco-design (reusability, recycling), resource efficiency and eco-packaging (Shi et al., 2012; Zhu et al, 2010), joint auditing, stakeholder education & training, supplier evaluation, joint recycling, green network design (Ivanaj et al., 2015; Hsu et al., 2013; Hu & Hsu, 2010; Ninlawani et al., 2010; Mont & Leire, 2009; Seuring & Muller, 2008; Walker et al., 2008; Srivastava, 2007; Chien & Shih, 2007; Wright & Elcock, 2006; Tsoulfas & Pappis, 2006; Yalabik et al., 2005; Evans & Johnson, 2005; Eveloy et al., 2005; Handfield et al., 2005; Widmer et al., 2005; WEEE, 2003).

In a consistent manner, another research direction leverages such co-creation for green purchasing, green operations (Shi et al., 2012; Zhu et al., 2010; Hu & Hsu, 2010; Ninlawani et al., 2010; Srivastava, 2007; Savaskan et al., 2004; Handfield et al., 2002) in terms of: specifying product design specifications, imposing standards and audits, evaluations (Srivastava, 2007). Similarly, another research strand focuses on: circular economy, reutilization of resources, co-evolution of GSCM with the quintuple helix (Shi et al., 2012; Eltayeb et al., 2011; Zhu et al., 2010; Seuring & Muller ,2008; Zhu et al., 2008; Chien & Shih, 2007; Ravi et al., 2005). Finally, a pioneering work performed by Shi et al (2012) argue for the need of a new co-evolution model with GSCM practices fully embedded within microsystems towards the development of “socially complex resources” based on ecological co-creation through mutual trust, commitment and common vision (Vachon & Klassen, 2007). Such co-evolution will thus, induce change pressure.

Diffusion from institutional level to ecosystem level: GSCM practice implementation at the institutional level imposes pressure at the enterprise (microsystem/mesosystem) level towards GSCM practice implementation (Dubey et al., 2015; Govindan et al., 2015; Tian et al., 2014; Gobbo et al., 2014; Zhu et al., 2012; Darnall et al., 2008; Andrews et al., 2003; Hoffman & Ventresca, 2002) by forming compatible relationships. Another influencer of GSCM practice evolution from institutional level to stakeholder level is the inner desire for public legitimacy (rather than to obey coercive policies/requirements) and thus institutions aim for legitimacy towards adopting environmentally sustainable practices (Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Golicic & Smith, 2013; Zhu et al., 2010; Testa & Iraldo, 2010; Nawroka, 2008; Walker et al., 2008; Chien & Shih, 2007; Hervani et al., 2005; Ginsberg & Bloom, 2004; Delmas

& Toffel, 2004; Gupta & Pierro, 2003; Rao, 2002; Chan & Lau, 2001; Hoffman, 2000). Such diffusion is critical especially since most of GSCM focus has been set on the institutional level rather than supply chain/microsystem level and there is a significant research gap in this sector (Tian et al., 2014; Gobbo et al., 2014; Cousins et al., 2004; Hsu et al., 2013; Srivastava, 2007; Sarkis, 2006).

- **Co-creation within the GSCM/GFT microsystem towards eco-practice implementation leads to:**
    - **Balanced eco-modernization of all stakeholders (with spillovers to the quintuple helix mesosystem) → EMT, DIT**
    - **The modernization process imposes co-creation, partnerships, knowledge flows which form strong networks that self-adapt, providing thus an enhanced environment for a potential self-adaptation in case of disruptions. → CAST**
    - **ST and INT explain how localized institutions aim to implement the quintuple helix eco-directives, however, such implementation imposes the co-creation which leads to more eco-modernization as explained by the EMT.**

Findings box 7: GSCM, GFT and co-creation

Finally, Figure 12 shows the literature that favours co-creation and co-evolution among the quintuple helix stakeholders towards achieving RGFT/RGSCM by stressing the need of leveraging eco-innovations from institutional level to mesosystem level. Specifically, Figure 12 argues that institutional practices can be leveraged to the mesosystem level through co-creation and then, mesosystem/stakeholder level practices will diffuse (trigger transformation) in a cycle at the institutional level (ensuring thus a sustainable mechanism).

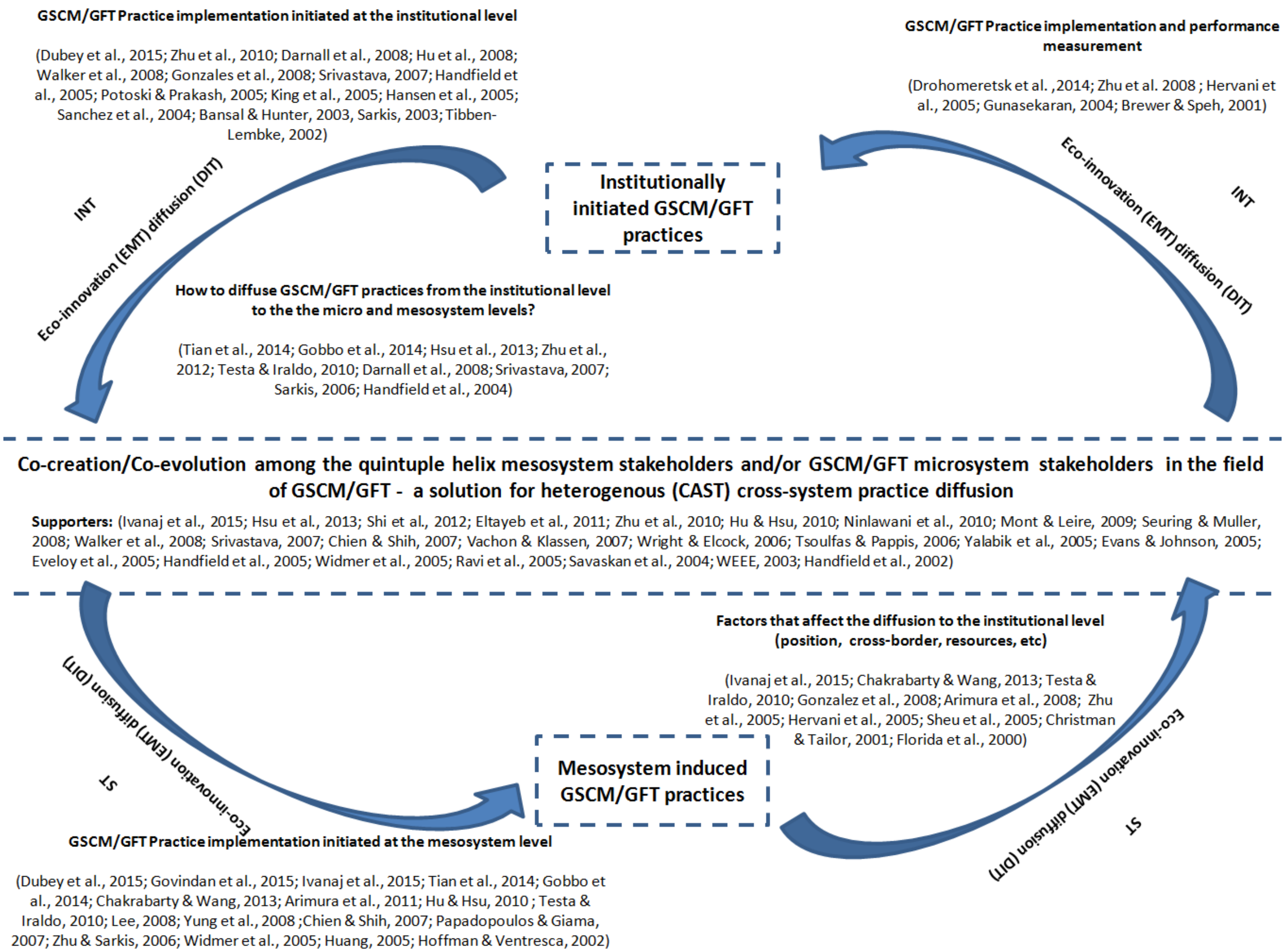

Figure 12: The requirements of co-creation & co-evolution

2.3.1.2 Answering RH5: Drivers and barriers to green practice implementation

Having recognized the importance of GSCM, stakeholders are developing and implementing programs to control and lower their environmental impact (Govindan et al., 2015; Hsu et al., 2013; Zhu et al., 2012; Boyer et al., 2009; Vachon, 2007; Rao, 2002) as well as to overcome the organisational resistance to the adoption and implementation of environmental solutions (Vachon & Klassen, 2007).

Driver: Efficiency (Internal)

Financial efficiency

Reduced costs for materials, energy, waste discharge and treatment, regulatory penalties, safety and injury trials, lower labour cost through better working conditions causing improved motivation (Govindan et al., 2015; Tian et al., 2014; Alzaman, 2014; Shi et al., 2012; Eltayeb et al., 2011; Carter & Rogers, 2008; Zhu et al., 2010, Ninlawani et al., 2010; Molina-Azorin et al., 2009; Carter et al., 2007; Chien & Shih, 2007; Mollenkopf et al., 2005).

Environmental efficiency:

Reduction of polluting gases, waste water and solid wastes (land fill), lower intake of hazardous materials, less environmental accidents and improved environmental behaviour of the institution (Govindan et al., 2015; Ivanaj et al., 2015; Alzaman, 2014; Tian et al., 2014; Hsu et al., 2013; Golicic & Smith, 2013; Eltayeb et al., 2011; Shi et al., 2012; Zhu et al., 2010; Testa & Iraldo, 2010; Ninlawani et al., 2010; Chien & Shih, 2007; Zhu & Sarkis, 2007; King et al., 2005).

Operational efficiency:

Improved goods delivery times, lower inventories, lower waste levels, improved product quality and line & capacity performance (Govindan et al., 2015; Hsu et al., 2013; Shi et al., 2012; Eltayeb et al., 2011; Zhu et al., 2010; Carter & Rogers, 2008; Zhu & Sarkis, 2007; Hanson et al., 2004).

Driver: Social responsibility & reputation/brand based on a culture of sustainability (Coercive)

GSCM is implemented towards denoting (coercive) social considerations (besides economic, environmental and operational (Govindan et al., 2015; Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Hsu et al., 2013; Shi et al., 2012; Rehman & Shrivastava, 2011; Zhu et al., 2010; Testa & Iraldo, 2010; Carter & Rogers, 2008; Chen, 2008; Vachon & Klassen, 2007; Chien & Shih, 2007; Ellen et al., 2006; Capaldi, 2005). However, Carder & Rogers (2008) in their fundamental work on defining sustainability in relation to SCM, argue that such a culture of responsibility and involves substantial change management and visionary nature of those involved. This coercive adoption of GSCM practices is fully in line with the ST and INT theories incorporated into the model of this thesis.

Driver: Innovation leaders as competitive advantage (inner)

GSCM practices are lately being implemented for promoting an innovative brand image for stakeholders (Govindan et al., 2015; Tian et al., 2014; Dornfield et al., 2013; Zhu et al., 2012; Rehman & Shrivastava, 2011; Testa & Iraldo, 2010; Vachon & Klassen, 2007; Zhu & Sarkis, 2007; Hervani et al., 2005; Khalid et al., 2004). In this context, green practices are considered as an innovative source of competitive advantage (Wolf, 2011; Matos & Hall, 2007; Li et al., 2006; Bansal & Roth, 2000). Even more, according to (Mann et al., 2010), having the transnational character of nowadays supply chains and implicitly logistical infrastructures, due to increased outsourcing, sustainability also became transnational rather than localized (Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Linton et al., 2007 and Seuring et al., 2008) – accross the entire GSCM microsystem whcich means that such eco-innovation leaders will access wider markets. This approach of adopting GSCM practices is in line with the DIT (specifically with the part related to the eco-innovation leader/disruptive innovation) and its diffusion across the ecosystem (EMT) as described in the model proposed by this thesis.

Driver: Imitation oriented/followers as competitive advantage (Mimetic)

GSCM practices/innovations are being adopted lately as means of practice imitation (Govindan et al., 2015; Tian et al., 2014; Zhu & Geng, 2013; Dornfield et al., 2013; Zhu et al., 2012;Zhu & Liu, 2010; Testa & Iraldo, 2010; Liu & Buck, 2007). However there is a significant research gap in terms of analysing imitability in GSCM adoption (Zhu et al., 2012; Carter & Rogers, 2008; Steensma & Corley, 2000). Mimetic drivers are perceived as a good approach towards motivating GSCM practice adoption, however a cross-stakeholder (quintuple helix) experience is required to ensure the imitation of the eco-innovation (Ivanaj et al., 2015; Zhu & Geng, 2013; Zhu et al., 2012; Zhu & Liu, 2010). This approach of adopting GSCM practices is in line with the DIT (specifically with the part related to the eco-innovation leader/disruptive innovation) and its diffusion across the ecosystem (EMT) as described in the model proposed by this thesis.

Driver: Policy compliance (Normative):

Policy compliance (as well as any other exogenous pressure) is also key drivers of GSCM (Govindan et al., 2015; Drohomeretsk et al., 2014; Lee & Kim, 2011; Mann et al., 2010). Similarly, other drivers come in form of stimulators and regulatory frameworks such as RoHS, ISO14001 (Nawrocka, 2008; Curkovic & Sroufe, 2011), NGOs (Argenti, 2004), and all the additional factors discussed in the previous section. Overall, policies are of core importance to ensure the implementation of policies related to GSCM practice adoption, however this does not guarantee the adoption of long-term sustainable behaviour in the business models of stakeholders as well as within the social behaviours – as long as proper co-evolution among all the involved stakeholders is not performed (Zhu & Geng, 2013; Zhu et al., 2012; Connel, 2010; Zhang et al., 2008; Frondel et al., 2008). This normative adoption of GSCM practices is fully in line with the ST and INT theories incorporated into the model of this thesis.

- **GSCM drivers category 1: businesses implement GSCM practices at the institutional level based on their inner motivations to become more efficient (financial, environmental, operational).**
- **GSCM drivers category 2: businesses implement GSCM practices at the institutional level as a coercive pressure from society/stakeholders (quintuple helix) and promote their brand as environmentally sustainable**
- **GSCM drivers category 3: businesses implement GSCM practices at the institutional level based on their inner motivation to innovate and modernize (leading the way for others in the ecosystem to follow).**
- **GSCM drivers category 4: businesses implement GSCM practices at the institutional level based on their mimetic drive to follow innovators from their microsystem.**
- **GSCM drivers category 5: businesses implement GSCM practices at the institutional level based on their normative drive to comply to regulations.**
- **Co-evolution and co-creation among the quintuple helix stakeholders is the key to ensure GSCM practice implementation at the mesosystem level.**

Findings box 8: GSCM drivers

Despite the persistence of such drivers and coercive means, the literature provides considerable barriers that hinder the process of GSCM adoption. These barriers have been summarized in Table 3:

Table 3: Summary of the barriers to GSCM implementation

Barrier to GSCM implementation (includes RGFT & RGSCM)	Source
Internal: Organizational culture	(Govindan et al., 2015; Ivanaj et al., 2015; Zaabi et al., 2013; Diabat & Govindan, 2011; Vuro et al.,

	2009; Mont & Leire, 2009; Hanna et al., 2000)
Internal: Top management support	(Govindan et al., 2015; Zaabi et al., 2013; Hoejmose et al., 2012; Balasubramanian, 2012; Diabat & Govindan, 2011; Vuro et al., 2009; D'Amato & Roome, 2009; Sarkis, 2009; Ravi & Shanker, 2005)
Internal + External: Employee/Stakeholder commitment, motivation, training and skills, information	(Govindan et al., 2015 Zaabi et al., 2013; Drohomeretsk et al., 2014; Balasubramanian, 2012; Diabat & Govindan, 2011; Sarkis et al., 2010; Soler et al., 2010; Vuro et al., 2009; del Brio et al., 2008; Yu & Hui, 2008; Walker & Preuss, 2008)
External: Proper environmental regulations and stakeholder communication means	(Govindan et al., 2015; Drohomeretsk et al., 2014;Zaabi et al., 2013; Balasubramaniam, 2012; Diabat & Govindan, 2011; Vuro et al., 2009; Andersen & Larsen, 2009; Walker et al., 2008; Lee, 2008)
Internal + External: Resistance to change (internal restructure), co-creation, heterogeneity issues	(Govindan et al., 2015; Ivanaj et al., 2015; Zaabi et al., 2013; Balasubramaniam, 2012; Diabat & Govindan, 2011; Vachon & Klassen, 2008; Sharfman et al., 2007; Verghese & Lewis, 2007; Hick, 2000)
Internal: Financial resources and lack of perceived benefit	(Govindan et al., 2015; Drohomeretsk et al., 2014; Zaabi et al., 2013; Diabat & Govindan, 2011; Connell, 2010; Alkhidir & Zailani, 2009; Walker et al., 2008; Presley et al., 2007; van Hemel & Cramer, 2002)
External: Uncertainty of GSCM practice development/direction globally	(Ivanaj et al., 2015; Schotter & Goodsite, 2013)

Finally, the core element sustained by the literature related to overcoming such barriers to GSCM practice implementation resides in the analysis of the co-creation among the (business partners, societal organizations - quintuple helix) stakeholders towards co-evolvement/co-modernization (Dubey et al., 2015; Ivanaj et al., 2015; Govindan et al., 2015; Tian et al., 2014;

Gobbo et al., 2014; Chakrabarty & Wang, 2013; Zhu & Geng, 2013; Zaabi et al., 2013; Zhu et al., 2012; Test & Iraldo, 2010; Holt & Ghobadian, 2009; Mont & Leire, 2009; Andersen & Larsen, 2009; Vachon & Klassen, 2008; Walker et al., 2008; Sharfman et al., 2007; Verghese & Lewis, 2007; Vachon, 2007; Hall, 2006; Vachon & Classen, 2006; Banerjee et al., 2003). Even more, Ivanaj et al. (2015) identify core research gaps in terms of the need of further investigation of the role of environmental practices on behaviours and social governance methods (Leventon et al., 2015), role of non-governmental actors (Diabat et al., 2014) with a truly cross-stakeholder and inter-disciplinary approach (Shrivastava et al., 2013).

As it can be seen, the heterogeneous, uncertain and in constant change/adaptation ecosystem for GSCM practice implementation (which is in line with the CAST influences of this thesis' model) requires proper and coordinated co-creation among the quintuple helix actors towards ensuring co-evolvement through eco-innovation (EMT) diffusion (DIT) from institutions to ecosystem and the opposite (INT, ST). Findings box 9 and Figure 13 display these facts.

Findings box 2.3.1.2.2:

- **GSCM barriers category 1 – Internal: organizational culture, top management support, financial resources, sustainability mentality.**
- **GSCM barriers category 2 – Internal & External: Employee/stakeholder motivation and commitment to the joint mission, flexibility and resistance to change, co-creation and collaboration abilities, managing heterogeneity, access to proper information, training and skills.**
- **GSCM barriers category 3 – External: uncertainty of GSCM practice advancements globally, proper policies and effective co-creation directives.**
- **Overcoming the GSCM implementation barriers resembles a system in full coherence with the model proposed by this thesis.**

Findings box 9: GSCM barriers

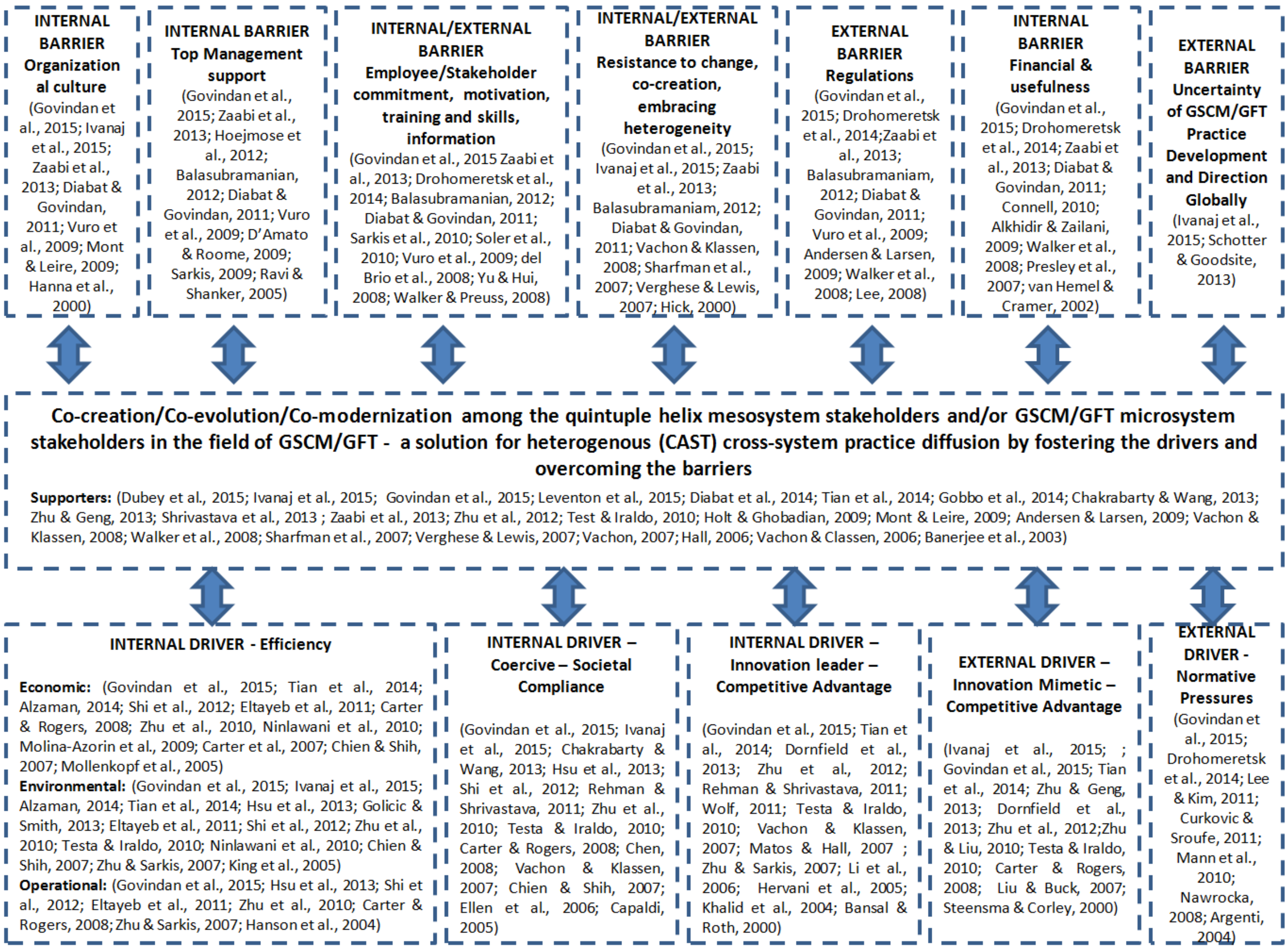

Figure 13: Overview on drivers & barriers to GSCM implementation

2.3.1.3 Answering RH7 and RH10: Support from GSCM/GFT stakeholders during green decision making and homogeneity of stakeholders' GSCM/GFT KPIs

Performance measurement is a key aspect in ensuring the effectiveness of SCM strategies throughout all operational layers (including freight transportation) and the literature provides considerable insight into this matter (Bhattacharya et al., 2014; Yang, 2012; Bhagwat & Sharma, 2009; Hoffman & Locker, 2009; Alfaro et al., 2007; Mettanen, 2005; Gunasekaran et al., 2004). Even more, converging to the global challenges in SCM, performance measurement has expanded to focus on GSCM by leveraging environmental and social responsibility as key business indicators (Bhattacharya et al., 2014; Green et al., 2014; Shen et al., 2013; Hsu et al., 2013; Taticchi et al., 2013; Hitchcock, 2012; Dei & Shefi, 2012; Bai et al., 2012; Shi et al., 2012; Olugu et al., 2010; Tsoulfas & Pappis, 2008, Rao & Holt, 2005; Hervani et al., 2005). However, a keypoint in GSCM performance measurement resides in Bhattacharya et al. (2014) citation:

- "*A good level of recognition is found amongst practitioners on the necessity for more knowledge on environmental performance across different actors in an SC* (Bjorklund et al., 2012)" which induces the need for co-creation within the GSCM/GFT microsystem and quintuple helix mesosystem (also in line with Hervani et al., 2005).

Even more, this argument is also in line with the work performed by Taticchi et al. (2013) which argue that;

- "*...while several reviews provide different perspectives on sustainability in supply chain management, few of them provide a performance measurement (PM) inter-organisational perspective involving the key supply chain stakeholders.*" (Taticchi et al., 2013; Hervani et al., 2005) which leads towards the need to foster co-creation, practice diffusion (EMT, DIT) and monitoring at least at a microsystem level, with a core gap in terms of relating this performance to the quintuple helix mesosystem (as it will be shown later on).

In the same manner, an earlier work that criticises the effectiveness of traditional SCM/GSCM performance measurement methods (balanced scorecard, SCOR model, performance prism

(Cagnazzo et al., 2009; Shepperd & Gunter, 2005; Neely et al., 2002)) argues that such performance measurement systems promote:

- "*lack of systems thinking*" – in the struggle to focus only on institutional level performance (Hartman & Moeller, 2014; Taticchi et al., 2013; Shepherd & Gunter, 2010) aspect which does not enable to grasp the actual performance of GSCM/GFT strategies at the microsystem and mesosystem levels and leads to significant gaps especially in terms of measuring the social impact of GSCM in true support and co-creation at the mesosystem level (Fahimnia et al, 2015; Tajbakhs & Hassini, 2015; Varsei et al., 2014; Taticchi et al., 2013; Hervani et al., 2005) – stressing thus the need to understand the transgression of eco-innovations (EMT) from institutional levels to (exo/meso/micro)system-levels as emphasized by the DIT, INT and ST.

Furthermore, following the work of Varsei et al (2014) which was taken forward by Fahimnia et al. (2015), measuring the impact of sustainability requires a paradigm shift:

- "*...where organisations see themselves at the forefront of sustainability coupled with appropriate measures from the political economy, public sector institutions and society as a whole (Banerjee, 2008)*". This is a clear evidence that co-creation at the quintuple helix mesosystem can provide the necessary framework for true GSCM practice diffusion within the GSCM/GFT microsystem.

Finally, the following statement of Varsei et al. (2014) which is in line with (Seuring, 2013; Winter & Knemeyer, 2013; Tang et al., 2008):

- "*It is essential for supply chains to consider who their stakeholders are and the interrelationships between supply chain members, resources, activities and interfaces comprising coordination, interaction, cooperation and competition. These may include internal stakeholders such as shareholders, employees and trade unions and external stakeholders such as customers, suppliers and other partners, competitors, government and regulators, NGOs and interest groups, and local and international communities (Bendell, 2003)* " add up more credibility to this thesis' model composed of integrated system. More specifically, the coordination/cooperation/co-creation mention of the authors resemble the CAST based RGSCM/RGFT microsystem which is integrated within the multi-stakeholder quintuple helix mesosytem where eco-innovation (EMT) should be diffused (DIT) from institutional level to (exo/meso/micro)system-level.

The systematic review shows a clear interest in GSCM performance measurement at more than just the institutional level by encompassing quintuple helix stakeholders in this process, however there is no specific evidence that a clear direction is taken for this purpose (apart from the later studies of Fahimnia et al. (2015) and Varsei et al. (2014)) but without a clear differentiation of the involved systems. The key characteristic of the literature mentioned above resides in scattered mentioning and isolated inclusions of various quintuple helix stakeholders in assessing the environmental and social performance of GSCM practices (besides the economic ones). For this purpose, a specific systematic analysis has been performed in terms of identifying what the literature proposes in relation to KPIs used to monitor GSCM performance and the results show that such indicators are more than just institutional (economic) related as they encompass measurements related to each quintuple helix stakeholder (either by coercive, inner or normative means).

However, despite of the already existence of these indicators, there is no structured and integrative approach taken to analyze how they can comprise a full working mesosystem (and microsystem) in order to assess the impact of GSCM implementation at wider levels. In order to guide the systematic review towards building upon the proposed model of this thesis, the KPIs have been grouped according to the contextual system and stakeholder to which they belong. The indicators are comprised from the work of: (Baumgartner et al., 2015; Piotrowicz, W., & Cuthbertson, 2015; Bhattacharya et al., 2014; Varsei et al., 2014; Ahi & Searcy, 2015a; Ahi & Searcy, 2015b; Gopal & Thakkar, 2012; Ninlawani et al., 2010; Shang et al., 2010; Aragon-Correa et al., 2008; Zhu et al., 2007; Vachon and Klassen, 2006; Hervani et al., 2005; Gonzalez-Benito, 2005; Rao and Holt, 2005; Zhu and Sarkis, 2004). Figure 14 displays these findings by showing the institutional level KPIs and the literature claim of making these KPIs measured at the mesosystem level.

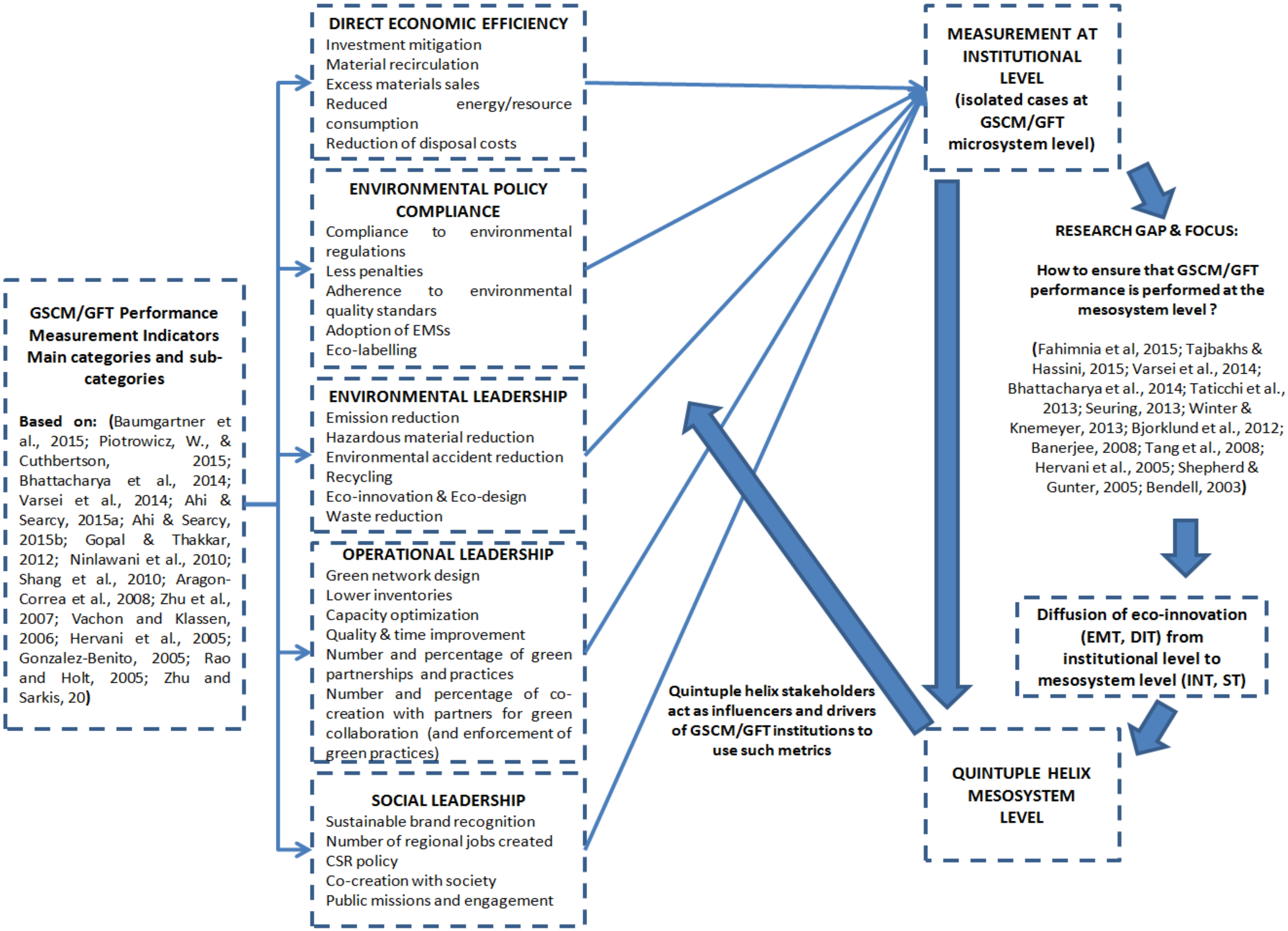

Figure 14: GSCM/GFT KPIs integrated with drivers/pressures and mesosystem leverage

2.3.1.4 Summary for RH4, RH5, RH7, RH9 and RH10 systematic analysis

This section provided a systematic overview on GSCM challenges tailored around five of the twelve research hypotheses(inquiries) which were devised in order to explore the theoretical framework proposed by this thesis. A brief summary for each of the five RHs is provided below as well as the interrelation between the systematic analysis of these five RHs and the theoretical framework. The results of this exploration are:

RH4 and RH9: *Understand to which extent do businesses implement green practices during their decision making processes and understand to what extent to businesses respond to ecosystem pressures in order to implement GSCM/RGFT practices.*

GSCM practices are implemented at the institutional level, however, performance reporting is being done at the Quintuple Helix Mesosystem level. This is in line with the EMT based explanations for eco-innovation diffusion, however there is a gap related to the diffusion of practices from the institutional level to the micro and mesosystem which means that there is at least one category of eco-innovations that are implemented due to coercive and normative measures imposed by the quintuple helix mesosystem.

Institutional GSCM practice implementation monitoring is done based on key controlled processes with stakeholder heterogeneity and lack of coordination issues when it comes to compatibility of green practice impact measurement at the microsystem level (and then at the mesosystem level. This is aspect is coherent with EMT & DIT influenced eco-innovation diffusion in CAST based systems.

Quintuple helix regulations (i.e. ISO14031) and performance measurements frameworks for GSCM practice diffusion from institutions to systems imply co-creation and diffusion of eco-innovations at the cross-systems level which encompass all five theories (EMT, DIT, CAST, INT, ST) on which this thesis' theoretical framework is based.

The position of an institution within the GSCM/GFT microsystem as well as inner resource capacities influence (further explained by the INT) the adoption of quintuple helix mesosystem imposed eco-innovations (further explained by the ST). This links with the CAST concepts where the position of an institution plays a key role in the self-adaptation/eco-resilience process (the adoption of eco-innovation during the resilience process).

Co-creation within the GSCM/GFT microsystem towards eco-innovation implementation leads to: balanced eco-modernization of all stakeholders (with spillovers to the quintuple helix mesosystem as explained by the EMT and the DIT). Furthermore, the modernization process imposes co-creation, partnerships, knowledge flows which form strong networks that self-adapt, providing thus an enhanced environment for a potential self-adaptation in case of disruptions (as explained by the CAST in relation to RGSCM/RGFT). Finally, the ST and INT explain how localized institutions aim to implement the quintuple helix eco-directives, however, such implementation imposes the co-creation which leads to more eco-modernization as explained by the EMT.

RH5: *Understand what drivers and barriers do businesses face when aiming to adopt/implement green practices*

The systematic review reveals several categories of drivers and barriers which have been grouped in a manner that enables to better guide the review towards the theoretical framework of this thesis:

GSCM drivers category 1: businesses implement GSCM practices at the institutional level based on their inner motivations to become more efficient (financial, environmental, operational) – in true conformance with the INT, however there is no evidence of how such institutionalized eco-innovations are diffused at the micro and mesosystem level.

GSCM drivers category 2: businesses implement GSCM practices at the institutional level as a coercive pressure from society/stakeholders (quintuple helix) and promote their brand as environmentally sustainable – in true conformance with the ST, however there is no coordinated manner to measure this implementation at the mesosystem level.

GSCM drivers category 3: businesses implement GSCM practices at the institutional level based on their inner motivation to innovate and modernize (leading the way for others in the ecosystem to follow) – in true conformance with the EMT and DIT, however there is no evidence of intentional co-creation of GSCM stakeholders at a wider level that the microsystem level.

GSCM drivers category 4: businesses implement GSCM practices at the institutional level based on their mimetic drive to follow innovators from their microsystem – in true conformance with the EMT and DIT, however there is no evidence to support the presence of a mediator that will ensure proper adherence to all goals (social, economic, environmental) when adopting a mimetic approach.

GSCM drivers category 5: businesses implement GSCM practices at the institutional level based on their normative drive to comply to regulations – in true conformance with the ST, however there is no coordinated manner to measure this implementation at the mesosystem level.

GSCM practice implementation barriers have been grouped in three main clusters:
GSCM barriers category 1 – Internal: organizational culture, top management support, financial resources, sustainability mentality (mostly institutionally related). GSCM barriers category 2 – Internal & External: Employee/stakeholder motivation and commitment to the joint mission, flexibility and resistance to change, co-creation and collaboration abilities, managing heterogeneity, access to proper information, training and skills. GSCM barriers category 3 – External: uncertainty of GSCM practice advancements globally, proper policies and effective co-creation directives.

Overcoming the GSCM implementation barriers and taking advantage of the drivers can be done only with proper co-creation at the mesosystem level in order to understand how institutional eco-innovations are leveraged at the micro and mesosystem levels (major research gap). The systematic literature denotes that institutions do not have a benevolent approach towards acting at the mesosystem level, unless they are coerced to do so. It is important to understand the reasons why institutions do not intent to have this co-creation which is required to fully grasp the impact of GSCM/GFT practices at the mesosystem level.

RH7 and RH10: *Understand how (to what extent) businesses interact with the GSCM/RGFT stakeholders and understand how do the GSCM/GFT KPIs of businesses match with the ones of the involved mesosystem's stakeholders.*

The systematic review shows a clear interest in GSCM performance measurement at more than just the institutional level by encompassing quintuple helix stakeholders in this process, however there is no specific evidence that a clear direction is taken for this purpose (as the previous findings suggested) which confirms that institutions respond to normative and coercive practices. This suggests that the ST explains how such conformance takes place, however this does not explain how EMT base innovations take place and get diffused (DIT) at the micro and mesosystem level.

For this purpose, a specific systematic analysis has been performed in terms of identifying what the literature proposes in relation to KPIs used to monitor GSCM performance and the results show that such indicators are more than just institutional (economic) related as they encompass measurements related to each quintuple helix stakeholder (either by coercive, inner or normative means). The key characteristic of the literature mentioned above resides in scattered mentioning and isolated inclusions of various quintuple helix stakeholders in assessing the environmental and social performance of GSCM practices (besides the economic ones). This aspects confirms the fact that there is no stringent approach from the institutional level practices (INT) to transcend to the micro and mesosystem level, and even more, the coercive and normative pressures are not strict enough to support eco-innovation implementation at wide scales than the institutional level (i.e. this also confirms the lack of co-creation status among the GSCM stakeholders).

However, despite of the already existence of these indicators, there is no structured and integrative approach taken to analyze how they can comprise a full working mesosystem (and microsystem) in order to assess the impact of GSCM implementation at wider levels and there is a core literature strand that advocates for this leveraged approach (from GSCM institutional level to mesosystem level) – in full coherence with the theoretical framework of this thesis.

Overall (as it can be seen on the image from the next page), the research hypotheses explored (RH4, RH5, RH7, RH9, RH10) through the systematic review in this section respond either fully or partially to the converged research questions (CRQs), theoretical framework pillars and research objectives (OBs). For example:

- RH4 and RH9 confirm the gap described in CRQ1 and provide partial responses to CRQ2 and CRQ4. In similar manner, RH4 and RH9 fully sustain Pillar 2 and partially, Pillar 3 and Pillar 5, while providing full insight into OB2.3.
- RH7 and RH10 provide partial response to CRQ3, gap confirmation for Pillar 4 and partial solution to Pillar 2, full insight into OB2.2 and OB2.6 and partial insight into OB3.1, OB3.2, OB3.3 and OB3.4
- RH5 provides partial response to CRQ3, gap confirmation for Pillar 4, and full insight into OB2.4.

Finally, it is important to mention that the "partial solutions/confirmations" are leveraged to "fully" (in most cases) in the next sections which discuss resilience, disruptions and RGFT in more specific terms. Figure 15 displays these findings by showing to what extent the literature review on the involved RHs respond to the need posed by the CRQs, OBs and TFT Pillars.

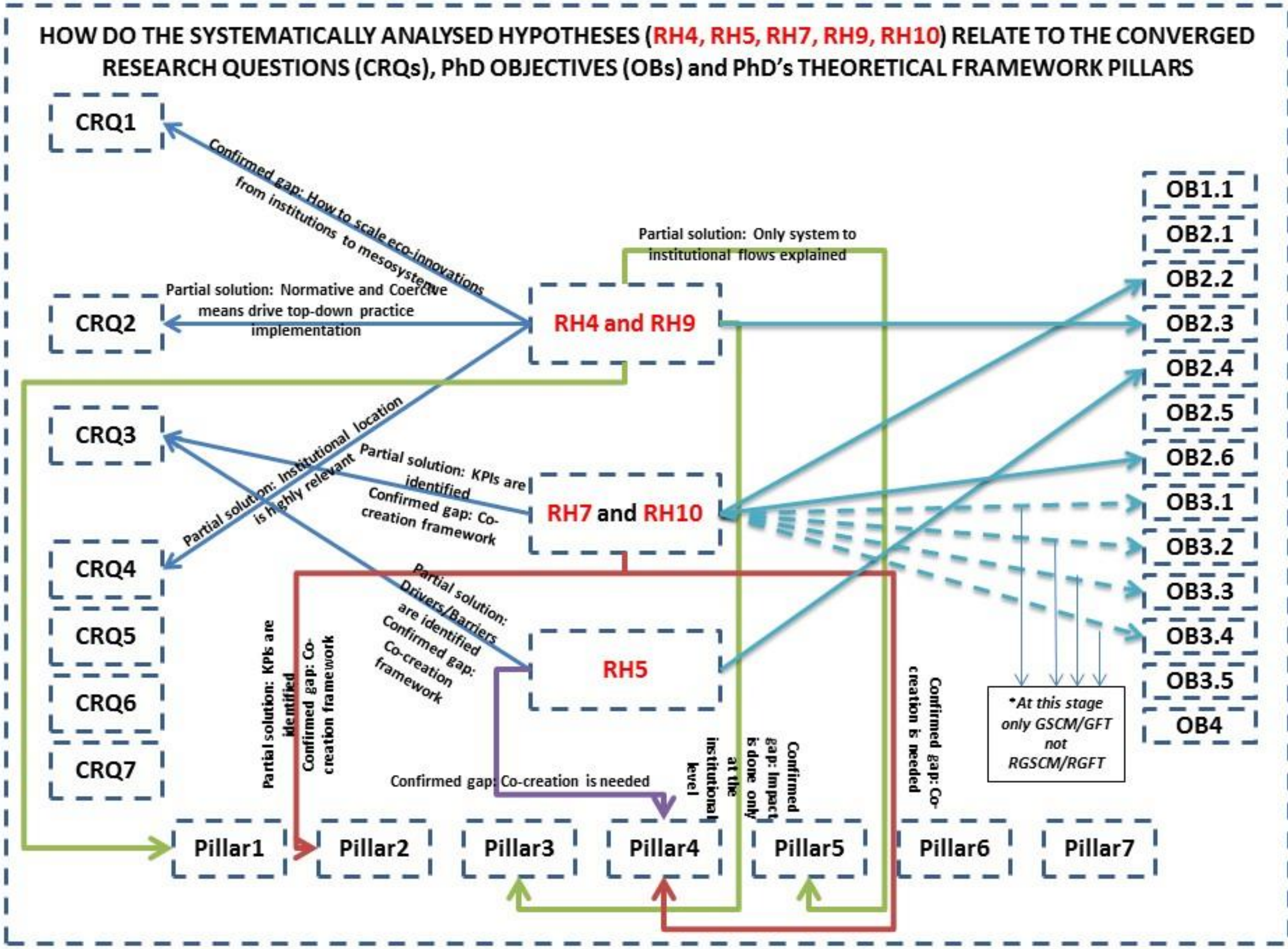

Figure 15: Impact of RH4, RH9, RH7, RH10 and RH6 outcomes on CRQs, OBs and TFT Pillars

2.3.2 From supply chain uncertainty and vulnerability to RGFT

2.3.2.1 Introduction to supply chain resilience

The increased competitive pressure in a stagnating and globalized market has led to the design of more efficient supply chains and logistical infrastructures. Since logistics are vulnerable towards many types of risks (Kumar et al., 2010) that increase exponentially in a globalising (Johnson, 2006) and knowledge based economy, dealing with large amount of information available for taking the right decisions has become a real challenge (Kamalahmadi & Parast, 2016; Fiksel et al., 2015; Melnyk et al., 2014). Decreased stocks, longer transports and increased dependency from fewer suppliers have led to an increased vulnerability of global logistics infrastructures. Local disruptions e.g. from disasters, terrorism or simply the failure of a supplier can have multiple consequences for a company and its customers all over the world. Apart from these, the environmental instability creates unpredictable disasters (WEF, 2013). The actual negative outcomes of such disruptions could be: environmental damage, loss of profit, late deliveries, client dissatisfaction, temporary stop of production, damage to business's reputation and decrease of shareholder's value (Ambulkar et al., 2015; Kim et al., 2015; Krause et al., 2014; WEF, 2013; Solomon et al., 2012; Holguin-Veras et al., 2012).

Furthermore, another factor that triggers disruptions in nowadays logistical operational environment is uncertainty and also poorer process visibility (Bode & Wagner, 2006), increasing thus the list of potential issues, especially if these two factors coupled with complexity can lead towards chaos if excessive reactions (i.e. resource consumption, inefficient routes), second time guessing, mistrust and inaccurate information within the supply chain are being performed (Solomon et al., 2012).

In scientific terms, logistics uncertainty refers to any deviation that prohibits the planned goals to be reached (Walker et al., 2003). By operating in the global market (Kamalahmadi & Parast, 2016; Fiksel et al., 2015; Melnyk et al., 2014; Arnold et al., 2012 and Buhman et al., 2005), enterprises face the challenge of forming longer (global) supply chains in order to grow and to reduce expenses. This challenge though, increases the risk and disruption occurrence rate and the need for proper solution mechanisms (Shah, 2006 and Datta & Christopher, 2011).

- As a proof, according to (Delloite, 2012) 85% of the supply chains encountered a critical disruption over their last 12 months.

- **Disruptions are an imminent and certain aspect of globalized and complex SCM/FT with clear impact on the environment → CAST**
- **Uncertainty and lack of visibility in the complex SCM/FT system are amplifying the disruptions with impact on the environment → CAST**

Findings box 10: Disruptions and SCM/FT

Thus, counteracting these issues is critical especially since the impact of these disruptions on the logistical sector is harsh. The literature provides a very consistent research focus on supply chain disruptions. For example, Datta & Christopher, (2011) investigated several uncertainty sources: local versus global goals, information sharing resistance, demand/supply sources, natural disasters, societal events. Consequently, Wang et al., (2006) argue that a source of uncertainty in supply chains is demand volatility (bullwhip effect) which is caused by responses to demand forecasting, order batching, price fluctuations and shortage management. Another reviewed source of uncertainty by the authors is perceived to be clock-speed amplification which describes the situation where manufacturers meet price decline and shorter product lifecycle by the end of the supply chain. All these elements have become known as supply chain risks.

To address uncertainty, Datta & Christopher, (2011) reviewed four main interconnected solutions: flexibility (respond to multiple real time changes (Rice & Caniato, 2003), agility (respond quicker to changes (Faisal et al., 2006)), supply chain information structure (Craighead et al., 2007) and integration (synchronization of multiple business entities (also in line with Kamalahmadi & Parast, 2016; Fiksel et al., 2015; Melnyk et al., 2014; Omar et al., 2012)). Addressing/Mitigating uncertainty and disruptions risks from within the supply chain falls into the category of supply chain resilience which becomes a critical topic for green freight transportation especially since this sector is more prone to direct and unpredictable disruptions as it will be explained later on.

Overcoming threats in an uncertain and vulnerable environment is not always possible. To this end, enterprises have recognized the importance of supply chain resilience which has become a central theme in SCM and implicitly in the logistical sector (Bakshi & Kleindorfer, 2008).

- In order to strengthen this argument, according to (WEF, 2013) 80% of companies are concerned with supply chain resilience.

- **Economic aspects, environmental sources, societal events cause disruptions in SCM/FT → Quintuple Helix Mesosystem**
- **Flexibility, agility, integration are critical to achieve resilience → CAST**

Findings box 11: SCM/FT and the quintuple helix under resilience

Generally, supply chain resilience refers to the ability of a supply chain to return to its normal operating mode or to a more efficient state after a disruption took place (Kamalahmadi & Parast, 2016; Fiksel et al., 2015; Melnyk et al., 2014; Christopher & Peck, 2004). In this context supply chain resilience becomes critical (Mandal, 2012). In the view of (Delloite, 2012), a resilient supply chain should have four main pillars: visibility, flexibility, collaboration/co-creation and control (based on key processes), all these support by three elements: people/society, process and ICT for decision support.

On a different approach, according to (Rowbottom et al., 2011), supply chain resilience can be achieved through the following elements: supplier risk management, flow management and demand forecasting. Petit et al., 2010 reviewed several other stages of implementing supply chain resilience: process re-engineering (modernization), information sharing (co-creation), agility and culture of risk management. Furthermore, supply chain resilience achieves maximum capacity when technology is used (Setia & Paterl, 2013; Mandal, 2012 and Dynes et al., 2007).

Mandal, (2012) identified a debate between the concepts of robustness and resilience in supply chains. While robustness employs the lean concept, resilience employs risk management (Juttner & Maklan, 2011; Christopher & Peck, 2004). Finally, supply chain resilience has its roots in risk management (Craighead et al., 2007 and Peck, 2005). Nevertheless, according to (Pettit et al., 2010), resilience differs from traditional risk management which operates as a continuous cycle of identification, assessment, analysis of potential solutions and of finding solutions. Supply chain resilience upgrades risk management by enabling long term forecasting mechanisms which enable supply chains to deal with uncertainty/vulnerability. Thus, enabling resilience in green freight transportation also requires a clear understanding of what are the potential risks and practices that this sector faces.

- **SCM/FT resilience is based on collaboration (co-creation) flexibility, agility, adaptability and controlled processes → CAST, in which the "people" element (including society) plays a crucial role → Quintuple helix mesosystem**
- **Resilience promotes long-term development through process re-engineering (modernization) and information sharing → EMT, CAST, DIT**

Findings box 12: SCM/FT and resilience based on co-creation

2.3.2.2 Introduction to resilient and green freight transportation

With 23% of global carbon-dioxide emissions originating from the transportation industry, it is imperative that significant emphasis and effort be squarely put in controlling its environmental impact (rather than on other sub-divisions of SCM). Globally, more than 8 billion tons of freight moves in international transportation (BTS, 2010) and it continues to grow. More specifically, freight transportation refers to:

- Freight transportation: the process of moving goods from raw materials to finished ones as well as waste, by relying on the public transportation infrastructures and involving multiple transportation means (Transport Research, 2009).

Moving freight creates traffic congestion, air pollution, noise and consumes fuel. Growing trade and intense pressure to reduce cost place immense pressure is causing rapid deterioration of the transportation infrastructure. Table 4 shows several key data about freight transportation in Europe summarized from (Transport Research, 2009).

Table 4: Freight transportation facts

Item	Fact
Total freight movement in EU	2650 billion tonnes-kilometres.
Road transport	72,7%
Rail transport	17,1%
Water transport	4,9%
Average annual growth rate of freight transportation in the EU	2,7%

Without a central focus on improving the transportation microsystem, the environmental impact of this outdated system will have serious and irreversible consequences. To this end, Demir et al. (2013) reviewed a large number of green road freight transportation studies and reached the following main conclusion relevant for this research:

> Most of the existing studies in the green road freight transportation sector have focused mostly on vehicle load and speed optimisation, disregarding congestion and other disruptions that may appear (i.e. environmental disruptions).

Another relevant finding which drives this research was performed by Huang et al. 2011 which states that:

> In the absence of proper solutions in the literature, it is important to investigate how to deal in real time with disruptions in freight transportation and how to adapt automatically while maintaining rationality and efficiency (both economic and environmental).

Furthermore, (Beuthe et al., 2002) argues that:

> Road freight transportation is a core polluting sector which is also prone to most of the risks, disasters and disruptions and since road freight transportation predominates (72,7% of EUs freight transportation for example), these issues become even more significant and need addressing.

- **SCM/FT resilience is based on collaboration (co-creation) flexibility, agility, adaptability and controlled processes → CAST, in which the "people" element (including society) plays a crucial role → Quintuple helix mesosystem**
- **Resilience promotes long-term development through process re-engineering (modernization) and information sharing → EMT, CAST, DIT**

Findings box 13: SCM/FT and CAST based resilience under EMT and DIT

These statements do not infer that the focus should be set only on road freight transportation, rather they mean that the proposed solutions should focus more on road freight transportation which is more prone to disruptions while also considering other modes such as rail and water transportation as alternative solutions to mitigate such disruptions. Thus one of the aims of nowadays' research should be to determine innovative solutions for increasing the efficiency and sustainability of the freight transportation during disruptions in order to enable resilience in an environmentally sustainable manner.

Even more, transportation is a critical part of the EU economy (David & Fistung, 2011; Caragin, et al. 2000), accounting for around 7% of EU's GDP and for 5% of the European job market. Up to now, there have been many approaches in the field of GFT. The research debate and also the EU funded initiative prove the importance of the GFT sector. As a proof, Table 5 presents several core GFT related projects and case studies.

Table 5: Freight transportation projects

Project/Case study	Description
Cargo Domino	Sustainable logistics through short intermodal freight transportation. (Cargo Domino EU Project, 2013)
StoraEnso	Intermodal system for paper reel and pallet loading. (StoraEnso Project, 2013)
Rail4Chem	Scheduling block trains through a hub system. (Rail4Chem EU Project, 2013)

Distrivaart	Innovative pallet level solution. (Distrivaart EU Project, 2013)
GIFTS	ICT for sustainable intermodal freight transportation. (GIFTS EU Project, 2013)
INTERFACE	More optimized border crossing procedures for freight transportation. (INTERFACE Project, 2013)
IMONODE	Match priorities for intermodal nodes development with existing and possible transport chains based on the transportation industry tendencies. (Aifadopoulou, 2004)
SMARTFREIGHT	ICT solutions for freight transportation. (SMARTFREIGHT Project, 2013)
i-CARGO	Intelligent cargo in efficient and sustainable global logistics operations. (i-CARGO Project, 2013)
ADVANCE-LOGISTICS	Advanced predictive analysis based decision support engine for logistics. (ADVANCE-LOGISTICS Project, 2013)
CASAGRAS	ICT based track and trace and standardisation. (CASAGRAS Project, 2013)
EURIDICE	Intelligent cargo for efficient, safe and environmentally friendly logistics (EURIDICE Project, 2013)
L4LIFE	Long term ICT based freight transportation efficiency (L4LIFE Project, 2013)
Other ICT Based GFT projects and case studies	(SUPERGREEN EU Project, 2013), (SMARTFUSION EU Project, 2013), (SMART-CM EU Project, 2013), (COFRET EU Project, 2013), CREAM [59] and (Low Carbon Supply Chains Project, 2012)

For the upcoming period, the growing importance of freight transportation towards progressing to GFT is even more pressuring especially with the latest EU environmental regulations and target objectives concerning this sector. More specifically, two relevant EU guidelines for GFT are the TEN-T programme for a competitive and resource-efficient transport system (Euopean

Commission, 2012; Ionescu, 2012 and Lile & Csorba, 2010) and Horizon2020 (Horizon2020 , 2012) for smart, green and integrated transportation with a heavy reliance on technology to achieve better support in decision making as well as towards enabling RGFT.

With such growing demand and implicitly emissions, noticeable at a global scale also, transportation accounts for 26-28% of the global CO2 emissions (Schipper et al., 2011; Chapman, 2007). Complexity within transportation systems is a critical aspect that drives the negative outcomes of environmental sustainability (Richardson, 2005 and Himanen, Lee-Gosselin, & Perrels, 2005) and that interferes with the achievement of the triple bottom line (economic, environmental and social equity sustainability) especially during the strive to achieve resilience in an environmentally sustainable manner.

In order to properly and systematically address the issue of RGFT, the next section is tailored to provide a systematic insight into the following research hypotheses (inquiries) which will be presented, each, in the upcoming subsections:

> **RH6:** Understand what resilience mechanisms (related to GFT) do businesses implement and to what extent these mechanisms include environmentally sustainable practices
>
> **RH8:** Understand how can the GFT/GSCM resilience mechanisms of businesses be supported/fostered faster by other stakeholders from the ecosystem
>
> **RH11:** Understand the importance of business partnerships interconnectedness in terms of enabling fast RGFT.

2.3.2.3 Answering RH6, RH8 and RH11: Intersecting resilience and environmentally sustainable practices at the cornerstone of eco-resilience diffusion in an interconnected complex system

The literature contribution to analysing supply chain (and freight transportation network) resilience is indeed wide and well established, however there is a substantially limited amount of papers that discus the concept of environmentally friendly resilience. One of the most recent studies (systematic review) on supply chain resilience provided by Kamalahmadi & Parast (2016) argues that nowadays complex and interconnected supply chains are in need for effective resilience mechanisms more than ever, especially in a globalized environment where the multitude and wide scales of disruptions could cause severe damage (Fiksel et al., 2015; Melnyk et al., 2014). Other core (but isolated) studies argue that resilience in supply chain management includes partially environmental and societal elements and some focus on the vision that disruptions are sources of innovation (aspect which provides substantial insight towards sustaining the theoretical framework proposed by this thesis – i.e. to fit within the proposed quintuple helix mesosystem under the boundaries of EMT, CAST, INT, ST, DIT). The systematic categorization of the findings towards this thesis' theoretical framework fundamentals are:

(Partial or isolated relation to) environmental supply chain (and freight transportation) resilience (RGFT) and ecological ecosystem linkage with the social meso and micro systems when analysing sustainable and resilient development: (Kamalahmadi & Parast, 2016; Minsker et al., 2015; Petit et al., 2013; Manzini, 2013; Jansson, 2013; Ponomarov, 2012; Fiksel, 2003).The core advancement in this field is performed by Govindan et al. (2015) which discuss the paradigms of lean, green and resilient supply chains in an effort to fill the literature gaps towards overcoming isolated researches on these topics (Francis & White, 2016; Azevedo et al., 2013; Cabral et al., 2012; Carvalho et al., 2012; Carvalho et al., 2011; Hong et al., 2009; Rosic et al., 2009; Anand & Kodali, 2008; Glickman et al., 2006, Kainuma & Tawara, 2006). The authors (Govindan et al., 2015) position green and resilient supply chains under the core drivers of improving supply chain performance (during resilience mechanisms) while reducing material waste and improving resource efficiency/consumption. Even more, a recent study by Francis & White (2016) demonstrates that a green and resilient supply chain requires strong individual cultures of both environmental sustainability and resilience (in order to ensure proper integration) – which is also in line with Burnard & Bharma (2011). Furthermore, Gogelci & Ponomarov (2013) establish how the increased capacity of an institution to foster eco-innovations influences the ability to incorporate resilience which becomes a key argument towards relating EMT and DIT in a closer manner towards explaining eco-innovation adoption within CAST based systems from institutions to mesosystem level (with further insight from INT and ST).

Supply chain (and freight transportation) resilience as a complex adaptive system through transformation, co-creation, flexibility and forward looking behaviour

(Kamalahmadi & Parast, 2016; Nooraie & Parast, 2016; Mari et al., 2015; Rajesh & Ravi, 2015; Kim et al., 2015; Durach et al., 2015; Barosso et al., 2015; Perera et al., 2015; Mensah et al., 2015; Gilly et al., 2014; Kristianto et al., 2014; Scholten et al., 2014; Carvalho et al., 2012; Lengnick-Hall et al., 2011; Burnard & Bharma, 2011; Christopher & Peck, 2004). The literature suggest a clear gap of resiliency supply chain analysis in relation to CAST (Mari et al., 2015; Perera et al., 2015; Li et al., 2013; Zeballosa et al., 2012; Zhao et al., 2011) – strengthening thus the need for a more in-depth analysis of supply chain (and freight transportation resilience) within CAST frameworks.

Interconnectedness and co-creation/collaboration of stakeholders – including stakeholder sensitivity and co-evolution (Kamalahmadi & Parast, 2016; de Siqueira et al., 2015; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Blackhurst et al., 2011; Petit et al., 2010; Falasca et al., 2008; Craighead et al., 2007; Tang, 2006, Christopher, 2004) – in the sense that too much density increases complexity and disruptions' impact, while isolation may also lead to severe disruptions.

Disruptions as sources of innovation for supply chain – including (technological) innovation outburst/adoption (and freight transportation) resilience (Francis & White, 2016; Choudhury et al., 2015; Akgun & Keskin, 2014; Gogelci & Ponomarov, 2013; Demmer et al., 2011; Christopher & Hollweg, 2011; Pham et al., 2008; Reinmoeller & Van Baardwijk, 2005; Hamel & Valikangas, 2003) - strengthening the argument towards the reliance on the DIT, however there is limited and isolated debate specifically about eco-innovations towards the convergence of the EMT with DIT in the CAST based microsystem.

Diffusion of (eco) innovations: Considering the above, the literature shows clear positioning of supply chain (and freight transportation) institutional (or best case microsystem) resilience within the CAST framework with interconnected entities, however the debate on EMT influenced eco-innovations diffusion through DIT, INT and ST is still under-developed which explains the lack of proper adoption of environmentally friendly resilience strategies (and only focusing on either one or the other). In order to address such gaps, a core work performed by Smith & Stirling (2010) focuses on the diffusion of (technological) eco-innovations and the involved transformations within social systems during resilience mechanisms. The authors present pillars of systems transitions to foster eco-innovation diffusion during resilience mechanisms: development of a shared eco/meso/micro – system level environmental sustainability goal, path and co-evolution (learning) which thus, involves co-creation and collaboration (in line with: Kamalahmadi & Parast, 2016; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Van der Brugge & Van Raak, 2007; Quist, 2007; Sondejker et al., 2006). The main gap identified by the authors reside, as in the previous cases, in terms of who is the driver of co-creation at the mesosystem level (quintuple helix).

In a similar context, a previous researches performed by Donnellan et al (2007) and Antonelli (2006) analyse how (technological) innovations diffuse across the mesosystem (quintuple helix) in order to ensure resilience in a creative/innovative manner (in line with: Francis & White, 2016; Choudhury et al., 2015; Akgun & Keskin, 2014; Gogelci & Ponomarov, 2013; Demmer et al., 2011; Christopher & Hollweg, 2011; Atwell et al., 2008) at wider scales (however without direct any reference to ecological practices as the more recent studies are performing). A pioneering work related to the diffusion of eco-innovations within quintuple helix mesosystems was provided by Grove et al. (2015) – which argue that towards ensuring sustainability within such a mesosystem, co-creation, co-design and multilateral eco-knowledge flows among the involved stakeholders are critical (in line with: Kamalahmadi & Parast, 2016; de Siqueira et al., 2015; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Cornell et al., 2013; Mauser et al., 2013; Craglia et al., 2012; Mandal, 2012; Blackhurst et al., 2011; Petit et al., 2010; Falasca et al., 2008; Craighead et al., 2007; Tang, 2006, Christopher, 2004).

These findings clearly suggest that co-creation at the quintuple helix mesosystem is the key driver to RGFT (or any eco-innovation) practice diffusion across CAST microsystems which is deemed to explain based on DIT, EMT, INT and ST how eco-innovation practices scale-up from institutional level to ecosystem level, however there are little incentives towards empowering the EMT to influence RGFT with eco-innovations (Figure 16 provides an overview).

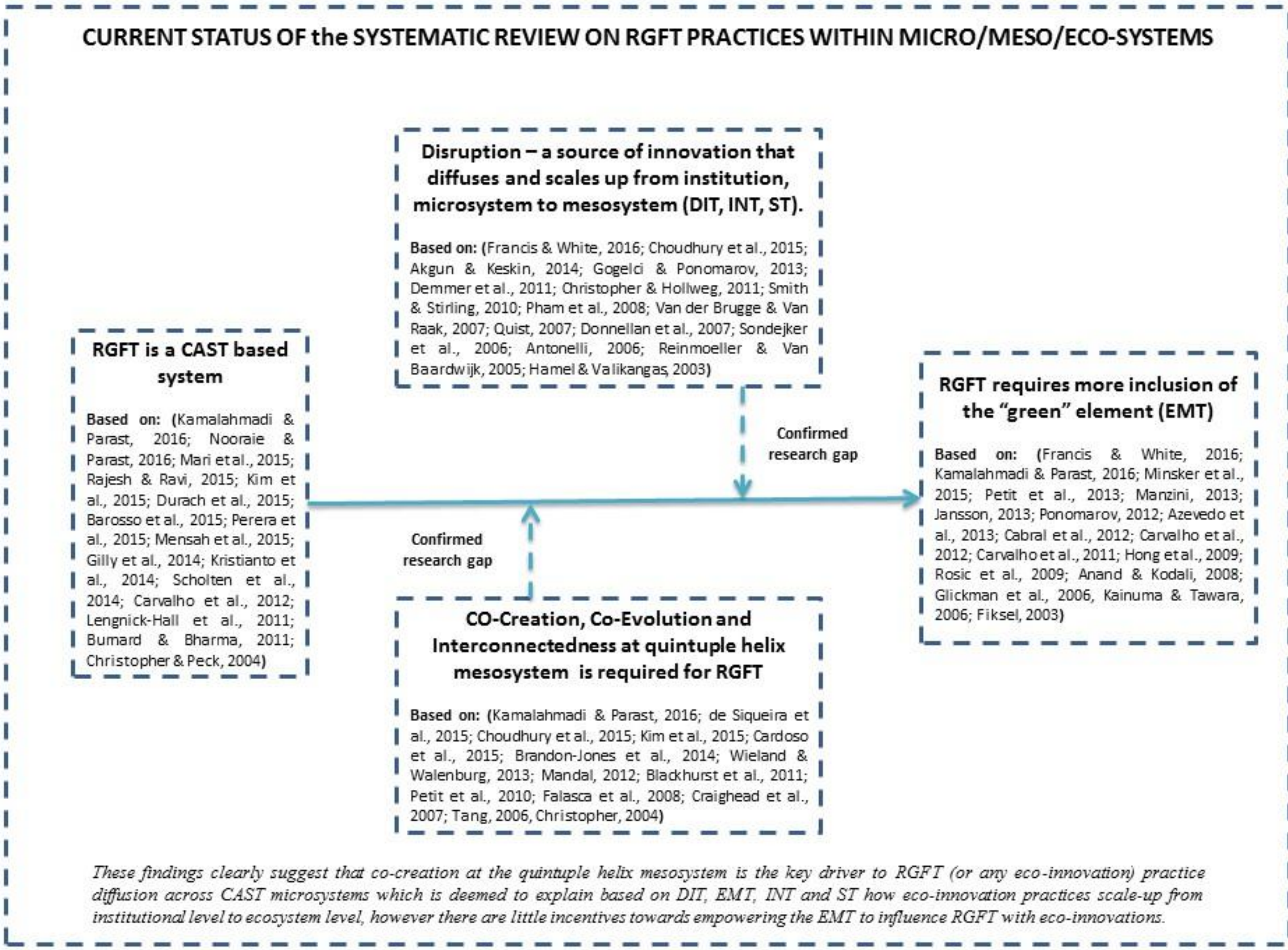

Figure 16: Systematic review status of the RGFT practices within micro/meso/eco-systems

2.3.2.5 Summary for RH6, RH8, and RH11 systematic analysis

Following the systematic analysis of RH6, RH8 and RH11, the following conclusions have emerged:

> **RH6:** *Understand what resilience mechanisms (related to GFT) do businesses implement and to what extent these mechanisms include environmentally sustainable practices*
>
> The results denote a clear segregation between resilience practice implementation and environmental sustainability practice implementation among institutions (supply chain and freight transportation) with very limited development in ensuring duality (both resilience and environmental sustainability). The very recent research efforts (2013-2016) suggest that further research is required in proposing solutions and models based on environmentally sustainable resilience mechanisms for supply chains (freight transportation) in order to ensure proper co-evolution at the mesosystem level.
>
> **RH8:** *Understand how can the GFT resilience mechanisms of businesses be supported/fostered faster by other stakeholders from the ecosystem*
>
> The majority of research focuses on analysing resilience in relation to CAST frameworks, however (as mentioned above) with substantial lack of including environmental concerns during the resilience (adaptation/transformation) processes of the RGFT microsystem. Even more, the literature promotes the need for enhanced co-creation at the mesosystem level in order for all the involved stakeholders to co-evolve, and exchange knowledge/information towards ensuring optimum resilience.
>
> **RH11:** *Understand the importance of business partnerships interconnectedness in terms of enabling fast RGFT.*
>
> The findings denote a clear need for co-creation in terms of innovation diffusion across the mesosystem towards enabling resilience in supply chain (freight transportation) microsystems. Even more, disruptions in microsystems are seen as key source of innovation/renewal for the entire mesosystem – however there is limited insight towards properly linking the EMT with DIT towards sustaining that there is similar behaviour for eco-innovations rather than for innovations related to general optimizations. Nevertheless, the findings support the CAST, INT and ST based influence in the

behaviour of scaling up institutional innovations to mesosystem level by ensuring proper network design at the microsystem level (optimized interconnectedness). Similarly as above, the clear research gap resides in frameworks that provide environmentally sustainable supply chain (freight transportation) microsystem resilience in true co-creation at the mesosystem level.

Overall, the systematic analysis sustains the targeted CRQs, the thesis's model's pillars and the thesis' OBs in the following manner:

RGFT practices are explained and sustained (RH6, CRQ3, Pillar 7, OB2.3, OB2.4, OB2.5) – however the core limitation resides in the lack of green practice inclusion during resilience decision making – as compared to GSCM practice adoption/implementation discussion. Thus there is a missing bridge between EMT, DIT, INT and ST in relation to RGFT implementation as compared to more generic GSCM practice implementation (where the influence of the EMT and DIT was truly confirmed as key drivers of eco-innovation).

RGFT practice adoption among the mesosystem/microsystem stakeholders is a confirmed gap especially in terms of eco-innovation diffusion and co-creation at the mesosystem level (RH11, CRQ4, Pillar 3, Pillar 4, Pillar 5, Pillar 6, OB3.4) towards ensuring proper co-evolution. There is a strong missing link both in terms of how DIT and EMT diffuse inner/institutional innovation across the mesosystem (as compared to GSCM practices where clear evidence of EMT and DIT influence was discovered) as well as in terms of how the INT and ST explain exogenous pressures towards RGFT practice adoption.

The RGFT microsystem reacts indeed as a CAST based system (RH8, CRQ1, CRQ3, CRQ7, Pillar 1, Pillar 2, Pillar 4, OB2.6, OB3.1) where interconnectedness among stakeholders should be balanced, however there is a clear segregation of the research in terms of ensuring environmentally sustainable and resilient supply chains (freight transportation) in parallel. All these are depicted in Figure 17 by showing to what extent the literature review on the involved RHs respond to the need posed by the CRQs, OBs and TFT Pillars.

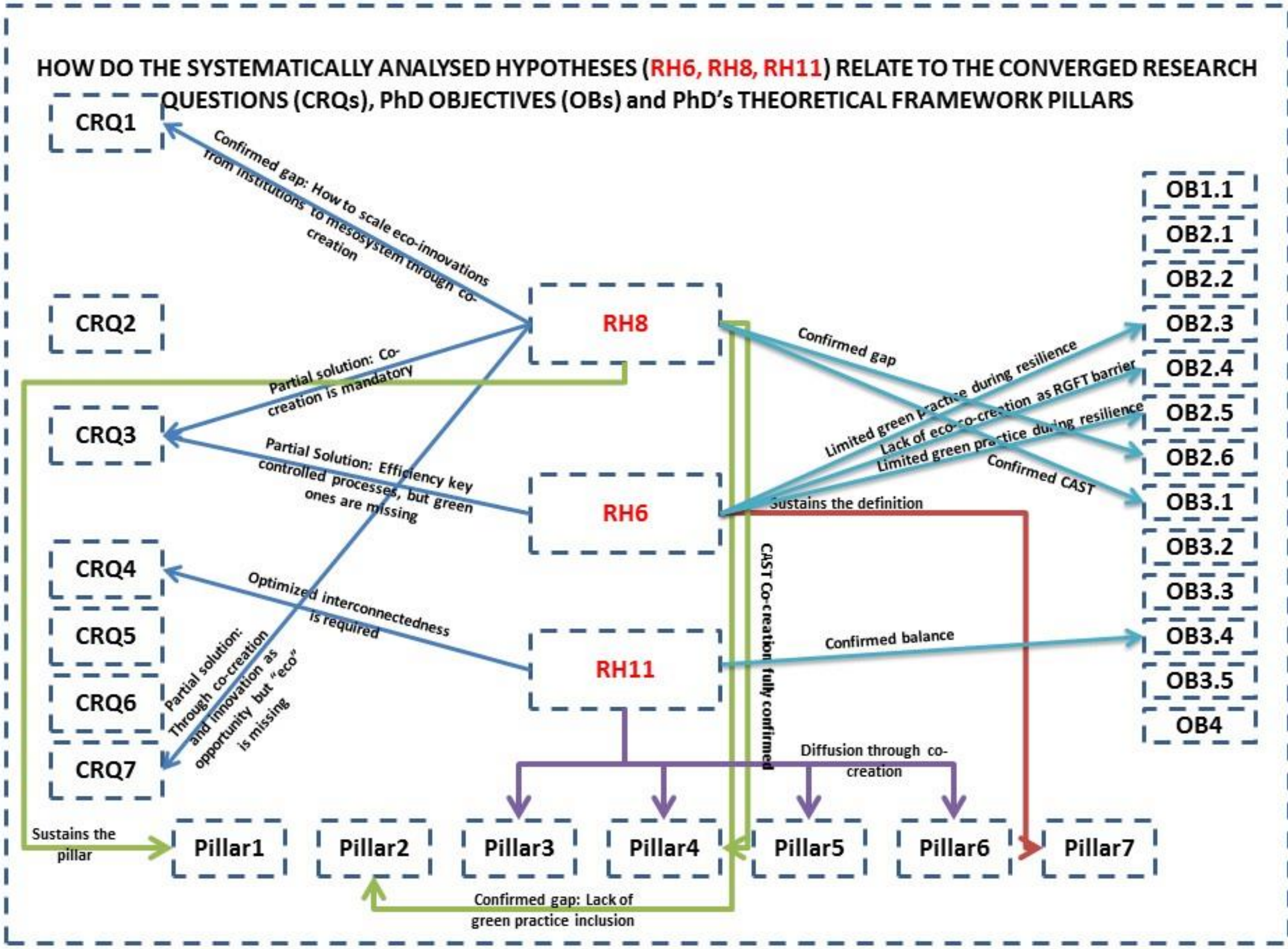

Figure 17: Impact of the RH8, RH6 and RH11 findings on the CRQs, OBs and TFT Pillars

2.3.3 Overview on natural/weather-induced disruptions on supply chains

The core aspect of focusing on natural/weather induced disruptions relates to the unpredictability and randomness of these occurrences that stretch beyond any other type of predictable/measurable disruptions (i.e. economic, political, social). While the majority of related research resides in proposing operational efficiency and optimization during disruptions, with nowadays societal pressure and empowerment, social and environmental responsibility can no longer be left aside. The view of this thesis is that weather induced disruptions are a core source of eco-innovation for the RGFT microsystem (and for the quintuple helix mesosystem overall) as only in such harsh and unforeseen conditions, institutions are totally driven to eco-innovate and self-adapt (achieve stability/resilience) in innovative ways which need to be outburst and scaled-up across the entire meso and ecosystem. The whole impact of weather-induced disruptions does not stand within the borders of supply chains microsystems, rather, the entire quintuple helix society is (physically) disrupted by such events. Whether weather induced disruptions can be indeed predicted (to some extent), as the following systematic analysis will show, co-creation at the mesosystem level is critical in order to support eco-innovations that will mitigate the damages and enable the restoration of the complex system in an ecologically modernized manner from individual institutions – to the entire stakeholder/system level.

In order to properly comprehend these aspects, this section is tailored to provide a systematic insight into the following research hypotheses (inquiries):

> **RH1:** Understand which weather conditions cause the most impactful disruptions in road freight transportation from SEE
>
> **RH2:** Understand what negative business outcomes emerge as a result of such disruptions
>
> **RH3:** Understand what key performance indicators do business use and to what extent when dealing with disruptions

The tremendous impact of natural/weather-induced disruptions in supply chains and quintuple helix mesosystems is putting an immense pressure for the involve stakeholders to better adapt, prepare and predict such calamities. Such disasters are deemed to have (recently – over the past 20 years) affected more than 5.1 billion people and have caused severe damage to the environmental ecosystem as well as to the quintuple helix social mesosystem and its stakeholders

(Ergun et al., 2010). Similar issues with more emphasis on financial losses is also confirmed by Li & Coates (2016). More specifically, the outcomes of such disruptions (caused by extreme weather-rain, hurricanes, snow, extreme cold, winds, blizzards, earthquakes, floods, drought) have damaged the physical infrastructures (i.e. road freight infrastructure, logistic centres, communication means) of quintuple helix mesosytems, have brought significant financial losses to the stakeholders, have created social disruptions (Keohane & Victor, 2016; Chhetri et al., 2016; Global risks, 2015; GAR, 2015; Walch, 2015; Van der Vegt et al., 2015; Thompson et al., 2014; Surminski, 2013; Contestabile, 2013;Jarvis et al., 2012; Linnenluecke et al., 2012; Natarajarathinam et al., 2009; Hale & Moberg, 2005) and have led a significant footprint on the environmental ecosystem both in terms of the damage created as well as by the post-crisis damage driven by ineffective (non eco-friendly) resilience operations (Snyder et al., 2015; Ergun et al., 2010; Nakano, 2009). Even more, uncertainty in such complex systems poses even more the gravity of such disruptions specifically for freight transportation (Loh & Thai, 2015; Mattson & Jenelius, 2015; Sanchez-Rodriguez et al., 2008) which is the most closely related/link with hard damages and practices (rather than soft/tactical). This context is highly in line with the EMT view on how the environment poses pressure/disruptions within its inner systems (i.e. quintuple helix mesosystem and RGFT microsystem).

In a similar manner, an in-depth study performed by Stecke & Kumar (2009) revealed that natural/weather induced disruptions such as heat, storms, wild fires, ice storms, and snow have caused more than 90% of economic losses from all natural/weather induced disruptions and laid a critical negative impact on the supply chain infrastructures (i.e. road freight transportation mircosystem) as well as on the natural habitat/environment (Savo et al., 2016; Kreibich et al., 2014; Stern et al., 2013; Linnenluecke et al., 2012; Ross, 2003). Other examples provided by Monahan et al., (2003) show how earthquakes in Taiwan caused severe loss in the manufacturing chains of microchips globally (thus, the propagation of the damage throughout the entire complex system). Other similar examples are provided by Linnenluecke et al. (2012). These findings prove even more the impact of EMT and its influence within the inner systems.

Such aspects have been highly acknowledged in a research that focused on resilient and environmentally sustainable supply chains during disruptions (Mari & Memon, 2014). The authors focus on weather-induced disruptions and argue that the resilience mechanisms that supply chains should adopt in such cases should be highly considerate towards low carbon practices and resource efficiency in a quintuple helix context (in line with: Wright, 2015; Cai et al., 2014; De Rosa et al., 2013; Cutter et al., 2013; Derissen et al., 2011; Rose, 2011; Turner, 2010; Lebel et al., 2006). This study is one of the most recent research which (tacitly) binds EMT and CAST towards explaining the eco-resilience during natural/weather induced disruptions in a quintuple helix mesosystem wider context.

Even more, one of the core and most recent papers (Bahadur & Doczi, 2016) positions the need of “autonomous” institutional level innovation as a key driver of specifically natural/weather induced disruptions mitigation towards ensuring resilience in an environmentally conscious and resource scarce quintuple helix context where all the actors should co-create and “mainstream”/adopt such innovations in order to adhere to a common mission of environmentally sustainable resilience/self-regulation (Radjou et al., 2012; Bound & Thornton, 2012;). The position of this paper is highly in line with the theoretical framework proposed by this thesis, in which institutional CAST based microsystem eco-innovations (EMT) are diffused across the quintuple helix stakeholders mesosystem (INT, ST, DIT) in order to enable environmentally sustainable resilience. A similar approach, specifically focused on transportation systems is discussed by King et al. (2016) in terms of quintuple helix co-creation, however no specific leverage of environmental sustainability is provided. These two recent advancements are also in line with a previous study performed by Thorpe & Fennel (2012) and Mari & Memon, (2014) which analysed the adaptive capacity of SMEs to natural/weather induced disruptions in terms of achieving resilience in a climate change friendly manner. The authors also argued that co-creation and proper bridges at the quintuple helix levels are critical for ensuring this endeavour.

Another key work related to this thesis was recently published by Pescaroli & Alexander (2016). The authors analyse the cascading effect of supply chain disruptions across the panarchies of complex and adaptive systems (CAST) in a multi-subsystem approach (in the same lines overall with the model propose by this thesis) and with the same ideology of the DIT based creative destruction concept (Holling, 2001) and innovation scale-up, however the authors do not relate their model to the full quintuple-helix (specifically on social and environmental considerations) – focusing rather on various subsystems included in the supply chain microsystem.

In a more societal manner, Linnenluecke et al. (2012) have analysed in details the natural/weather induced disruptions within the quintuple helix mesosystem in order to understand what are the outcomes of such disruptions as well as how does the current operational behaviour of individual institutions drives climate change (and thus, most of the extreme natural/weather induced disruptions). This approach is highly in line with this thesis' model – specifically on the intersection of the quintuple helix mesosystem with the environmental ecosystem (explain thus such interactions rather than most of the other existing research which remotely focuses on analysing the relationship between the supply chain microsystem and the quintuple helix mesosystem). The author's work is also in line with (Winn et al., 2010; Alley et al., 2003; Hulme, 2003; Scheffer et al., 2001) which also sustain this co-dependence and adherence to the quintuple helix co-creation/cohesion. Linnenluecke et al. (2012) also argue for the need for constant adaptation of this complex societal system in order to shape-around and co-evolve with the ecological ecosystem (similar with EMT based modernization in CAST systems).

In the same line, (Van der Vegt et al., 2015) leverages the importance of such adaptation, especially in the context where dense networks of actors (i.e. quintuple helix mesosystem and even RGFT microsystem) suffer the most from tremendous weather-induced disruptions throughout all the involved sub-systems. To the same extent, the authors also argue that organizational resilience is the core element that will enable micro and mesosystem resilience through enhanced institutional capabilities that will later-on leverage to the system level to ensure wider scale resilience – only through effective quintuple helix co-creation (Bach, 2015; Tihanyi et al., 2014; Roechrich et al., 2014; Stevenson, 2014; Kahn et al., 2013; NRC, 2011; McManus et al., 2008) – highly in line with the CAST concern of the interconnectedness and proximity of stakeholders when it comes to eco-innovation practice diffusion (EMT, DIT, INT, ST). However, the heterogeneity and the different KPIs/goals of individual quintuple helix institutions may hinder this co-creation towards ensuring weather-induced resilience in supply chains (Van der Vegt, 2015; Agranoff, 2006; Ospina & Saz-Carranza, 2005).

Finally, some of the key research limitations which require further analysis which have been identified are (Pescaroli & Alexander, 2016; Li & Coates, 2016; Chhetri et al., 2016; Snyder et al., 2015; Linnenluecke, 2015; Van der vegt, 2015; Mari & Memon, 2014; Thorpe & Fennel, 2012; Linnenluecke et al., 2012; Winn et al., 2010; Natarajarathinam et al., 2009; Stecke & Kumar, 2009; Maon et al., 2009; Gorton et al., 2006; Berkhout et al., 2006; Spillan & Crandall, 2002):

- Development of a base with natural/weather induced disruptions on supply chains and their actual impact on the stakeholders involved – with the view that disruptions are a source of renewal/(eco)-innovation.
- Develop better co-creation and communication mechanisms at the mesosystem level that would enable enhanced prediction and communication of such natural/weather induced disruptions with initial root at the complex microsystem level (Chhetri et al., 2016)
- Understand how green and eco-efficient practices can be implemented during and post-(natural/weather induced) disruptions (this is a major confirmed literature gap) and how do the systems co-evolve with the environment (during the resilience process).
- Enable policy/quintuple helix co-creation and better assessment of the eco-resilience mechanisms at the mesosystem level (or in the view of Li & Coates (2016) – better integration of the involved "agents"/stakeholders in terms of their KPIs and goals).
- A core limitation specifically argued by (Linnenluecke, 2015) resides in quantifying organizational change (across the systems) with better optimization between strictly controlled practices and the freedom of innovations, flexibility and adaptation (Taleb, 2011; Farjoun, 2010). This is taken even further to argue the need to measure resilience at the multi-stakeholder (quintuple helix) level where resilience should scale-up through co-creation (in line with: Xavier, 2014; Urciuoli et al., 2014; Zoback, 2014; Voss et la., 2013; Klibi et al., 2010; Ingirige et al., 2008; Craighead et al., 2007).

All these outcomes are visually displayed in Figure 18 which shows how the EMT driven ecosystem generates disruptions that propagate across the mesosystem and the microsystem (which respond in a non-environmentally friendly manner – showing the key literature gap).

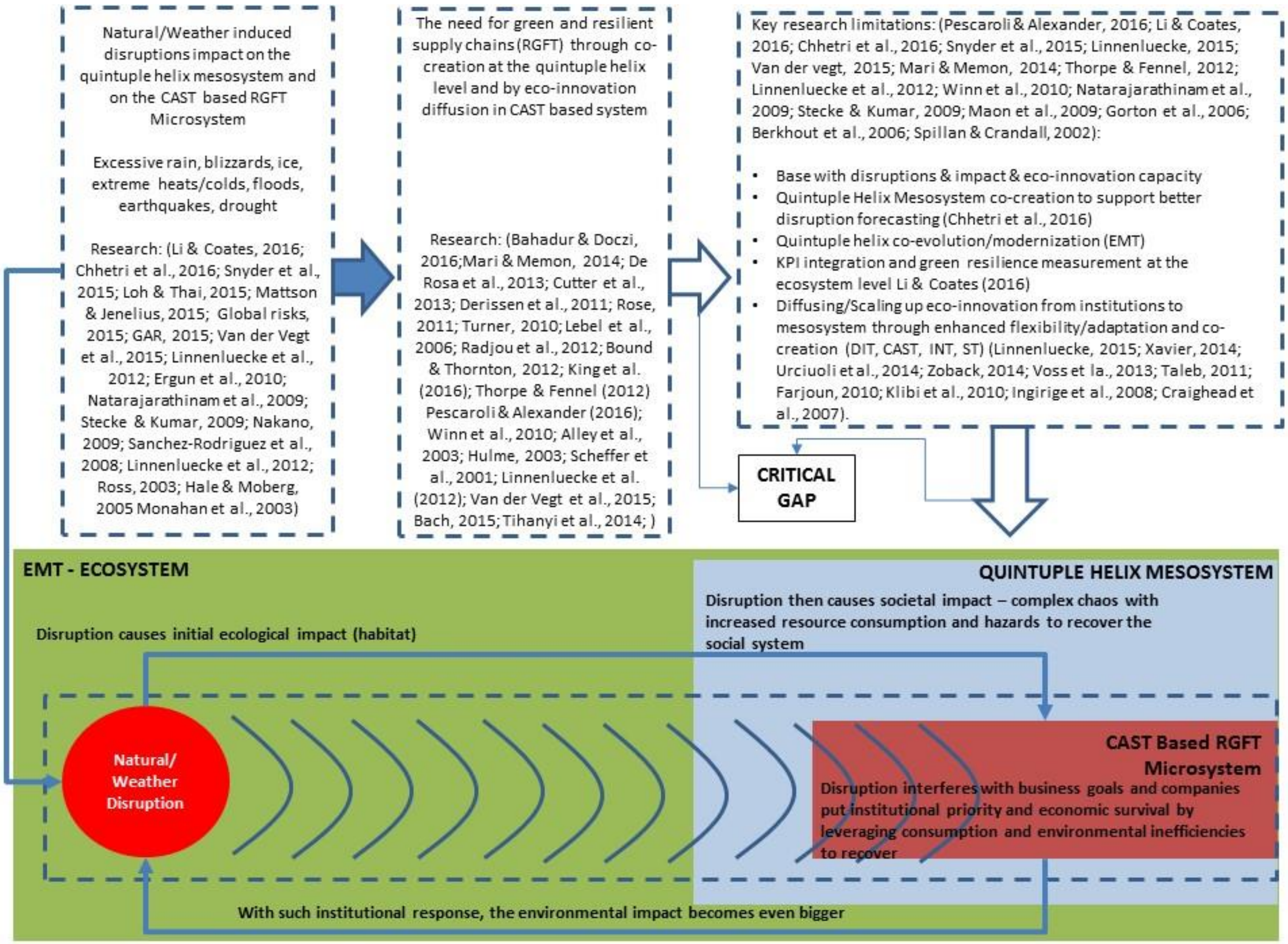

Figure 18: Weather induced disruptions and their cross-system impact

Overall, the findings related to natural/weather-induced disruptions in RGFT/RGSCM are very scarce, however the research gaps sustained by the literature are in high coherence with the ones identified for the previous RHs.

RH1: *Understand which weather conditions cause the most impactful disruptions in road freight transportation from SEE.*

The core conditions that have been identified are related to extreme weather-rain, hurricanes, snow, extreme cold, winds, blizzards, earthquakes, floods, drought however there is no specific research that focuses on an in-depth analysis of these conditions in relation to RGFT/RGSCM within a territory. Due to these limitations, RH1 partially responds to OB1.1.

RH2: Understand what negative business outcomes emerge as a result of such disruptions

The core negative outcomes induced by such disruptions result primarily in economic downturns (this is a core focus of the literature) with limited (and very recent) incentives to include societal and environmental consideration properly within the decision making factors when performing damage assessment. RH2 is highly in line with CRQ4 in terms of the interconnectedness of the institutions when it comes to disruption propagation and eco-innovation diffusion, however due to the significant research gaps, it only partially responds to OB2.1

RH3: *Understand what key performance indicators do business use and to what extent when dealing with disruptions*

As in the previous cases, the indicators are mostly related to economic/operational performance with limited implications for environmental/social factors. However, the core finding of the literature for this purpose resides in the necessary leverage of quintuple helix co-creation towards ensuring proper disruption assimilation in an environmentally sustainable manner (i.e. RGFT/RGSCM) however, there is a significantly large research gap confirmed by the majority of the literature. For this purpose, RH3 is highly in line with CRQ1,3,6,7 as well as with Pillars1,2,3,4,7 and partially in line with Pillars5,6 and OB2.2-3.1 and OB3.3, 3.4. All these outcomes are visually displayed in Figure 19 by showing to what extent the literature review on the involved RHs respond to the need posed by the CRQs, OBs and TFT Pillars.

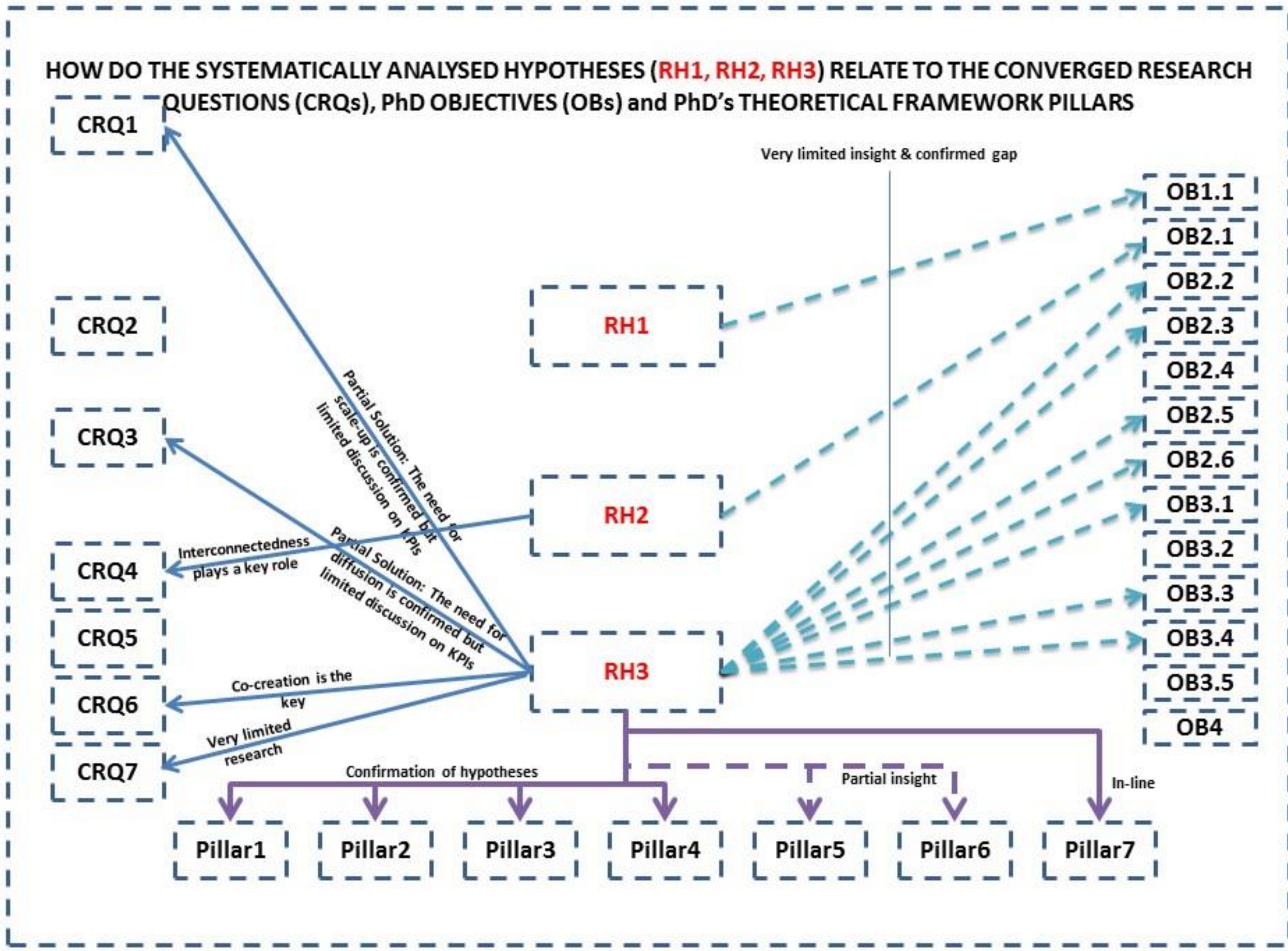

Figure 19: Impact of RH1, RH2 and RH3 systematic outcomes on the CRQs, OBs and TFT Pillars

2.3.4 Thinking glocal: the region of South East Europe and RGFT

The focus of this thesis on the area of South East Europe (Figure 20 – which shows a UN map for natural disasters and humanitarian crises clasification) is highly in line with the literature trends in terms of providing solutions for developing and low-income regions where the need for efficient, future oriented and long term sustainable are highly necessary in order to support regional development and growth. To this end, literature strongly supports research contributions for low-income/less-developed regions in order to ensure quintuple helix growth (Ketikidis et al., 2016; Bahadur & Doczi, 2015; Vogelstein, 2015; Basu et al., 2013; Radjou et al., 2012; Gupta, 2009). Even more, there are specific research suggestions denoting the need for environmental sustainability (Bourlakis et al., 2014a; Bourlakis et al., 2014b) and resilience mechanisms against disruptions in less developed/low income/conflict regions, strengthening thus even more the necessity of this thesis' model (Bullough et al., 2014; Branzei et al., 2010).

To this end, whether developed countries are constantly adapting to the latest trends in RGFT/RGSCM, the SEE region is still struggling to grasp the complexity of achieving a true enabling environment especially from a quintuple helix co-creation point of view (Baresel-Bofinger et al., 2007 and Baresel-Bofinger(b) et al., 2007). The reason for this aspect is usually driven by past heavy industrial production, mono-industrial areas, weak environmental regulations, regulatory framework, industrial restructuring, environmental constrains, high energy intensity, inefficient energy technologies (Baresel-Bofinger(b) et al., 2007), which have severely impacted on the freight transportation infrastructure (and supply chain infrastructure overall) and which have limited research in this area. Furthermore, according to Ramudhin et al. (2009), SEE is not a homogeneous area which makes regional cooperation and policy integration harder as well as any pro-environmental behaviours. All these issues have also been generated by past war experiences in the central and western SEE, ex-communist influence and the recent harsh economic crisis. Nevertheless, efforts are being made in SEE in order to overcome these shortcomings.

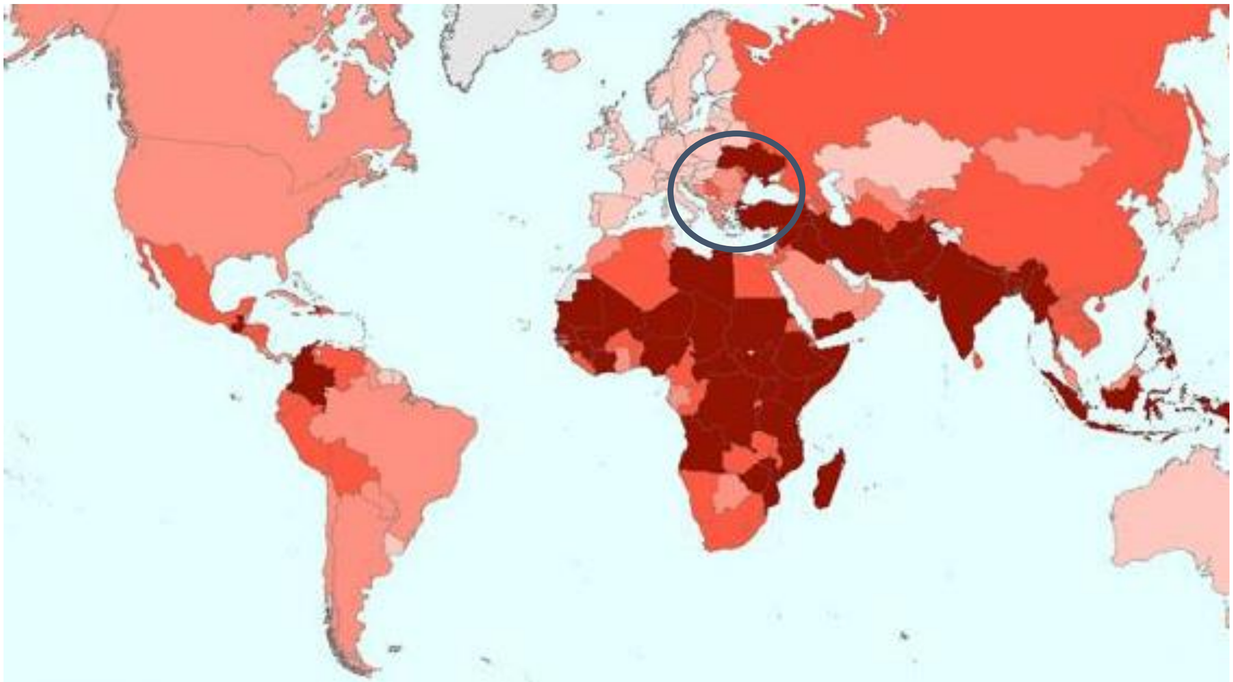

Figure 20: Geographical area of South East Europe (circled on the map)

Due to these issues, the SEE region requires rapid advancements in the field of (RGFT/RGSCM) because and their integration within the quintuple helix mesosystem because:

The SEE region is a developing area which soon will properly integrate with other highly developed and quantity intensive European freight transportation/supply chain corridors (SEETAC, 2012). This aspect will have devastating effects on the SEE freight transportation when increased volumes of traffic will prevail and will cause increased quintuple helix disruptions under natural/weather induced events (due to the expectedly increased interconnectedness and density of the systems). Even more so, this aspect will be worsened as SEE is the freight gateway of Europe to the Far East.

In times of harsh economic crisis and economic regulations, the SEE region requires proper mechanisms for sustainable development which will also enable economic growth and competitiveness (SEETAC, 2012 and Beskovnik & Jakomin, 2010). To this end, RGFT/GSCM and better co-creation at the quintuple helix mesosystem in SEE will lead to increased efficiency and better environmental regulation as well as multilateral growth.

The SEE region has a historical background on environmental disasters (as other European extremities with critical impact on freight transportation and supply chains – including, implicitly, impact at the quintuple helix mesosystem) – earthquakes, landslides, droughts, floods, extreme temperatures, wildfires, storms and heavy snow during winter (UN, 2008) – which have significant impact on the freight transportation infrastructure by causing infrastructure degradation and disruptions which lead to severe environmental damage (Vaughan et al., 2015; Cashin et al., 2015; O'Brien et al., 2015; Bedia et al., 2015; Bedia et al., 2014; Dasari et al., 2014; O'Connor et al., 2014; Maurer et al., 2014). To this end, the SEE region highly requires proper understanding of RGFT/RGSCM.

There are initiatives in SEE for achieving sustainable transportation, such as in the case of the GIFT Project (2013) which aims to develop and ICT tool for intermodal trip planning with minimum carbon foot print, however there is no evidence of any initiative from this region to support directly resilience against the imminent natural/weather induced disruptions in a network with a forecasted increased interconnectedness.

Similarly, in the context of the lack of research focus on the provision solutions freight transportation in SEE and in general for freight transportation (Baresel-Bofinger(b) et al., 2007), research and policy argues that SEE should adhere to several global trends from the transportation sector such as resilience, decision making and co-creation (Hoa & Hansenova, 2006; Lile & Csorba, 2010; EU DG, 2006; Paraschiv et al., 2009 and Paraschiv et al., 2010).

It is thus of core relevance to focus the (primary) research in understanding the situation in SEE towards properly proposing a global level framework for RGFT/RGSCM implementation within the theoretical boundaries proposed by this thesis' model.

2.3.5 Summary of the systematic literature review

Table 6 shows an overview on the current findings emerged from the systematic literature review:

Table 6: Brief outcomes of the systematic literature review

Systematic analysis results of the converged research questions (CRQs)	
CRQ	**Brief outcome**
CRQ1**: Bottom-up: How can local level institutional EMT driven eco-innovations (either transformative or disruptive) diffuse faster under the DIT behaviour and scale-up across the RGFT CAST driven microsystem panarchy during crises towards enabling resilience.**	**Findings**: Eco-innovations are implemented at the institutional level with very limited "eco" relation in RGFT/RGSCM/. **Gaps**: Quintuple helix co-creation for eco-innovation scale-up.
CRQ2**: Top-down: How can the modernized ecosystem level (explained by the ST) generate eco-innovation exogenous pressures on the individual institutions (explained by INT) in an international ecosystem and what are the institutional level responses to such induced modernization.**	**Findings**: Eco-innovations are implemented at the institutional level mostly as coercive means. **Gaps**: The role of ST, INT, EMT and DIT is not analysed in-depth within CAST micro/mesosystems. There is a high need to analyse such diffusion at the mesosystem level especially in low-income regions.
CRQ3**: Transversal: What are the local level institutional controlled processes of the CAST driven RGFT microsystem and how do these institutional controlled processes integrate and co-evolve with the ones of other quintuple helix stakeholders in order to enable co-creation and fast eco-innovation adoption (EMT, DIT) towards ensuring RGFT at the quintuple helix mesosystem-level**	**Findings**: The internal processes (KPIs) rarely involve both green and resilience typologies. **Gaps**: A common vision/goal and integration of the KPIs at the quintuple helix mesosystem towards enabling RGFT/RGSCM.
CRQ4**: Transversal: What are the effects of the interconnectedness of the institutional level stakeholders and the location of the disruption within a quintuple helix CAST based mesosystem on the RGFT process in terms of the effectiveness of the emerged eco-innovation (EMT) diffusion (DIT).**	**Findings**: Eco-innovation diffusion requires high interconnectedness towards enabling RGFT/RGSCM, however this scenario leads to high disruption impact. **Gaps**: A quintuple helix moderated approach to balance interconnectedness.
CRQ5**: Methodologies: What CAST systems modelling and simulation, mixed-methods research and behavioural analysis can be performed within an ecosystem**	*This item will be analysed in the methodology section of this thesis.*
CRQ6**: Exogenous: How can stochastic externalities induced disruptions (such as natural/weather conditions) be better overcame in CAST ecosystems through eco-innovation (EMT, DIT)**	**Findings**: Natural/weather induced disruptions can be overcame through RGFT/RGSCM only at the Quintuple Helix mesosystem through co-creation. **Gaps**: An assessment and categorisation of such disruptions and their impact on the involved (sub)systems.

CRQ7**: Transversal: How does the DIT properly explain the adoption of EMT by CAST based RGFT institutions**	**Findings**: DIT is core influencer however the eco-innovation adoption is mostly normative/coercive and in some cases reacts as innovation leadership. . **Gaps**: An assessment of the enecessary co-creation and co-evolution at the quintuple helix mesosystem to better foster eco-innovation diffusion.

The individually tested research hypotheses (RHs) (as demonstrated in the previous subchapters) are highly in line with the proposed model, with the CRQs and with the OBs:

RH1: *Understand which natural/weather conditions cause the most impactful disruptions in road freight transportation from SEE.*

> Core conditions rain, hurricanes, snow, extreme cold, winds, blizzards, earthquakes, floods, drought however there is no specific research that focuses on an in-depth analysis of these conditions in relation to RGFT/RGSCM within a territory such as SEE. Due to these limitations, RH1 partially responds to OB1.1.

RH2: Understand what negative business outcomes emerge as a result of such disruptions

> Lack of environmental and societal factors inclusion in the processes. RH2 is highly in line with CRQ4 in terms of the interconnectedness of the institutions when it comes to disruption propagation and eco-innovation diffusion, however due to the significant research gaps, it only partially responds to OB2.1.

RH3: *Understand what key performance indicators do business use and to what extent when dealing with disruptions*

> Consistent with RH2. However, the core finding of the literature for this purpose resides in the necessary leverage of quintuple helix co-creation towards ensuring proper disruption assimilation in an environmentally sustainable manner (i.e. RGFT/RGSCM) however, there is a significantly large research gap confirmed by the majority of the literature. For this purpose, RH3 is highly in line with CRQ1,3,6,7 as well as with Pillars1,2,3,4,7 and partially in line with Pillars5,6 and OB2.2-3.1 and OB3.3, 3.4.

RH6: *Understand what resilience mechanisms (related to GFT) do businesses implement and to what extent these mechanisms include environmentally sustainable practices*

> Limited integration between environmental sustainability and resilience in RGFT/RGSCM. The very recent research efforts (2013-2016) suggest that further research is required in proposing solutions and models based on environmentally sustainable resilience mechanisms for supply chains (freight transportation) in order to ensure proper co-evolution at the mesosystem level.

RH8: *Understand how can the GFT resilience mechanisms of businesses be supported/fostered faster by other stakeholders from the ecosystem*

> The majority of research focuses on analysing resilience in relation to CAST frameworks, however (as mentioned above) with substantial lack of including environmental concerns during the resilience (adaptation/transformation) processes of the RGFT microsystem under proper quintuple helix co-creation and co-evolution.

RH11: *Understand the importance of business partnerships interconnectedness in terms of enabling fast RGFT.*

> The findings denote a clear need for co-creation in terms of innovation diffusion across the mesosystem towards enabling resilience in supply chain (freight transportation) microsystems. Even more, disruptions in microsystems are seen as key source of innovation/renewal for the entire mesosystem – however there is limited insight towards properly linking the EMT with DIT towards sustaining that there is similar behaviour for eco-innovations rather than for innovations related to general optimizations. Nevertheless, the findings support the CAST, INT and ST based influence in the behaviour of scaling up institutional innovations to mesosystem level by ensuring proper network design at the microsystem level (optimized interconnectedness).

RH4 and RH9: *Understand to which extent do businesses implement green practices during their decision making processes and understand to what extent to businesses respond to ecosystem pressures in order to implement RGSCM/RGFT practices.*

GSCM practices are implemented at the institutional level, however, performance reporting is being done at the Quintuple Helix Mesosystem level. This is in line with the EMT based explanations for eco-innovation diffusion, however there is a gap related to the diffusion of practices from the institutional level to the micro and mesosystem which means that there is at least one category of eco-innovations that are implemented due to coercive and normative measures imposed by the quintuple helix mesosystem. Co-creation within the GSCM/GFT microsystem towards eco-innovation implementation leads to: balanced eco-modernization of all stakeholders (with spillovers to the quintuple helix mesosystem as explained by the EMT and the DIT). Furthermore, the modernization process imposes co-creation, partnerships, knowledge flows which form strong networks that self-adapt, providing thus an enhanced environment for a potential self-adaptation in case of disruptions (as explained by the CAST in relation to RGSCM/RGFT). Finally, the ST and INT explain how localized institutions aim to implement the quintuple helix eco-directives, however, such implementation imposes the co-creation which leads to more eco-modernization as explained by the EMT.

RH5: *Understand what drivers and barriers do businesses face when aiming to adopt/implement green practices*

Drivers: institutional needs towards becoming more efficient (INT) but without diffusion at the mesosystem level, coercive (quintuple helix pressures), inner drive to modernize (EMT, DIT), institutional adoption as mimetic action (DIT) and institutional adoption as normative pressure.

Barriers: Internal - organizational culture, top management support, financial resources, sustainability mentality (mostly institutionally related). GSCM barriers category 2 – Internal & External: Employee/stakeholder motivation and commitment to the joint mission, flexibility and resistance to change, co-creation and collaboration abilities, managing heterogeneity, access to proper information, training and skills. GSCM barriers category 3 – External: uncertainty of GSCM practice advancements globally, proper policies and effective co-creation directives.

Overcoming the GSCM implementation barriers and taking advantage of the drivers can be done only with proper co-creation at the mesosystem level in order to understand how institutional eco-innovations are leveraged at the micro and mesosystem levels (major research gap). The systematic literature denotes that institutions do not have a benevolent approach towards acting at the mesosystem level, unless they are coerced to do so. It is important to understand the reasons why institutions do not intent to have this co-creation which is required to fully grasp the impact of GSCM/GFT practices at the mesosystem level.

RH7 and RH10: *Understand how (to what extent) businesses interact with the GSCM/RGFT stakeholders and understand how do the GSCM/GFT KPIs of businesses match with the ones of the involved mesosystem's stakeholders*

The systematic review shows a clear interest in GSCM performance measurement at more than just the institutional level by encompassing quintuple helix stakeholders in this process, however there is no specific evidence that a clear direction is taken for this purpose (as the previous findings suggested) which confirms that institutions respond to normative and coercive practices. This suggests that the ST explains how such conformance takes place, however this does not explain how EMT base innovations take place and get diffused (DIT) at the micro and mesosystem level. However, despite of the already existence of these indicators, there is no structured and integrative approach taken to analyse how they can comprise a full working mesosystem (and microsystem) in order to assess the impact of GSCM implementation at wider levels and there is a core literature strand that advocates for this leveraged approach (from GSCM institutional level to mesosystem level) – in full coherence with the theoretical framework of this thesis.

2.4 Summary

Finally, to answer the CRQs and to explore the TFT Pillars derived from the organizational theory review (2.1) as well as from the wide-scale systematic literature review (section 2.3 based on the methodology from section 2.2), provided in Chapter 2, the following research aim and objectives pertain:

Aim: Develop a quintuple helix framework for the implementation of resilient and green road freight transportation (RGFT/RGSCM) during natural/weather induced disruptions in South East Europe.

Specific Objectives:

- **OB1: Assessment of extreme weather conditions (heavy rain, heat waves, snow, flods and others) impact (institutional and ecosystem level, mixed methods):**
  - **OB1.1:** Understand which weather conditions cause the most impactful disruptions in road freight transportation from SEE (relates to CRQ6).

- **OB2: Assessment of business impact and decision making processes against the disruptions caused by such weather conditions (institutional level, mixed methods):**
  - **OB2.1**: Understand what negative business outcomes emerge as a result of such disruptions
  - **OB2.2:** Understand what (green) key performance indicators do business use and to what extend when dealing with disruptions
  - **OB2.3:** Understand to which extent do businesses implement green practices during their decision making processes
  - **OB2.4:** Understand what drivers and barriers do businesses face when aiming to adopt/implement green practices
  - **OB2.5:** Understand what resilience mechanisms do businesses implement and to what extent these mechanisms include environmentally sustainable practices
  - **OB2.6:** Understand how (to what extent) businesses interact with the RGFT stakeholders.

- **OB3: Develop a framework for stakeholders to implement resilient and green road freight transportation practices:**
  - **OB3.1:** Investigate how can the resilience mechanisms of businesses be supported/fostered faster by other stakeholders from the ecosystem (relates to CRQ1, CRQ7).

- **OB3.2:** Investigate to what extent do businesses respond to ecosystem pressures in order to implement RGFT practices (relates to CRQ2).
- **OB3.3:** Compare the RGFT KPIs of businesses with the ones of the involved mesosystem's stakeholders (relates to CRQ3).
- **OB3.4:** Establish the importance of business partnerships interconnectedness in terms of enabling fast RGFT (relates to CRQ4).
- **OB3.5:** Use modelling tools (SCEnAT) to show practical underpinnings of implementing suitable RGFT (relates to CRQ5)

- **OB4: Develop several simulations to test the proposed framework with RGFT mesosystem stakeholders (modelling & simulation)**

The next chapter (Chapter 3 - primary research/methodology) will present in details how the findings from the literature review (which form and sustain the CRQs, OBs and TFT Pillars) will be further extended/explored and investigated within the quintuple helix mesosystem of South East Europe.

Chapter 3: Research Methodology

3.1 Introduction

Scientific research methods are used to enable researchers to make valid observations, interpretations and generalizations of certain phenomena through a set of standardized techniques accepted by the wide research community. Taylor (2005) argues that nowadays, research is an integral part of our society in which both quantitative (statistical) and qualitative (textual, interpretive) methods are being employed. This is highly in line with the research directions in RGFT/RGSCM which pushes towards the utilization of mixed methods (both qualitative and quantitative) in order to derive critical insights in this highly complex and expansive field (Faisal, 2016; Dubey et al., 2015; Chouwdhury & Hossan, 2014; Molina-Azorin & Lopez-Gamero, 2014; O'Rourke, 2014; Golicic & Davis, 2012; Zhu et al., 2012; Seuring, 2011; Psychogios and Priporas, 2007; Mangan et al., 2004; Creswell, 2003; Christy and Wood, 1999; Goodman, 1999).

In order to achieve their effectiveness, (Bhattacherjee, 2012) argues that research methods should have the following qualities: replicability (other should be able to replicate the research), precision, falsifiability (theory should have the property of being disproven, and parsimony (always choose the simplest explanation). Basically, from a theoretical point of view, scientific research for phenomenon explanation or investigation, require concepts – properties of that phenomenon that can be generalized. Furthermore, since the phenomenon is composed of many concepts, constructs are required to abstractly study the properties of a concept in order to iteratively analyze the phenomenon. Finally, variables are used to measure constructs and explain phenomena (Bhattacherjee, 2012).

Generally, conducting research involves as a preliminary stage conducting a literature review in order to achieve a state of the art of a chosen phenomenon, to identify key researchers and ideas related to the phenomenon and to identify the research limitations/gaps that need to be addressed. Then, a proper research methodology is being performed, followed by data collection, analysis and interpretation. Bhattacherjee (2012) argues that pilot testing is a critical part of any research since it can detect early stage problems, even though it is generally neglected. Additionally, the quality of research design can be measured through four variables: internal validity (checks the causality among the tested construct variables), external validity (generalization of results), construct validity (appropriate measurement for the theoretical concept) and statistical conclusion validity (appropriateness of statistical methods) (Muijs, 2004).

Selecting a proper research methodology varies from project to project and choosing the most adequate one can significantly contribute to the successful outcome of the research. To this extent, the literature provides many scientifically accepted methodologies, designs and their related issues, which (Bhattacherjee, 2012) summarized: exploratory research, descriptive research, explanatory research, experimental studies, survey research, secondary research, case research, focus group research, action research, ethnography, all of which can fall under either qualitative (understanding a phenomenon) or quantitative (proving a phenomenon) research categories.

After selecting the most suitable research methodology driven by the research type, a major stage that influences the successful outcomes of the research is sampling (selecting a representative subset of an entire population on which the research will be performed. (Bhattacherjee, 2012) discusses two main categories of sampling methods: probability sampling (simple random sampling, systematic sampling, stratified sampling, cluster sampling, matched pairs sampling, multi-stage sampling and non-probability sampling (convenience sampling, quota sampling, expert sampling and snowball sampling).

Furthermore, after having the sample from which the desired data is intended to be collected, data analysis and interpretation techniques are being employed in order to either collect new findings, confirm theories or reveal issues. Depending on the research methodology used which influences the collected data, data analysis can be qualitative (textual input mostly) or quantitative (measurable and fixed data).

One example of qualitative data analysis techniques (either as a follow-up of interviews or focus groups) is the inductive content analysis (as qualitative data analysis method) is used in situations where theory building (i.e. through framework development) is required (which is exactly the case for the purpose of this research) which means that this methodology is used in cases where there is substantial lack of research/information to build a robust model that can be subjected to confirmatory approaches (Elo & Kyngas, 2008; Thomas, 2006). To this end, inductive content analysis has been recently used quite extensively in environmentally sustainable (including resilient) supply chain research due to the lack of sufficient models that would grasp and properly integrate the complexity of this supply chain evolution (Wilhem et al., 2016; Perrez-Franco et al., 2016; Chiarini & Douglas, 2015; Saldanha et al., 2015; Stevenson & Busby, 2015).

Regarding quantitative data analysis, techniques can vary. For example, Bhattacherjee (2012) discusses two main categories of such techniques: descriptive analysis and inferential analysis (hypothesis testing). Quantitative data analysis is usually done using computer assisted programs (such as SPSS, SAS.) and data preparation is a key step before analysis. Depending on the desired outcomes, a number of various statistical analysis techniques (univariate, bivariate, multivariate, variance analysis.) and algorithms can be employed (Newman & Benz, 1998; Muijs, 2004).

A particular interest especially in logistics and operations management research is the usage of computer science paradigms such as modelling and simulation which have been adopted as social science research methods due to their capabilities (Lee et al., 2002; Fleisch & Tellkamp, 2003; Simchi-Levi, 2000; Wu & Olson, 2008; Chan & Chan, 2006; and Craighead et al., 2007). Nevertheless, there is a clear distinction between software development and modelling and simulation methodologies since modelling and simulation are the "products" of the software development process (usually modelling and simulation involve analysis, design, algorithm implementation, testing.).

Model development methodologies can widely vary and usually they are tailored around the characteristics of the product to be developed. More specifically, these characteristics can refer to the status of requirements gathering (at the beginning, ongoing, ambiguous), of the complexity of the product, on the desired level of efficiency, on the available resources to allocate when developing the product. Some of these methodologies are: the waterfall model (step by step process with all the requirements known before-hand), spiral (linear-iterative process), incremental, prototyping, rapid application development, scrum, extreme programming.

Thus, the availability of research methods for scientific research can widely vary and have been adapted for various purposes and from various disciplines. The main driver of their implementation relies in the nature of the research question and in the desired outcomes. To this extent it is of high importance to choose the most appropriate methods for a specific research as it will be shown in the following sections which present in details, the methodology pursued by this thesis.

3.2 Research philosophy

The literature on research philosophies provides various directions and approaches when it comes to adopting such view-points that influence the design and outcomes of a specific research, however the most suitable research philosophy that drives this thesis consists of the critical realism paradigm (initiated by Roy Bhaskar). Critical realism bridges natural and social worlds by emphasizing the need for special methods required to model/adapt to social structures (as compared to basic scientific experimentations such as modelling numbers or discrete events). Social structures, in the views of critical realism, are capable of pursuing post-event reflection and self-adaptation - as the entire goal of social structures is always to progress (Laclau & Bhaskar, 2015; Archer et al., 2013; Bhaskar, 2013; Fleetwood & Ackroyd, 2004). Overall, critical realism has substantial influence in economics, social structures and movements, international relations and in modern social science research which proves the evolution of this paradigm to support nowadays research necessities.

Relating to the social science fundament of this thesis, it is of core importance to mention that CAST, EMT, DIT, INT and ST are directly discussed in the literature under the framework of the critical realist perspective of bridging natural and social worlds and thus, by adopting this paradigm, the emerged research capacity is supported by the literature. Even though CAST is also discussed from the points of view of other disciplines (for more details please see section 2.1.3), for the purpose of this thesis, CAST is positioned at the intersection of the natural world and the social world – being thus in full coherence with the critical realism perceptions. Overall, detailed elements in terms of how CAST, EMT, DIT, INT and ST integrate with critical realism are discussed in section 2.1 (in terms of presenting the social science foundations of each theory).

Finally, besides critical realism, this research adopts also a post-positivism approach (in which describing a phenomenon can be done using empirical analysis combined with formalized logical reasoning by viewing the results in a probabilistic manner rather than in a certain one) (Bhattacherjee, 2012) in order to strengthen the argument for the utilization of mixed-method research in good coherence with the related scientific research.

3.3 Research design

The proposed research design contains a combination of several research methods that are progressively integrated in order to achieve the desired outcomes. The research methodology is composed on three main stages and a preliminary stage which is comprised of an in-depth systematic literature review on RGFT/RGSCM (section 2.3) that will serve as input to each of the remaining stages and which will also be updated and consolidated after each stage.

Kleindorfer et al. (2005) performed a comprehensive literature review on sustainable operations management and argues that research at that time was still at the beginning of understanding (environmental) sustainability in operations research, thus also in freight transportation research. Furthermore, researchers (such as Fahimnia et al., 2015; Govindan et al., 2014; Dobers et al., 2013; Lin et al., 2013; Dekker et al., 2012; Touati & Jost, 2012; Psaraftis & Panagakos, 2012; David & Fistung, 2011; Chapman, 2007; Schipper et al., 2011; Facana & Horvath, 2007) and policy makers (Horizon2020, 2012) are arguing for further research and advances in RGFT/RGSCM overall and in SEE (Baresel-Bofinger et al., 2007), especially since there is little evidence from the initial literature review that significant scientific debate on RGFT/RGSCM exists in this region.

The initial investigation also revealed that the use of technology (modelling & simulation) as a methodological approach for RGFT/RGSCM research should also be further researched in order to achieve its maximum potential especially for the resilience components (Ferguson & Hadar, 2011; Melville, 2010; Helo & Szekely, 2005; Auramo et al., 2005). This is also revealed (as shown in the previous section 2.3) by the systematic literature review. All this literature is sound and highly cited in the field of RGFT/RGSCM (according to the high impact online citation indexes from different sources), however it does not enable a critical understanding and positioning of RGFT/RGSCM within the quintuple helix mesosystem.

In addition, previous research described in section 2.3 (systematic literature review) argues indeed for the need of the quintuple helix approach proposed by this thesis, however there are very little publications that discuss (or the suggest) the need for the adequate and specific research methods necessary for undertaking such a mission. Still, an initial (and very recent) overview (related also to the systematic literature review presented in the previous section) supports the methodological approach of the thesis under the framework of critical realism and post-positivism (as it will be shown below) which is required in order to reveal theory in the highly complex field investigated by this research:

Research claiming for the need for mixed methods research in GSCM/GFT (Faisal, 2016; Dubey et al., 2015; Chouwdhury & Hossan, 2014; Molina-Azorin & Lopez-Gamero, 2014; O'Rourke, 2014; Golicic & Davis, 2012; Zhu et al., 2012; Seuring, 2011; Psychogios and Priporas, 2007; Mangan et al., 2004; Creswell, 2003; Christy and Wood, 1999; Goodman, 1999).

Research claiming for the need of mixed methods research in relation to analysing resiliency performance in supply chains with tangency to RGFT/RGSCM (Hohenstein et al., 2015; Qazi et al., 2015; Kilubi et al., 2015; Tabrizi & Razmi, 2013; Pettit et al., 2013; Cadden et al., 2013).

Research claiming for the need of quantitative based modelling & decision support in GSCM/GFT (Heckmann et al., 2015; Qazi et al., 2015; Tattichi et al., 2015; Huerta-Barrientos et al., 2015; Seuring, 2013; Wu & Olson, 2008; Craighead et al., 2007; Srivastava et al., 2007; Chan & Chan, 2006; Fleisch & Tellkamp, 2003; Lee et al., 2002; Simchi-Levi, 2000).

Research claiming for the need of mixed methods when analysing systems that include environment, society and cross-system innovation/practice diffusion – quintuple helix (Soosay & Hyland, 2015; Smith & Rupp, 2015; Sounders et al., 2015; Power & Gruner, 2015; Deacon et al., 2014; Storer et al., 2014; Soundararajan & Brown, 2014; Iofrida et al., 2014).

In order to provide an initial overview on the methodology undertaken by this thesis, the main aspects related to the theoretical framework developed through the systematic literature review (as well as the findings of the literature review) will be reiterated to understand its implications for the selected research methodology:

- **Methodological implication 1:** The theoretical framework involves multiple stakeholders across various systems that aim to achieve co-creation towards eco-practice diffusion in order to lead to RGFT/RGSCM. Thus, heterogeneity and lack of common understanding prevails. Regardless of whether the focus of the research will be set upon institutions and how RGFT/RGSCM practices scale-up and then then down towards/from mesosystem level, a major problem will be to undertake a confirmatory approach that will bind all stakeholders – which points towards the fact that a more in-depth analysis and insight into individual stakeholders will be required at some point throughout the methodology. This aspect implies that the use of qualitative research methods are necessary.

- **Methodological implication 2:** There is very limited research in SEE (and in general, globally, in the literature) on all RGFT/RGSCM aspects (see all CRQs and objectives of the PhD thesis) such as: the practices utilized by institutions, drivers, barriers, intentions towards practice adoption, proper explanation of how INT, ST, DIT, CAST and EMT interrelated, evidence of how cross-system quintuple helix interaction takes place. Regardless of the fact that the literature provides isolated findings and evidence of individual level research of the aforementioned aspects, there is no research that binds all these elements together. Thus, in order to enable a large SEE scale confirmatory approach (quantitative) of all these elements and to measure the impact and validity of the arguments, an initial exploratory (in depth, qualitative such as expert interviews) will be required in order to consolidate the systematic literature review findings specifically for SEE. Only after such a phase, the idea of large scale confirmation (or even exploration) can be achieved. However, it is of core importance to notice that (due to the lack of proper research), the findings of the systematic literature review are highly biased on institutional level and do not properly explain how (even if confirmed) these institutional practices scale-up to ecosystem level and trigger the necessary co-creation that will lead the intended RGFT/RGSCM at its maximum potential (apect which drives a key demand for further research).

This institutional focus of the literature does not also explain how these practices of supply chain institutions integrate and how they are monitored within the quintuple helix mesosystem nor how resilience mechanisms are assimilated by all societal stakeholders. Thus, (considering also Methodological implication 1 – inability to perform mass confirmation among the heterogeneous quintuple helix mesosystem) – therefore after completing a large scale confirmatory approach at the institutional level in SEE (which may contain institutional perceptions of how the quintuple helix interacts and co-creates), another stage would be required in order to explore how this co-creation, KPIs alignment and developing a common mission at the quintuple helix mesosystem is required. One approach for this exploration resides in taking the confirmed findings of the large scale confirmatory study on SEE institutions and open debate (through focus groups and/or interviews for example at a quintuple helix level) in order to understand how the quintuple helix (mesosystem) could adopt/enable/support such practices and co-evolve/co-modernize together with institutions through eco-innovation diffusion (and then influence other institutions to eco-modernize). However, the idea of subjecting the confirmed large scale findings should be done in a coherent and applied/case-study manner in order to provide the quintuple helix stakeholders with realistic scenarios of how the intended outcomes of RGFT/RGSCM could be achieved. Therefore, this leads to Methodological implication 3.

Methodological implication 3: Generally, as it will be shown below, there is a gap in the literature in terms of providing modelling & simulation (software based) of RGFT/RGSCM. There are indeed a wide number of simulated models focused on optimization and cost efficiency (as shown by the systematic literature review), however there is very little attempt to model & simulate resilience and even more – to model and simulate environmentally sustainable resilience (RGFT/RGSCM). This implication is in high cohesion with Methodological implication 2 which claims for the need of realistic models of RGFT/RGSCM of institutions required to be subjected by an open exploratory debate at the quintuple helix mesosystem level.

Thus, up to this point, the methodological implications derived by the systematic literature review in relation to the theoretical framework of the thesis lead to the following proposed research design that is undertaken by this thesis:

- *Stage one:* Initial qualitative exploratory approach (expert interviews in six SEE countries) to gain a consolidated understanding of institutional level implementation of RGFT/RGSCM in SEE.
- *Stage two:* Large scale exploratory (qualitative) & confirmatory (quantitative) approach of the findings identified in Stage one (including items that would enable to identify the perceptions of institutions of how they co-create with other quintuple helix stakeholders). Final valid sample N=311.
- *Stage three*: Implementation of three focus groups with quintuple helix stakeholders (with a focus on Greece this time to enable usable & context specific outcomes) aimed at confirming and extending the items explored and investigated in Stage two (as well as any other item not analysed in Stage two) but at a quintuple helix mesosystem level. The findings of the focus group will serve as a quintuple helix implementation framework for RGFT/RGSCM/ Finally, the supply chains of three companies from Greece will be modelled and simulated using the Supply Chain Environmental Analysis Tool (SCEnAT) towards identifying CO2 hotspots induced by weather disruptions in the transportation system and the corresponding framework emerged through the previously implemented focus groups (as well as the survey instrument results from Stage two) will be proposed as mitigating strategies (subjected to final cross-validation by the three companies involved).

An overview on the research design is presented in Figure 21 below and in-depth specifications and justifications of each methodological stage will be performed in the upcoming subsections.

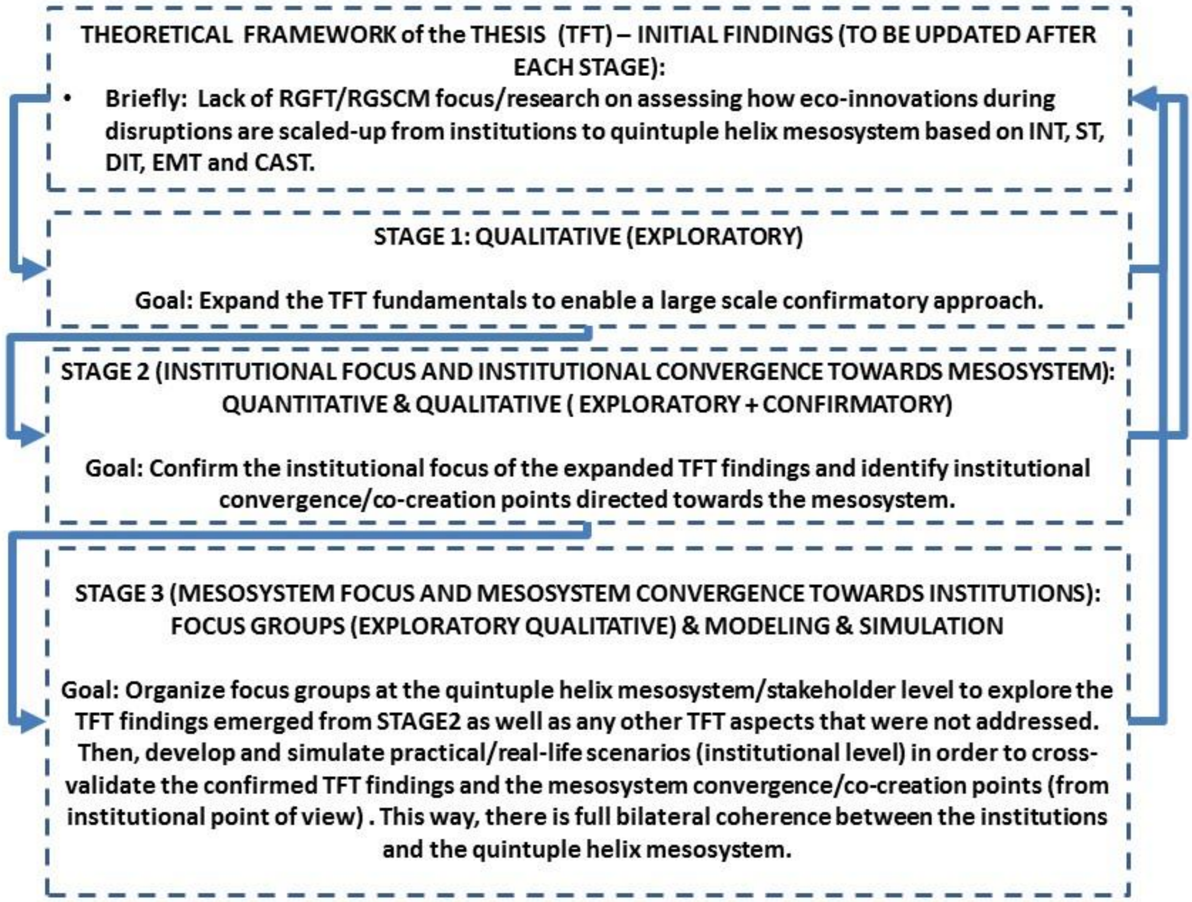

Figure 21: Overview on the research design stages

Finally, the research questions driving the research design and stages are the CRQs defined in section 2.1.6 as well as the OBs defined in section 2.4 in order to sustain the theoretical framework of the thesis pillars defined in section 2.1.7.

3.3.1 Stage one (Institutional Level) – Qualitative interviews

Qualitative methods in the area of SCM (including RGFT/RGSCM) have a very limited application against the prevalence of pure quantitative (mathematical) models (for pure optimization purposes) which dominate the related research. However, as it will be shown below, over the recent years, qualitative methods are becoming more and more relevant with the progressive integration of supply chains within quintuple helix mesosystems in terms of the pressures and direction related to the impact of supply chain activities on societies. This aspect is even more pertinent for RGFT/RGSCM as this highly recent/new discipline requires a much more in-depth understanding from a multi-stakeholder point of view, aspect which cannot be fully enabled by quantitative means. Thus, qualitative exploration is required. The claim for exploratory qualitative methods in supply chain research has several core research support:

- Exploratory (qualitative) methods (expert and semi-structured interviews) are highly relevant for supply chain research in order to fully understand specific behaviours that involve complexities especially where there is substantial lack of knowledge (Bhamra, 2012; Ghencev et al., 2011; Peters et al., 2011; Golicic & Mentzer, 2005; Mollenkopf et al., 2007; Yin, 2003). Similar arguments are supported by (Faisal, 2016; Dubey et al., 2015; Chouwdhury & Hossan, 2014; Molina-Azorin & Lopez-Gamero, 2014) which integrate qualitative research in their mixed-method research strategy which is the case of this thesis as well).
- Exploratory (expert qualitative interviews) based on carefully selected samples can provide high replicability features (and increase model/construct validity) of the research findings for supply chains risks & resilience (Lin & Zhou, 2011; Yin, 2009; Fowler, 2009; Seuring, 2008; Cooper & Schindler, 2008).
- Exploratory qualitative approaches are relevant towards understanding supply chain information flows throughout and among institutions (Roh et al., 2008)
- A core research which is highly relevant to this thesis is the one performed by Azevedo et al. (2012) and earlier (partially) discussed by (Carvalho et al., 2010 and Folke et al., 2002; Lewis, 2000) which prove how an exploratory qualitative (expert) approach can provide better understanding of how environmentally sustainable practices are adopted by institutions and how these practices scale-up to the mesosystem in order to understand the actual impact at the quintuple helix mesosystem level. This approach comes as means of overcoming lack of clarity of phenomena and lack of behavioural understanding of the involved events/actions (Rowley, 2002, Yin, 2002, Rosenzweig & Singh, 1991) with tangency towards understanding sustainability practice implementation within supply chains (Koplin et al., 2007, Tucker & Cohen, 2004). Similar arguments are supported by (Soosay & Hyland, 2015; Smith & Rupp, 2015; Sounders et al., 2015; Power & Gruner, 2015; Deacon et al., 2014; Storer et al., 2014; Soundararajan & Brown, 2014; Iofrida et

al., 2014) which integrate qualitative research in their mixed-method research strategy which is the case of this thesis as well).

- Another research performed by Wedawatta et al. (2010) utilizes exploratory qualitative methods (complemented by quantitative –mixed methods) such as case studies and focus groups in order to understand supply chain resilience under weather/natural induced disruptions.
- Furthermore, Gogelci & Ponomarov (2013) adopt a qualitative scenario-based approach towards understanding the relation between firm innovation (and innovation diffusion) and the effectiveness of the resilience strategy and claim for the need of qualitative approaches for this purpose.
- A more recent utilization of exploratory qualitative methods is performed by Govindan et al. (2014) which aim to explore the impact of institutional environmentally sustainable resilience on supply chains by incorporation the social element (converging thus to the quintuple helix mesosystem).
- Finally, converging on the resilience aspect, Fiksel (2006) strengthens the need of focusing on complex systems approaches by arguing for the need of more qualitative approaches when it comes to modelling & simulating such system's behaviours (relating thus to the CAST based RGFT/RGSCM microsystem).

To sum up, it can be surmised that qualitative exploratory approaches can provide substantial insights into researching environmentally sustainable resilience in complex RGFT/RGSCM microsystems with integration in the quintuple helix mesosystem. To this end, there is a good ground to pursue such an approach for the first stage of this research. Following the systematic literature review outcomes, due to the lack of significant research in the research questions and PhD objectives that were the drivers of the systematic literature review, a qualitative expert-based interview (open ended questions based on the aim & objectives of the PhD) is proposed as means of gathering more insight into these matters (but with specific focus on SEE) in order to be able to proceed to the large scale confirmatory survey (quantitative).

Thus, a qualitative interview has been developed based on the research objectives of this PhD thesis (which are sustained by the converged research questions, by the proposed theoretical framework's pillars and by the systematic review outcomes). The following items/questions presented in Table 7 have been included in the interview:

Table 7: First stage inquiries and their relation to CRQs, OBs and TFT Pillars

Interview item	Related CRQ	Related OB	Related Pillar
Overview on the business sector, business value, availability of environmental management department and demographics.	All	All	All
Overview on the negative business outcomes induced by (which) weather-induced disruptions upon the transportation system and identification of the utilized resilience KPIs	CRQ6	OB2.1 OB2.2	Pillar 1
Understand what green practices (in general) does the company implement and what drivers & barriers are countered (with relation to quintuple helix aspects also)	CRQ2	OB2.3 OB2.4	Pillar 2
Understand what environmentally sustainable resilience practices does the company implement and how does the company communicate/co-creation with other stakeholders (i.e. other enterprise level institutions or quintuple helix ones)	CRQ3	OB2.5 OB2.6	Pillar 4 Pillar 7
Understand how can the resilience mechanisms of businesses be supported/fostered faster by other stakeholders from the quintuple helix mesosystem and what are the motivators (i.e. pressure, competition, interconnectedness).	CRQ1 CRQ2 CRQ4 CRQ7	OB3.1 OB3.2 OB3.4	Pillar 4 Pillar 5 Pillar 6
Understand how compatible are the KPIs of the company with the ones of the other quintuple helix stakeholders	CRQ3	OB3.3	Pillar 2 Pillar 3

The main purpose of this stage is not to pilot the main study that will follow in the second stage, but to consolidate and further explore/confirm the available information (resulted from the systematic review) which will be used in order to create/confirm the structured survey in the second stage (which basically will have structured information with clear purposes). Thus, this first stage primarily aims to collect/explore a wide amount of textual information about RGFT/RGSCM in SEE as well as to confirm/explore the conclusions emerged through the literature review. To this extent, this stage is a qualitative exploratory study performed via telephone interviews with key stakeholders through semi-structured interviews (since it contains questions with text input required from the interviewee as well as structured questions). The survey structure including all consent forms and information sheet can be found in Appendix A. It is important to mention that the information sheet contains general aspects about the terminology and concepts investigated by the research, however a very limited insight has been provided to the interviewee in order not to lead to biased or suggested answers.

Since this stage aims to provide in-depth quality input for the second stage which will deal with wide sample surveys, its chosen sample is relatively small (six interviews – one per country), however it is comprised from key stakeholders that have the most experience with RGFT/RGSCM issues in SEE. Thus, the sampling method used is non-probability expert sampling and the targeted population is formed out of port institutions, intermodal centres, logistic centres, transport research centres, production/manufacturing companies with integrated transportation.

Regarding data collection for this phase, during the telephone interviews the interviewee's answers have been recorded (after their written consent) in order to be able to make accurate transcripts of their provided answers. The interviewees knew beforehand the questions of the survey. Qualitative data analysis was performed on the collected data and based on the quality of the new findings, the previously identified findings and variables were updated. The qualitative analysis process was achieved by relying on the thematic analysis and keyword mapping which enabled objective qualitative data interpretation.

During this phase, a number of six interviews (each) from (Romania, Bulgaria, Serbia, FYROM, Greece and Slovenia) have been approved and performed during January-February 2014. Research ethics approval for the interviews has been received by the appropriate department from the University of Sheffield. More details about the findings of this stage can be found in the data analysis section.

3.3.2 Stage two (Institutional level) – Quantitative & qualitative survey

The second stage is both a descriptive confirmatory and exploratory research formed of semi-structured questionnaire surveys, which aims to confirm at a large scale the TFT emerged from the systematic literature review and updated/enhanced through the previous stage (qualitative exploratory). In order to achieve this aspect, a semi-structured questionnaire survey was designed by using as input source the TFT pillars that grasp the literature advances complemented by the previous stage. The questionnaire is semi-structured in order to enable the quantitative measurement of the responses as well as qualitative data collection. The use of open ended questions has been limited only to the questions where qualitative input could better enhance the value of the response. As there is no specific model to properly test (quantitatively) the TFT it becomes thus critical to enable scientifically valid means that would lead to such a model development. The survey design together with the consent forms and afferent documents can be found in Appendix B.

With regards to the focus of the survey – due to the limited access to a large pool of quintuple helix actors - the survey targets industry (businesses) in order to gain insights into the TFT at the institutional level, however at core points, the perceptions of these institutions towards quintuple helix mesosystem co-creation is also tested in order to better prepare the next stage of the methodology as well as to identify the readiness of institutions to engage in the necessary quintuple helix co-creation proposed by the TFT which is a core element of proper RGFT/RGSCM implementation.

The questions from the survey cover the following constructs (Table 8) emerged from the TFT and updated through the previous qualitative (exploratory) stage (with more specializations as it can be seen in Appendix B):

Table 8: Second stage inquiries and their relation to CRQs, OBs and TFT Pillars

Survey Construct	Related CRQ	Related OB	Related Pillar	Sample of the literature that influenced the construct selection
Overview on the business sector, business value, availability of environmental management department and demographics.	All	All	All	
Overview on the negative business outcomes induced by (which) weather-induced disruptions upon the transportation system and identification of the utilized resilience KPIs (economic, operational, social, environmental)	CRQ6	OB2.1 OB2.2	Pillar 1	Bahadur & Doczi, 2016; Chhetri et al., 2016; Global risks, 2015; GAR, 2015; Van der Vegt et al., 2015; Mari & Memon, 2014; Zhu et al., 2012; Ivanon et al., 2012; Van den Berg, 2011; Folke et al., 2010; Stecke & Kumar, 2009; Bansal & Mcknight, 2009; Chertow, 2009; Pathak et al., 2007; Holling, 2001
Understand what green practices (in general) does the company implement and what drivers & barriers are countered (with relation to quintuple helix aspects also)	CRQ2	OB2.3 OB2.4	Pillar 2	Dubey et al., 2015; Govindan et al., 2015; Ivanaj et al., 2015; Tian et al., 2014; Shi et al., 2014; Chakrabarty & Wang, 2013; Sarkis et al., 2011; Lee, 2008; Chien & Shih, 2007; Papadopoulos & Giama, 2007; Rivera, 2004
Understand what environmentally sustainable resilience practices does the company implement and how does the company communicate/co-creation with other stakeholders (i.e. other enterprise level institutions or quintuple helix ones)	CRQ3	OB2.5 OB2.6	Pillar 4 Pillar 7	Dubey et al., 2015; Govindan et al., 2015; Zhu et al., 2010; Darnall et al., 2008; Hu et al., 2008; Walker et al., 2008; Gonzales et al., 2008; Handfield et al., 2005; Hervani et al., 2005; Christopher & Peck, 2004; Bansal & Hunter, 2003, Sarkis, 2003
Understand how can the resilience mechanisms of businesses be supported/fostered faster by other stakeholders from the quintuple helix mesosystem and what are the motivators (i.e. pressure, competition, interconnectedness).	CRQ1 CRQ2 CRQ4 CRQ7	OB3.1 OB3.2 OB3.4	Pillar 4 Pillar 5 Pillar 6	Govindan et al., 2015; Fahimnia et al., 2014; Zhu et al., 2012; Moore & Westley, 2011; Van den Berg, 2011; Chertow, 2009; Atwell et al., 2008; Jacobsson & Brgek, 2008; Walker et al., 2006; Walker et al., 2004
Understand how compatible are the KPIs of the company with the ones of			Pillar 2	Ivanaj et al., 2015; Govindan et al., 2015; Fahimnia et al., 2014; Hsu et al., 2013; Hu & Hsu, 2010; Ninlawani et al., 2010; Mont & Leire, 2009; Seuring &

the other quintuple helix stakeholders	CRQ3	OB3.3	Pillar 3	Muller, 2008; Walker et al., 2008; Srivastava, 2007; Chien & Shih, 2007; Wright & Elcock, 2006; Tsoulfas & Pappis, 2006; Yalabik et al., 2005; Evans & Johnson, 2005; Eveloy et al., 2005; Handfield et al., 2005; Widmer et al., 2005; WEEE, 2003
Intentions to adopt RGFT/RGSCM strategies/practices	CRQ3	OB2.5 OB2.6	Pillar 4 Pillar 7	Acquaye et al., 2014; Koh, 2014; Shi et al., 2014; Zhu et al., 2012; Venkatesh et al., 2003
Perceived usefulness of implementing/adopting RGFT/RGSCM strategies/practices	CRQ3	OB2.5 OB2.6	Pillar 4 Pillar 7	Shi et al., 2014; Zhu et al., 2012; Bai et al., 2012; Venkatesh et al., 2003
Perceived ease of use of RGFT/RGSCM strategies/practices	CRQ3	OB2.5 OB2.6	Pillar 4 Pillar 7	Shi et al., 2014; Genovese et al., 2014; Zhu et al., 2012; Venkatesh et al., 2003

After designing the survey, a pilot study was conducted with ten respondents (several institutions used in the previous stage were contacted again, however other contact persons that the ones used in the first stage in order to avoid biases) in order to assess the validity and acceptance/first impression of the survey. More specifically, the pilot tested: the design and sample of the study, time resource consumption and behaviour of the respondents. The population of the pilot was selected using expert sampling techniques, since key stakeholders are required in order to guide the direction of the study. These pilot stakeholders are of the same type as the ones used in the first stage. The results of the pilot leaded to a minor adaptation of the survey and of the procedure overall (no major or specific concerns were raised during the pilots).

Systematic sampling was used in order to select the proper population of RGFT/RGSCM related stakeholders from SEE. Based on the number of the available population, a number of 1121 questionnaires were delivered in hard copies to the following type of RGFT/RGSCM stakeholders from SEE: port authorities, intermodal and logistical centres/hubs, logistic carriers and freight transporters, intermediary logistics companies, 3PL companies, chambers of commerce, research centres and academic institutions that focus on transportation and logistics in SEE, related policy makers and governmental bodies, business associations, NGOs, environmental associations. The targeted respondents are CEOs/general managers, operations managers, environmental managers, consultants, and logistics experts from the previously mentioned sectors.

The collected data was:

- (for the quantitative part) integrated into a statistical analysis software (SPSS) and quantitative analysis techniques were. The analysis and discussion is provided in section 4.3.
- (for the qualitative part) processed using inductive content analysis. The analysis and discussion is provided in section 4.3.

3.3.3 Stage three (Mesosystem level) – Focus groups and modelling

Whether the previous two stages collected and confirmed data (qualitatively and quantitatively) mostly at the institutional level (and with limited institutional perception towards the mesosystem), the third stage is aimed at cross-validating and exploring the previously identified findings from the institutional level to the quintuple helix mesosystem level. While the results of the previous two stage cover six countries over SEE, the third stage will focus (in-depth) only on Greece in order to ensure a well-defined framework that can be applied successfully in a specific quintuple helix context. This was achieved through:

- **Three focus groups** over one and half years have been organized with the support of the Triple Helix Association Chapter of Greece. The focus groups consisted of quintuple helix stakeholders and their main purpose was to: i) cross-validate from a quintuple helix point of view the institutional level findings emerged from the first two stages and ii) collect primary data concerning the quintuple helix mesosystem approach towards ensuring a proper implementation of RGFT/RGSCM framework.

- **Modelling and simulation** of the supply chain of three representative companies from Greece (after the quintuple helix level exploration & data collection). In order to achieve this, the Supply Chain Environmental Analysis Tool (SCEnAT) was utilized (SCEnAT, 2016). SCEnAT enables business process modelling and supply chain mapping in an online platform towards establishing the CO2 footprint of supply chain operations and towards the identification of environmentally and financially problematic hotspots within the supply chains. Qualitative interviews with the specific companies were conducted in order to collect and confirm data. Following the interviews, a SCEnAT model for each supply chain was developed and for each of the problematic CO2 hotspots (focus was set on CO2 intensive transportation resilience hotspots) the results from Stage one, Stage two and Stage three were mapped as a prospective RGFT/RGSCM implementation framework (i.e. In this segment of the supply chain which is CO2 and energy intensive caused by heavy snowfall, the following RGFT/RGSCM practices were recommended under the following drivers/barriers). After the models were finalized, the companies have been contacted again in order to cross-validate the proposed framework (both from an institutional and quintuple helix mesosystem level).

3.3.3.1 Focus groups design

Focus groups, as means of engaging small groups into discussion a thematic topic under the moderation from the principal investigator, are perceived to be a key research method when dealing with multi-heterogeneous stakeholders that require co-creation/co-evolution towards establishing a common ground for that specific theme/topic (Sweeney et al., 2015; Kamberelis & Dimitriadis, 2013; Wibeck et al., 2007; Freeman. 2006).

Still, developing a strategy for effective and accurate knowledge capturing during a focus groups represents a key challenge. To this end, one of the leading authors in focus group research (Stevens, 1996) argues for the need of the following guidelines in the development of the focus group questions and in the moderation of the focus group (also supported by Kamberelis & Dimitriadis, 2013; Freeman, 2006; Kidd & Parshall, 2000):

- Perceived relevance of the topic in discussion and emotions management
- Identification of the main conflict and disagreement momentums during the focus group
- Identification of the commonalities and alliances/agreements during the focus group
- Identification for the dominant stakeholder
- Identification of the silent stakeholder

- What enabled conflict resolutions
- Which interests were the most prevailing ones

Additionally, another focus group organization best practices proposed by Freeman (2006) proposes key strategies in terms of group composition (homogeneity and heterogeneity). Specifically, the author recommends the need for a balanced heterogeneity within the group (or at least for the participants to have some common prior knowledge or co-creation motivation) as otherwise the points of view may never converge. This aspect is critical for the purpose of this thesis as the focus groups target quintuple helix mesosystem stakeholders (i.e. policy makers, industry, society stakeholders, innovation stakeholders, environmentalists) – however, quintuple helix co-creation necessity is highly confirmed (globally), and thus, as it will be shown in the focus group analysis section, the convergence points do happen (regardless of the heterogeneity of the stakeholders). Such views on heterogeneity are also shared by (Sweeney et al., 2015; Kamberelis & Dimitriadis, 2013; Wibeck et al., 2007; Mangan et al., 2004; Kidd & Parshall, 2000).

One of the core research strands that extends the above mentioned practices but directly in the field of supply chain management (SCM) in order to understand the co-implementation of SCM in a multi-stakeholder environment (i.e. quintuple helix mesosystem) is comprised by (Sweeney et al, 2015; Stock et al., 2010; Guinpero et al., 2008; Seuring, 2005; Mangan et al., 2004). The authors argue for the high need of methodological pluralism in addressing such complex topics and focus groups become thus a key advancement in SCM methodological research especially when it comes to multi-stakeholder convergence issues. Such pluralism is also pertinent in organizational science research (i.e. ST, INT and CAST) that involve a multi-stakeholder approach towards co-creating solutions towards stability (i.e. DIT & EMT based solutions). Still, there is very limited such effort in specific relation to RGFT & RGSCM as a subset of SCM (Gualandris et al., 2015; Pagel & Shevchenko, 2014; Connolly & Hyndman, 2013; Global Reporting Initiative, 2013; Gomzales-Benito et al., 2011; Simpson, 2011; Sarkis et al., 2010).

In order to proceed with the focus groups organization, the handbook/methodology proposed by the University of Cambridge Social Science Research Guides (Hennink, 2007) was adapted and utilized (as this was one of the highest cited resource for this purpose according to various citation indexes):

- **Step 1 – Preparation**
    - Definition of the aim and objectives of the focus group:
        - Converge & collect data over the 1st and 2nd stage of this thesis' results
        - Converge & collect data over the CRQs, OBs and TFT Pillars of the thesis.
    - Establishment of the actual questions/discussion topics to be utilized during the focus groups
    - Establishment of the focus group duration (60-90 minutes)
    - Establishment & training of the key people during the event (1 principal investigator, 1 moderator and 2 note takers)
    - Establishment and preparation of all ethics considerations and consent sheets
    - Establishment of the targeted dates and broader topics of the events (to be noted that the focus groups have been integrated within wider scale round-table discussion organized by the Triple Helix Association Chapter of Greece).

- **Step 2 – Identification, recruitment and information of the focus group participants**
    - Representatives (convenience expert sampling) from the following categories have been targeted: policy makers, industry representatives, societal organization representatives, environmental organization representatives, innovators/researchers/academics. The liaison with the representatives has been done with the support of the Triple Helix Association Chapter of Greece. The group composition mode was designed according to the guidelines provided by Hennink, 2007 towards enabling meaningful knowledge co-creation. Specifically, the following three aspects have been considered:
        - Novelty/objectivity of the groups (which were pre-existing groups in constant interaction either fully or partially at various other events)
        - Demographic diversity
        - Ensuring no power or friendly control within the group (to enable free speech and limited biased answers)
    - The participants received an information sheet (prior to the event) upon which they confirmed their interest in taking part.

- **Step 3 – Focus group implementation**
    - Briefing phase (brief introduction by the moderator on the topic of discussion & on-spot logistics)
    - Ethics sheets signing and collection
    - Moderation style
        - Performed by an expert moderator which encouraged viewpoint diversification and free speech through innovative moderation techniques, non-verbal means and stimulating materials.
    - Two professional note-takers thoroughly reported the event as well as the principal investigator (as the participants did not agree on the use of recorded medias) based on the best practices mentioned above.

- **Step 4 – Post focus group reporting**
    - Raw note consolidation by the two note-takers with counter-validation by the principal investigator and moderator
    - Final raw-note validation by the stakeholders present during the focus group (email follow-up was performed for them to approve the notes).
    - Application of inductive content analysis as qualitative data analysis on the confirmed notes (following the approach described in section 4.1)

This stage covers all CRQs, OBs and TFT Pillars of this thesis. The specific analysis of this phase can be found in section 4.4.1.

3.3.3.2 Modelling and simulation

SCM modelling was brought in context as a way to achieve the compromise between complexity and the graspable representation/encapsulation of supply chain structures and behaviours into models (Siddhartha & Sachan, 2016; Bruno et al., 2012; Min & Zhou, 2002). The authors have created a taxonomy of supply chain modelling with four main directions: deterministic models, stochastic models, hybrid models (simulation) and ICT driven models (ERP/GIS). Additionally, the authors present an integrated modelling framework for supply chains with the following elements: supplier selection/inventory control, production/inventory, location/inventory control, location/routing, and inventory control/transportation. Similarly, Pandey, (2013) presented steps towards low-carbon transportation by modelling freight transport networks to evaluate the impact of route-mode-mix optimization. However, there is very limited research on RGFT/RGSCM modelling that encapsulates both environmental sustainability and resiliency.

Even more, simulation is one of the most effective methods to investigate logistics and supply chain behaviour since it can also provide good outcomes in global optimization problems (Siddhartha & Sachan, 2016; Barbati et al., 2012; Lee et al., 2002). The authors argue that any simulation model is based on either one of the two main methods – discrete and continuous. Furthermore, supply chain simulation can also be used as an effective analysis tool to measure performance (Simchi-Levi et al., 2000).

Furthermore, according to (Barbati et al., 2012; Fleisch & Tellkamp, 2003), supply chain simulation is being used when certain characteristics of supply chains cannot be modelled with analytical models. The authors argue that simulation cannot be used for optimization but just for performance measurement. On the other hand, (Maheshwari & Jain, 2015; John & Sridharan, 2015; Wu & Olson, 2008 and Chan & Chan, 2006) argue that simulation can provide good opportunities in dealing with supply chain risks and uncertainty which could indeed provide insight into the very limited existing research on modelling & simulation for RGFT/RGSCM.

Modern RGFT/RGSCM requires in-depth analysis when it comes to modelling and simulation and to this end, Lifecycle Assessment (LCA) methods that provide the CO2 footprint of the modelled entities become more prevailent in the low carbon supply chain literature which aim to address the current limitations offered by the purely quantitative modelling solutions that dominate this sector (Horton et al., 2015; Aquaye et al., 2014; Chourdhary et al., 2013; Genovese et al., 2013; Koh et al., 2011; Lee et al., 2011).

In this context, one of the suitable tools that can be used to model RGFT/RGSCM business processes is the Supply Chain Environmental Analysis Tool (SCEnAT) which is highly acclaimed in the field of low carbon optimization with immediate impact on economic and social indicators (SCEnAT Tool Report, 2015; SCEnAT LCA Report, 2015; Koh et al., 2013; Acquaye et al., 2012). SCEnAT has been used by more than 50 companies around the world (cross-sectors) as well as by many academics as means of exploring and consolidating their low carbon frameworks. To this end SCEnAT will be used in the following manner in this research:

- **Step 1**: Identification of a sample of three (3) representative industry institutions (convenience sampling) from Greece that have a wide supply chain and an interest in eco-efficient resilience strategies. The rationale is to map the supply chains of these companies inside SCEnAT and identify the CO2 hotspots induced by weather disruptions. For each of these hotspots, SCEnAT will automatically provide recommendations (mostly on energy efficiency), however these recommendations will be consolidated with the RGFT/RGSCM findings from the focus groups. Basically, this exercise will enable companies to have an assessment of their negative environmental impact caused by weather induced disruptions within their supply chains (through SCEnAT) complemented by a framework to overcome these disruptions in an environmentally sustainable manner and in full integration with the quintuple helix mesosystem. At this stage, the framework has been consolidated at the quintuple helix level through the focus groups meaning thus, that the proposals inside the framework are converging with the views of the quintuple helix stakeholders and thus - the company will adopt strategies which are compliant with all stakeholders' views/requirements.
- **Step 2**: In-depth exploratory qualitative interviews (expert interviews with managers) with the chosen companies towards collecting data to be used for modelling. The data to be collected consists of the bill of materials, supply chain structure, distances/locations of the centres, personnel employed, energy consumption (a full list of such contents is found in Appendix D).
- **Step 3**: Modelling using SCEnAT of the chosen companies' supply chains and development of the quintuple helix RGFT/RGSCM framework implementation recommendations based on the emerged CO2 hotspots and previous findings from the focus groups (previous sub-stage). In more details modelling will be done in the following situations: during normal operational flow (before any disruption), during significant disruptions and after applying a suggested RGFT/RGSCM strategy (as resulted from Stage two and confired in Stage three part one).

- **Step 4**: Confirmatory interviews with the chosen companies towards receiving their feedback on the perceived suitability of the proposed recommendations.

The final input received by the three companies will be used to triangulate & specialize the findings emerged from the focus groups towards ensuring that the RGFT/RGSCM implementation framework becomes more focused.

3.4 Research ethics

All three primary research stages have been subjected to the University of Sheffield's research ethics policy under the following approach:

- Research ethics applications have been developed, submitted and approved at the departmental and university level.
- All participants (in all stages) have received an information sheet and consent form that needed to be signed prior to the research. Appendices A, B and C show samples of such information sheets and consent forms.
- No relation between personal identification information and data collected has been kept and/or maintained.
- All raw (primary data) is being kept confidential at the research office of the South East European Research Centre (for up to five years after the data collection) and only aggregated/processed data has been stored on a secure Google Drive location.
- There are no financial benefits involved in the data collection process, nor there will be any financial benefits gained after the completion of the research.
- All respondents/participants were informed about their right to withdraw at any point from the studies and they were subjected to now harm.

3.5 Summary of the research design

Overall, the proposed research design methodology introduces a novel approach in RGFT/RGSCM research by proposing a combination of research methods (under the framework of critical realism and post-positivism) that will enable a cutting edge exploration of the issues involved. While responding to most of the literature claims in terms of the necessity of such an approach towards understanding the multi-stakeholder environment, the following high level limitations of the methodology are foreseen (more limitations are provided in the conclusion – Chapter 6): Use of expert sampling for the interviews may lead to biased responses and potential omissions of other relevant stakeholders; The large geographical span may interfere with the data consistency and reliability in the quantitative stage; The lack of general knowledge of the respondents in relation to RGFT/RGSCM may trigger validity concerns in their responses; The confirmation of the modelling and simulation results may often lead to biased responses from the companies in discussion (especially if the CO2 emissions are significantly high – the companies may be reluctant to approve this result); Finally, unless data analysis shows homogeneity among the responses from all countries in the first two stages, then the specialization of the third stage on Greece only may trigger data validity concerns.

To conclude, a flow-chart of the entire methodology design against the timeline which was required to ensure the full implementation is presented in Figure 22:

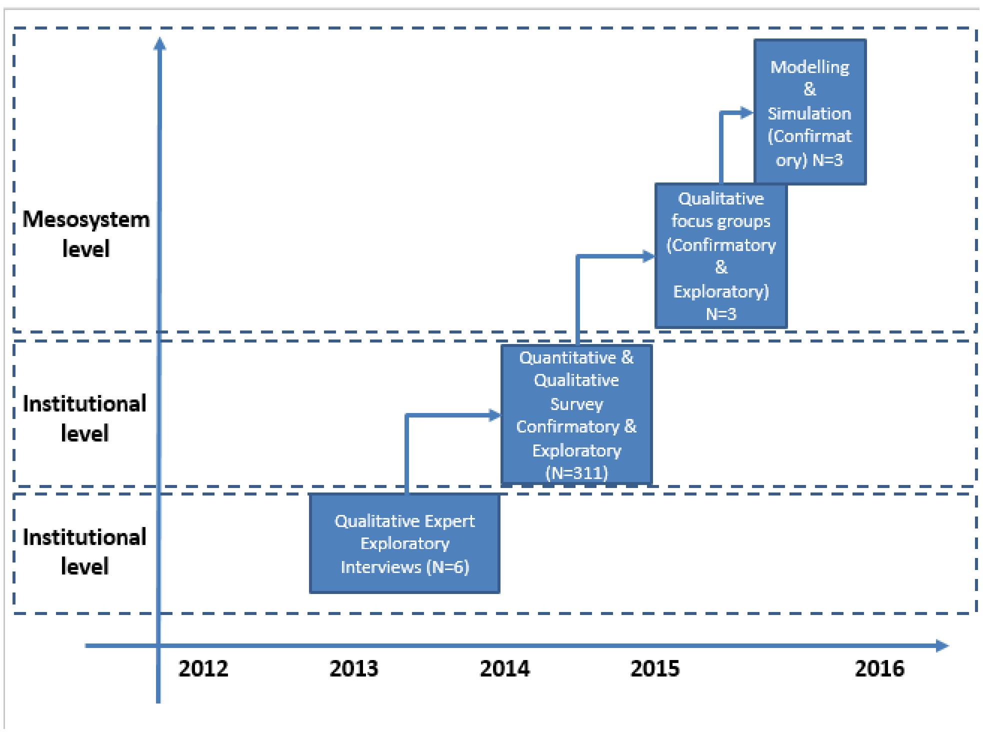

Figure 22: Methodological timeline

The next chapter (Chapter 4) presents the data analysis process following the implementation of the research described in Chapter 3.

Chapter 4: Data Analysis

4.1 Introduction

This chapter provides detailed insights into the data analysis and interpretation processes of each stage of the methodology employed by this thesis. Each of the three research stages is discussed in a separate section: Section 4.2 presents the results of Stage one; Section 4.3 presents the results of Stage two (with details for each item of the survey); Section 4.4 presents the results of Stage three (with details for both the focus groups and modelling and simulation); and Section 4.5 presents the overall summary of the data analysis.

The data analysis process for each stage is performed in a critical manner by relating to the literature as well as to the CRQs, OBs and TFT Pillars, however the triangulation and advanced critical discussion (of all stages together) is being performed in Chapter 5 (Discussion).

4.2 Stage one: Qualitative exploratory interviews

This first stage (as described in the methodology design section) consists of qualitative exploratory (expert) interviews with a representative sample (six) undertaken with companies from Romania, Bulgaria, Serbia, Greece, FYROM and Slovenia.

4.2.1 Methodological approach for performing inductive content analysis

The literature provides various qualitative data analysis methodologies (such as grounded theory, keyword mapping) however, for the purpose of this research, the key qualitative data analysis methodology is inductive content analysis based on its suitability for the purpose of this first (qualitative exploratory stage) as well as based on the high convergence of the literature towards this methodology which in the view of Thomas (2006) – is gaining the best momentum in qualitative research (the publication of Thomas, 2006 is the leading one on qualitative research data analysis through inductive content – with more than 2000 citations according to Google Scholar as well as by various journal citation indexes).

Inductive content analysis (as qualitative data analysis method) is used in situations where framework development is required (which is exactly the case for the purpose of this research) which means that this methodology is used in cases where there is substantial lack of research/information to build a robust model that can be subjected to confirmatory approaches (Elo & Kyngas, 2008; Thomas, 2006). To this end, inductive content analysis has been recently used quite extensively in environmentally sustainable (including resilient) supply chain research due to the lack of sufficient models that would grasp and properly integrate the complexity of this supply chain evolution (Wilhem et al., 2016; Perrez-Franco et al., 2016; Chiarini & Douglas, 2015; Saldanha et al., 2015; Stevenson & Busby, 2015). Based on the work of (Thomas, 2006), primarily, and confirmed/complemented by the aforementioned authors, inductive content analysis has the following goals and assumptions:

Goal of inductive content analysis: comprise heterogeneous wide ranges of text into a very objective summary towards building well defined connections between the findings of the analysis and the research objectives of the research. The ultimate goal is to propose/consolidate a framework about a certain behaviour that was explored through the qualitative research.

Assumption 1: Inductive content analysis (considering the fact that it builds links between the findings and the initial research objectives) is thus a mix of deductive (i.e. the research objectives/hypotheses emerged through a systematic literature review) and inductive (the actual outcome of content analysis).

Assumption 2: Inductive content analysis is based on data categorization (labels, text placed within the labels, inter-category links – all these integrated within a hierarchical or open network) that would provide relevant input towards supporting an initial research model or research objectives.

Assumption 3: Inductive content analysis may be biased on the experience and interest of the researcher/interpreter and to mitigate this, a clear differentiation of what is of core relevance in the analysis must be set. Having this bias, the trustworthiness and validity of the emerged model should be subjected to the following additional methodologies: research replication, triangulation, comparison with similar models (if they exist), feedback from the research participants as well as from the final users.

Thus, the inductive content analysis (Figure 23 shows its methodological stages) provides substantial incentives to support the research ideology of this thesis. In more specific terms, up to this point, an initial theoretical framework (research model) has been proposed in two stages: 1) firstly through and organizational theoretical foundation point of view of the INT, ST, DIT, CAST and EMT point of view in terms of explaining how RGFT/RGSCM can be implemented in a continuous process (from institutions to mesosystem and from mesosystem back to institutions). 2) Secondly this model based on the theoretical foundation fundament was subjected and supported/updated through a highly focused systematic literature review which revealed the potential of sustaining the validity of this model, however it also revealed a severe lack of research that would consolidate the model. This lack is even more severe as the focus of the model is SEE (which lacks research in comparison to average available publication in the global environment).

At this point (after the systematic literature review which leaded to an initial model development from which the specific research objectives have been derived), inductive content analysis will provide a further step in developing/consolidating this model by ensuring qualitative linkages among the core elements of the model that lacks substantial data (exactly in line with the goal of inductive content analysis as well as with Assumption 1 and Assumption 3).

Even more, Assumption 3 of inductive content analysis is highly in line with the overall methodology that will fully sustain the proposed model. More specifically, in order to ensure the validity of the inductive content analysis contribution to the model, three more stages will be employed (in full coherence with Assumption 3): the findings of the inductive content analysis will be triangulated with a large scale quantitative study and modelling & simulation as well as focus groups & interviews with the actual users of the model (institutions and mesosystem stakeholders) will be performed. Finally, in terms of the actual stages of inductive content analysis, the following roadmap (Figure 23) sustained by (Wilhem et al., 2016; Perrez-Franco et al., 2016; Chiarini & Douglas, 2015; Saldanha et al., 2015; Stevenson & Busby, 2015; Elo & Kyngas, 2008; Thomas, 2006) has been implemented:

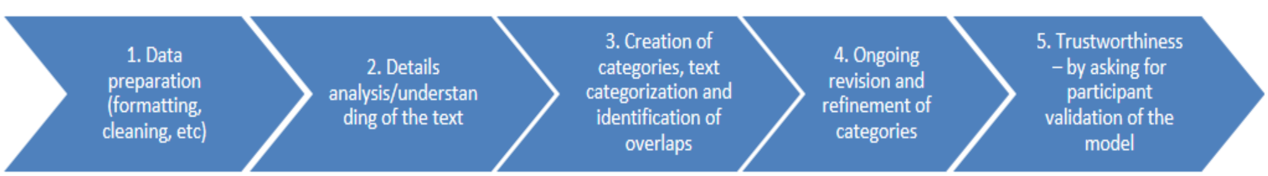

Figure 23: Inductive content analysis roadmap

4.2.2 Qualitative exploratory interviews – findings

As described in section 3.3.1 and 4.2.1, a number of six qualitative unstructured/open-ended interviews (phone interviews, about 50-60 minutes) have been performed during June-September 2014 (one per country from SEE) and inductive content analysis has been implemented in order to achieve the goal of this first stage: to further consolidate through exploration the theoretical framework derived through the systematic literature review. The participants (top-managers in their companies) have accepted to disclose their brand names as no highly sensitive data was requested. The profile of the companies is the following as presented in Table 9:

Table 9: First stage demographics

Company	Country/ Branch	Sector	Profile
Alcatel-Lucent (was bought by Nokia in 2016)	Romania	Telecommunications R&D department with integrated global supply chain (intermodal)	ROI: >10 M EUR pa Status: Large enterprise
Alcatel-Lucent (was bought by Nokia in 2016)	Bulgaria	Warehousing & Financial Services department with integrated global supply chain (intermodal)	ROI: >10 M EUR pa Status: Large enterprise
Autoprevoznistvo "Branko Urdih"	Serbia	3PL Cross-SEE Freight Transporter (road freight)	ROI: <0.5 M EUR pa Status: SME
Transcombi	Greece	3PL Cross-SEE Freight Transporter (road freight)	ROI: <0.5 M EUR pa Status: SME
Autoprevoznistvo "Branko Urdih"	Slovenia	3PL Cross-SEE Freight Transporter (road freight)	ROI: <0.5 M EUR pa Status: SME
Provident Foods	FYROM	Canned food producer with integrated cross SEE freight transportation. (road freight)	ROI: <0.5 M EUR pa Status: SME

Overall, the findings resulted after performing inductive content analysis with the strategy described in section 4.2.1 (as it will be shown in Table 10) did not bring substantially new information, however the findings did confirm to a certain extend the theoretical framework of the thesis leaving a promising ground for the next stage (confirmatory).

Table 10: Stage one outcomes

Stage one – Qualitative exploratory interviews findings			
Interview item	**Romania**	**Bulgaria**	**Serbia**
Overview on the negative business outcomes induced by (which) weather-induced disruptions upon the transportation system and identification of the utilized resilience KPIs.	Financial losses & inefficiencies (wastes) caused (only) by snow blizzards, storms, icy roads and occasionally floods. No brand damage as the company is market leader. Three main KPIs for resilience: cost, time and number of wrong deliveries.	Financial losses & inefficiencies (wastes) caused (mostly) by winds, storms, icy roads and occasionally floods or heat waves. No brand damage as the company is market leader. Main KPIs for resilience: cost, transportation time, time-on-stock, transportation distance, staff involvement.	Financial losses & severe freight deterioration caused (mostly) by winds, storms, icy roads and occasionally floods or other hazards. Since the company is 3PL – severe brand damage is encountered. Main KPIs for resilience: cost, transportation time, accuracy and safety/integrity of the product delivery.
Understand what green practices (in general) does the company implement and what drivers & barriers are countered (with relation to quintuple helix aspects also)	The company has environmental certification and utilizes generic green mechanisms: recycling, work-place energy efficiency & staff training. Green behaviour is normative and the main barriers are cost and lack of employee interest.	The company has environmental certification and utilizes generic green mechanisms: recycling, work-place energy efficiency & staff training. Green behaviour is normative and the main barriers are cost and lack of employee interest coupled with lack of inter-partner agreements.	The trucks comply to the necessary normative pressures (environmental), however the company does not have any dedicated green practices. Lack of motivation for more green practices is due to lack of normative drivers, lack of societal/coercive drivers and lack of interest from the contractors that higher this 3PL.
Understand what environmentally sustainable resilience practices does the company implement and how does the company communicate/co-creation with other stakeholders (i.e. other enterprise level institutions or quintuple helix ones)	Such practices are related to resource consumption efficiency and the limitation of hazardous products (normative driver) which are imposed to its transportation subcontractors. The only interaction at the quintuple helix level is normative towards policy and brand reputation (inner drive) towards the social image.	Such practices are related to resource consumption efficiency and the limitation of SKUs (inner financial driver) which are imposed to its transportation subcontractors. The only interaction at the quintuple helix level is normative towards policy compliance with very limited societal engagement.	Such practices are related to resource consumption efficiency and the limitation of hazardous products (normative driver) which can cause regulatory penalties as well as driver safety issues. No co-creation is being performed.
Understand how can the green resilience mechanisms of businesses be supported/fostered faster by other stakeholders from the quintuple helix mesosystem and what are the motivators (i.e. pressure, competition, interconnectedness).	Green resilience can indeed be faster only through collaboration at the quintuple helix stakeholder (mutual support and standardisation of practices/policies & transparency of operations, technology). Main driver: normative. Main blocker: fear of competition and of practice disclosure to environmental/societal actors. Eco-innovation implementation is feasible but risky.	Green resilience can indeed be faster only through collaboration at the quintuple helix stakeholder (mutual support and standardisation of practices/policies & transparency of operations, technology). Main driver: normative. Main blocker: heterogeneity and complexity of such collaboration. Eco-innovation implementation is feasible but risky.	Green resilience can indeed be faster only through collaboration at the quintuple helix stakeholder (mutual support and standardisation of practices/policies, transparency of operations, better regional planning, enhanced transportation infrastructure, use of technology). Main driver: normative. Main blocker: heterogeneity and complexity of such collaboration. Eco-innovation implementation is not something that the company can afford.
Understand how compatible are the KPIs of the company with the ones of the other quintuple helix stakeholders	The mission (green resilience) can be indeed compatible, however the mechanisms and the individual goals & KPIs cannot be aligned.	Green resilience mostly under resource efficiency) can be indeed compatible, however the mechanisms and the individual goals & KPIs cannot be aligned especially	In absence of a proper quintuple helix governance and integration of all actors in the decision making processes, there is no compatibility among the KPIs involved.

		due to lack of governmental support and no societal pressure.	
Stage one – Qualitative exploratory interviews findings			
Interview item	**FYROM**	**Greece**	**Slovenia**
Overview on the negative business outcomes induced by (which) weather-induced disruptions upon the transportation system and identification of the utilized resilience KPIs	Financial losses, delays and cargo deterioration caused (mostly) by winds, storms and blizzards. Since the company operates in the food sector, transportation safety is critical. KPIs for resilience: cost, transportation time, accuracy and safety/integrity of the product delivery.	Financial losses & inefficiencies (wastes) caused (mostly) by winds, storms, and occasionally icy roads or heat waves. Since the company is 3PL –brand damage is encountered. KPIs for resilience: cost, transportation time, accuracy and safety/integrity of the product delivery.	Financial losses & inefficiencies (wastes) caused (mostly) by winds, storms, icy roads and occasionally floods or other hazards. Since the company is 3PL – severe brand damage is encountered. Main KPIs for resilience: cost, transportation time, accuracy and safety/integrity of the product delivery with core leverage of safety factors.
Understand what green practices (in general) does the company implement and what drivers & barriers are countered (with relation to quintuple helix aspects also)	The trucks comply to the necessary normative pressures (environmental), however the company does not have any dedicated green practices due to lack of normative and coercive pressures.	The company has environmental certification and utilizes generic green mechanisms: work-place energy efficiency & staff training. Green behaviour is normative and the main barriers are cost and lack of employee interest coupled with lack of inter-partner agreements.	The trucks comply to the necessary normative pressures (environmental), however the company does not have any dedicated green practices. Lack of motivation for more green practices is due to lack of normative drivers, lack of societal/coercive drivers and lack of interest from the contractors that higher this 3PL (recent trends are developing)
Understand what environmentally sustainable resilience practices does the company implement and how does the company communicate/co-creation with other stakeholders (i.e. other enterprise level institutions or quintuple helix ones)	Such practices are related to resource consumption efficiency (financial driver). No co-creation is being performed. Other environmentally sustainable practices are related to renewable energy (solar panels) but there is no general strategy in this matter (normative & coercive)	Such practices are related to resource consumption efficiency and the limitation of social & environmental hazards (normative driver). Co-creation is starting to be initiated in terms of collaboration with environmental and/or social organizations however there is lack of coordination.	Such practices are related to resource consumption efficiency and the limitation of hazardous products (normative driver) which can cause regulatory penalties as well as driver safety issues. Co-creation is starting to be initiated in terms of collaboration with environmental and/or social organizations.
Understand how can the green resilience mechanisms of businesses be supported/fostered faster by other stakeholders from the quintuple helix mesosystem and what are the motivators (i.e. pressure, competition, interconnectedness).	Green resilience can indeed be faster only through collaboration at the quintuple helix stakeholder (mutual support and standardisation of practices/policies, transparency of operations, better regional planning, enhanced transportation infrastructure, use of technology), however the FYROM context is far behind.	Green resilience can indeed be faster only through collaboration at the quintuple helix stakeholder (mutual support and standardisation of practices/policies & transparency of operations, technology). Main driver: normative & coercive. Main blocker: heterogeneity and complexity of such collaboration. Eco-innovation implementation is feasible but risky and requires collaboration at the regional level.	Green resilience can indeed be faster only through collaboration at the quintuple helix stakeholder (mutual support and standardisation of practices/policies, transparency of operations, better regional planning, enhanced transportation infrastructure, use of technology). Main driver: normative. Main blocker: heterogeneity and complexity of such collaboration. Eco-innovation implementation is not something that the company can afford.
Understand how compatible are the KPIs of the company with the ones of the other quintuple helix stakeholders	In absence of a proper quintuple helix governance and integration of all actors in the decision making processes, there is no compatibility among the KPIs involved (nor will be in the near future).	There is very limited compatibility of the KPIs, however normative (and lately coercive – society & environmental organisations) play a great role towards KPI alignment.	In absence of a proper quintuple helix governance and integration of all actors in the decision making processes, there is no compatibility among the KPIs involved – however society pressures for this compatibility.

4.2.3 Qualitative exploratory interviews – implications

The findings presented in section 4.2.2 have been cross-validated (by asking confirmation from the interviews after the interview results have been structured through inductive content analysis). The findings are, in general lines, in coherence with the proposed theoretical framework, however in certain cases – as it will show below, novel insight has been provided. These outcomes will be used to strengthen the systematic literature review based theoretical framework of this thesis and to provide core input for the second stage.

The implications of the first stage's results on the OBs, CRQs and TFT Pillars are:

Firslty, this first research stage contributes to CRQ1, CRQ2, CRQ3, CRQ6, CRQ7 (also relates to OB3.1, OB3.2, OB3.3, OB3.4) by arguing that in order for eco-innovations to be diffused (as stipulated by the DIT) at the entire mesosytem level, co-creation is required pointing towards EMT research in a quintuple helix framework (*"[…] will work only if all actors collaborate", "I believe that working together […] can enable beter adoption/implementation of such practices, however I am not sure that this is actually happening"*) – being thus consistent with (Ivanaj et al., 2015; Hsu et al., 2013; Hu & Hsu, 2010; Ninlawani et al., 2010; Mont & Leire, 2009; Seuring & Muller, 2008; Walker et al., 2008; Srivastava, 2007; Chien & Shih, 2007; Wright & Elcock, 2006; Tsoulfas & Pappis, 2006; Yalabik et al., 2005; Evans & Johnson, 2005; Eveloy et al., 2005; Handfield et al., 2005), as well as by providing insights into the fact that the modernized & complex mesosystem can indeed generate normative (institutional) pressures (explained by INT and ST) on the mesosystem (i.e. to adopt especially technology based RGFT/RGSCM practices) towards enabling eco-resilience (CAST based), however this process is not properly taking place due to lack of a general "orchestrator"/moderator of this complex system as well as due to the different objectives of the involved quintuple helix stakeholders as also mentioned by (Dubey et al., 2015; Govindan et al., 2015; Ivanaj et al., 2015; Tian et al., 2014; Chakrabarty & Wang, 2013; Lee, 2008; Chien & Shih, 2007; Papadopoulos & Giama, 2007) (Hu & Hsu, 2010; Zhu & Sarkis, 2006; Widmer et al., 2005; Huang, 2005).

For example, in Greece and Slovenia it has been identified that society & environmental organisations are the triggers/generators/orchestrators of eco-innovation adoption at the ecosystem level as well as the triggers of quintuple helix KPI and eco-goal alignment in terms of

RGFT/RGSCM practice adoption *("society including out customers are pushing us [businesses] to be green and responsible more than the actual governmental regulations […] at the end of the day we need to comply to what our target market demands")*. On the other hand, in Romania, Serbia and Bulgaria, the government is seen as key stakeholder that should trigger the quintuple helix co-creation towards eco-innovation adoption ("*the government is the key actor that pushes us [businesses] to be green*"). Alternatively, in FYROM, the perception is that there is no such contextual discussion due to the underdeveloped stage of the country ("*there is very little talk at each stakeholder about these issues*") confirming thus (Govindan et al., 2015; Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Hsu et al., 2013; Shi et al., 2012; Rehman & Shrivastava, 2011; Zhu et al., 2010; Testa & Iraldo, 2010; Carter & Rogers, 2008; Chen, 2008; Vachon & Klassen, 2007; Chien & Shih, 2007; Ellen et al., 2006; Capaldi, 2005). There is no clear evidence of how this first stage impacts though on **CRQ4 and CRQ5** (as this was not the purpose of this stage). These findings provide also (limited but useful) confirmation of **Pillar 2, Pillar 3, Pillar 3, Pillar 5 and Pillar 6** of the TFT. **Pillar 1 and Pillar 7** are not substantially informed by these findings.

Secondly, the first stage also contributes to OB1 by confirming several of the extreme weather disruptions identified through the systematic literature review. For example, Romania, Slovenia, Bulgaria and Serbia countries encounter extreme winds, blizzards, icy roads, storms and in several cases floods – as core disruptions for the freight transportation system, while Greece and FYROM encounter mostly extreme winds, storms and in very isolated cases – extreme wheat waves extending thus the work of (Li & Coates, 2016; Chhetri et al., 2016; Snyder et al., 2015; Loh & Thai, 2015; Mattson & Jenelius, 2015; Global risks, 2015; GAR, 2015; Van der Vegt et al., 2015; Linnenluecke et al., 2012; Ergun et al., 2010; Natarajarathinam et al., 2009; Stecke & Kumar, 2009; Nakano, 2009; Sanchez-Rodriguez et al., 2008; Linnenluecke et al., 2012; Ross, 2003; Hale & Moberg, 2005 Monahan et al., 2003).

Thirdly, the first stage contributes to OB2.1, OB2.2, OB2.3, OB2.4, OB2.5, OB2.6 by denoting the following negative business outcomes induced by natural/weather disruptions: financial losses, delays (in all countries), cargo deterioration (in FYROM and Serbia), brand damage (Serbia, Slovenia, FYROM) and general inefficiencies/wastes (in Romania, Bulgaria, Greece and Slovenia). Additionally, the first stage revealed that businesses use the following KPIs when dealing with resilience: cost, recovery time and accuracy of the delivered product (all countries), safety of the product delivery (Serbia, FYROM, Greece, Slovenia), on-stock-timeline (Bulgaria). Furthermore, businesses do implement green practices as means of normative drivers, however most of these practices are not directly linked to eco-resilience (being rather indirect effects of cost optimization – such as resource efficiency) supporting thus the claims of (Govindan et al., 2015; Ivanaj et al., 2015; Zaabi et al., 2013; Balasubramaniam, 2012; Diabat & Govindan, 2011; Vachon & Klassen, 2008; Sharfman et al., 2007; Verghese & Lewis, 2007; Hick, 2000).

Nevertheless, as mentioned before, in countries such as Greece and Slovenia – environmental and social considerations are seen to become the new drivers of coercive (this time) adoption of RGFT/RGSCM practices as wider depths. The interviews revealed that there is no clear reference to specific resilience practices rather than having generic risk mitigation mechanisms under cost & time efficiency – primarily *("yes we implement risk mitigation […] and management but we do not have an environmentally friendly approach to forecast and prepare this")*. Finally, the results show that there is limited co-creation among the quintuple helix stakeholders and that there is no general coordination in terms of RGFT/RGSCM practice diffusion and KPI alignment ("*we need collaboration and working together but this […] is not happening at the moment*") being thus consistent with (Ivanaj et al., 2015; Hsu et al., 2013; Hu & Hsu, 2010; Ninlawani et al., 2010; Mont & Leire, 2009; Seuring & Muller, 2008; Walker et al., 2008; Srivastava, 2007; Chien & Shih, 2007; Wright & Elcock, 2006; Tsoulfas & Pappis, 2006; Yalabik et al., 2005; Evans & Johnson, 2005; Eveloy et al., 2005; Handfield et al., 2005; Widmer et al., 2005; WEEE, 2003). Countries such as Greece and Slovenia believe that the co-creation triggers should be society & environmental organizations, while the others, perceive that the government should be the trigger.

These aspects revealed through the first stage do provide an initial input into understanding the core disruptions, and serve as basis for inclusion (besides many other factors revealed through the literature review) in the second stage (confirmatory survey) in order to test and explore at large scale and in more depths the hypotheses.

4.3 Stage two: Quantitative confirmatory & exploratory survey

The second stage of the research methodology (survey) was implemented in six SEE countries (Romania, Serbia, FYROM, Bulgaria, Greece, Slovenia) and the following industries were targeted: freight transportation carriers, general logistics service providers, 3PL/4PL carriers, Production/Manufacturing with integrated transportation companies, and retail/commerce companies with integrated transportation.

The surveys were hand delivered to the companies via a market survey and research company. They were handed to managers and/or staff responsible for environmental management. After the completion of the surveys by the managers, the responsible staff collected the hard copies of the surveys and mailed the responses to the researcher (with full anonymity and without any reference to the company and the person filling in the survey). The data collection process took four months (December 2014 and March 2015) and there were no major delays or issues encountered in this endeavour. All the ethical consideration mentioned in Appendix B (and also mentioned in the research design section) have been considered and duly respected in order to confirm with the regulation of the University of Sheffield.

The principal investigator (the PhD candidate) has received all the filled in hard copies of the survey and has coded all the complete ones into SPSS. For this purpose, only fully completed surveys have been coded into SPSS in order to enable full data consistency and uniformity.

In total, a number of 1121 hard copies were distributed to companies from the six countries from which 392 responses have been collected (34% response rate). From the 392 responses, 311 (27% valid response rate) were fully completed (as well as the respondent answered the he/she was responsible for environmental concerns in their companies). This was deemed valid and were coded in SPSS.

Each measured variables was mapped into a SPSS spreadsheet column. In total, 147 variables were created in SPSS in order to be analysed. Consequently, 311 data lines were added to incorporate the values provided by each valid respondent.

The following subsections present in details (each) various analyses that have been performed on the coded data and the implications for the TFT. The analyses cover basic demographics and their impact/relevance on the data, weather conditions that cause disruptions, key performance indicators, current use of green practices, drivers and barriers to the use of green practices, resilience mechanisms and strategies, and behavioural analysis for the implementation/adoption of resilient and green freight transportation (RGFT/RGSCM) strategies at the institutional level (and the convergence to mesosystem level).

4.3.1 Demographics

Demographics are valuable indicators as well as critical factor when it comes to decision making processes towards the application of new technologies, transportation resilience mechanisms and environmental strategies that cross the boundaries of one specific region or country.

When it comes to the transportation infrastructure, the SEE region is very homogenous especially in the problems encountered by road freight carriers. Additionally, the businesses that operate in the freight transportation sector have similar structures and mindsets towards technology adoption for resilience and environmental solutions. Similar contextualized work has been performed by (Matopoulos et al., 2009; Matopoulos et al., 2007; Manthou et al., 2005), however not specifcally focused on environmental solutions. To this end, it is important to identify what demographic trends related to these aspects persist in SEE and how exactly these variables impact and influence other decision making variables with implications for the TFT.

The data collected has the following country distribution: Romania (28.30%), Bulgaria (26.69%), Greece (17.68%), Serbia (10.61%), Slovenia (10.29%) and FYROM (6.43%). These numbers are in totally conformity with the proportional numbers of country size, population and number of freight transportation related companies form that country, leading to a uniform distribution of the findings (Table 11).

Secondly, the companies that have participated to the survey, fall into the following categories: freight transportation carriers (44.37%), general logistics (14.47%), 3PL/4PL (10.93%), production/manufacturing with integrated transportation (11.90%), and retail/commerce with integrated transportation (18.33%). These findings are very relevant and useful since the majority of the respondents (freight transportation carriers and general logistics) have full expertise and interest in advancing their freight transportation systems since this is their main business objective/means, while for the others (3PL/4PL, production/manufacturing and retail/commerce), freight transportation comes just a s a part of their business model.

Table 11: Stage two- sectoral distribution

		Sector					
		Freight transportation	General logistics	3PL/4PL	Production/ Manufacturing	Retail/ commerce	Totals
		Count	Count	Count	Count	Count	
Country	BG	40	12	9	4	18	83
	FYROM	5	4	3	3	5	20
	GR	30	8	4	5	8	55
	RO	31	12	15	18	12	88
	SLO	13	6	0	4	9	32
	SRB	19	3	3	3	5	33
	Totals	138	45	34	37	57	311

Thirdly, regarding the company size, the answers were somewhat proportionally distributed with the following values: 27.97% of the companies have under 25 employees, 23.79% of the companies have 26-50 employees, 26.05% of the companies have 51-250 employees and 22.19% of the companies have over 251 employees. This distribution is very good for the reliability and usability of the findings since various business types with integrated/tangent transportation systems have been covered by the survey (MMEs, SMEs and large enterprises).

Fourthly, the companies were asked to state the annual turnover range and the following values have emerged: 45.98% of the companies have an annual turnover under 1 million Euros, 32.80% of the companies have an annual turnover between 1 and 5 million Euros, 20.90% of the companies have an annual turnover between 5 and 10 million Euros and 0.32% of the companies have an annual turnover over 10 million Euros. These turnovers are relevant when it comes to devising proper strategies that affect the freight transportation of those specific companies (having in mind the actual business value of the company).

Fifthly, 80.06% of the respondents were male, while only 19.94% of them were female, denoting the gender imbalance from this sector. In similar manner, the age groups of the respondents show that 50.80% of them are between 50 and 64 years old, while 49.20% of them are between 36 and 49 year old. The age ranges are consistent with the general expertise and experience required to be qualified for the duties of the job nature of the respondents. Additionally, 65.92% of the respondents have a Bachelor's degree, 29.26% of them have also a Master's degree and 4.82% of them have a PhD.

Sixthly, in order to briefly view the trend of technology and new practice adoption in the targeted companies, the respondents were asked whether their company has had such a behaviour in the last five years. As a result, 84.89% responded positively, while 15.11% declared that the company did not make any such adoption/implementation in the last five year (Table 12).

Table 12: Stage two- Technology adoption accross ROI

		Turnover				
		<1 M	1M-5M	5M-10M	>10M	Totals
		Count	Count	Count	Count	
Technology Adoption	NO	19	16	11	1	47
	YES	124	86	54	0	264
Totals		143	102	65	1	311

4.3.2 Weather/Natural conditions that cause disruptions

4.3.2.1 Weather conditions

The weather conditions variable was tested using a 5 level Likert Scale, where 1 denoted that the tested environmental condition was rarely or never causing disruptions to the respondent's company during their transportation operations, while 5 denoted very high frequency and high disruptions to the operations of the company.

The most frequent weather event (that caused disruptions) encountered by the respondents was "Icy roads" (4.16 out of 5), then "Snowfall" (4.15 out of 5), "Fog" (3.88 out of 5), "Heavy rains" (3.45 out of 5), and "Blizzards" (3.77 out of 5). At the opposite pole, the weather conditions that caused the least disruption to the company were: "Heat waves" (1.31 out of 5), "Cold weaves" (1.46 out of 5), "Strong winds" (2.87 out of 5), "Floods" (2.08 out of 5), and "Thunder storms" (2.13 out of 5). These findings are coherent with (Li & Coates, 2016; Chhetri et al., 2016; Snyder et al., 2015; Loh & Thai, 2015; Mattson & Jenelius, 2015; Global risks, 2015; GAR, 2015; Van der Vegt et al., 2015; Linnenluecke et al., 2012; Ergun et al., 2010; Natarajarathinam et al., 2009; Stecke & Kumar, 2009; Nakano, 2009; Sanchez-Rodriguez et al., 2008; Linnenluecke et al., 2012; Ross, 2003; Hale & Moberg, 2005 Monahan et al., 2003).

These findings confirm the geographical analysis performed on the countries in which the survey was carried out, showing that the main disruption in the fright transportation systems of companies' are proportional and linked with the most problematic weather conditions faced by those countries (which are mostly due in winter time and rain extremes during summer).

Table 29 (Appendix F) shows the weather conditions and their relevance per country. The findings do not show high country related specificity (the SD of each indicator per country is around 8%) in terms of the impact of these weather conditions that cause disruptions, which confirms the homogeneity of the road freight transportation conditions in SEE.

4.3.2.2 Business outcomes of the weather conditions

The business outcome/damage (after whichever weather conditions) variable was tested using a 5 level Likert Scale, where 1 denoted that the tested business outcome/damage was rarely or never frequent to the respondent's company during their transportation operations, while 5 denoted very high frequency of the business outcome/damage to the operations of the company.

According to the results, the most frequent business outcome/damage encountered by the respondents' companies was "Delays in delivery" (4.51 out of 5), "Overall coordination issues" (4.19 out of 5), "Client complains" (4.06 out of 5) , "Loss of revenue" (4.05 out of 5), "Increased fuel consumption" (4.03 out of 5), "Extra cost" (3.98 out of 5), "Decrease of speed" (3.85 out of 5), "Increased CO2 emission" (3.60 out of 5), "Inventory inconsistencies" (3.53 out of 5), "Congestion" (3.46 out of 5), "Longer distance" (3.38 out of 5), "Missed deliveries" (3.21 out of 5), "Staff complains" (3.02 out of 5) which confirm the work of (Li & Coates, 2016; Chhetri et al., 2016; Snyder et al., 2015; Loh & Thai, 2015; Mattson & Jenelius, 2015; Global risks, 2015; GAR, 2015; Van der Vegt et al., 2015; Linnenluecke et al., 2012; Ergun et al., 2010; Natarajarathinam et al., 2009; Stecke & Kumar, 2009; Nakano, 2009; Sanchez-Rodriguez et al., 2008; Linnenluecke et al., 2012; Ross, 2003; Hale & Moberg, 2005 Monahan et al., 2003).

On the other side, the least business damage that was encountered as an outcome of the weather conditions was "Damage to infrastructure" (1.93 out of 5) followed by "Increased truck degradation" (1.95 out of 5), "Increased lubricant consumption" (2.03 out of 5), "Safety issues" (2.14 out of 5) and "Damage to vehicles" (2.17 out of 5). These findings are in contradiction with certain findings of (Global risks, 2015; GAR, 2015; Van der Vegt et al., 2015; Linnenluecke et al., 2012).

Additionally, near each business outcome/damage encountered, the respondents had the option to qualitatively provide the weather condition from the previous table which caused the specific business outcome. Table 30 (Appendix F) summarizes the relations between the most frequent/relevant weather conditions (that scored over 3 out of 5) and the most damaging business outcomes (that scored over 3 out of 5). These findings are consistent with (Li & Coates, 2016; Chhetri et al., 2016; Snyder et al., 2015; Loh & Thai, 2015; Mattson & Jenelius, 2015).

4.3.2.3 Relations between weather conditions and business outcomes

As it can be seen in the Table 31 (Appendix F), the most relevant relations between the most frequent weather conditions and the most frequent negative business outcomes are consistent with the previous findings. A correlation for internal consistency and homogeneity and an ANOVA (Table 13) test for reliability show the following significance for the relation between business outcomes and weather conditions:

Table 13: Stage two - business outcomes & weather conditions - ANOVA

Statistical/Scientific test	Observation
	• **Triangulation**: Both the qualitative analysis (first stage) and the quantitative rating converge over the same findings. • **ANOVA** (the following selection retrieves only the variables with significance coefficient under 0.05):

ANOVA Factor	Groups with significance coefficient under 0.05

<table>
<tr><td rowspan="6">Test-Retest reliability and validity</td><td>Cold waves</td><td>Overall coordination issues (0.04)</td><td>Longer Distances (0.49)</td><td>Safety issues (0.31)</td><td></td></tr>
<tr><td>Heavy rains</td><td>Extra cost (0.03)</td><td>-</td><td>-</td><td></td></tr>
<tr><td>Icy roads</td><td>Inventory inconsistencies (0.019)</td><td>-</td><td>-</td><td></td></tr>
<tr><td>Strong winds</td><td>Overall coordination issues (0.005)</td><td>-</td><td>-</td><td></td></tr>
<tr><td>Thunder Storms, Blizzards, Floods, Snowfall, Heatwaves</td><td>-</td><td>-</td><td>-</td><td></td></tr>
<tr><td>Fog</td><td>Damage of goods (0.004)</td><td>Decrease of speed (0.002)</td><td>Damage to vehicles (0.041)</td><td></td></tr>
<tr><td>Partial correlation tests</td><td colspan="5">Since the survey elements for this specific construct adopt an exploratory approach towards the identification of these variables, an initial assumption of a potential linear relationship (either positive or negative) has been made. However, partial correlation test for the relation between weather conditions and business outcomes suggests that there is no significant correlation (as all values either positive or negative are between -0.3 and -0.3). Still this aspect does not necessarily contradict the findings emerged in the previous tables (i.e. where there are high percentages of the sample that for example believe that snow fall is responsible in 87% of the cases for loss of revenue). The existence of this non-linearity points towards the fact that a multi-variable approach/decision making is involved in such correlation.</td></tr>
</table>

4.3.3 Key performance indicators

4.3.3.1 Economic and operational key performance indicators

The economic and operational key performance indicator variable was tested using a 5 level Likert Scale, where 1 denoted that the tested indicator was not important for the company, while 5 denoted that the indicator was very important for the decision making process of the company.

The most important economic and operational key performance indicators were: “Customer satisfaction” (4.09 out of 5), “Total fuel consumption” (4.00 out of 5), “Total time” (4.00 out of 5), “Focal firm profit” (3.99 out of 5), “Cost per TKM” (3.97 out of 5), “Efficiency during disruptions” (3.15 out of 5), “Corridor availability and capacity” (3.11 out of 5), “Efficiency before disruptions” (3.08 out of 5), “Service frequency” (3.08 out of 5),”Distance to cover” (3.05 out of 5), “Reliability of transport” (3.04 out of 5), “Safety of transport” (3.03 out of 5) and “On time deliveries” (3.03 out of 5). On the other side, the least important economic and operational key performance indicators were: “Load and unload time” (2.85 out of 5), “Iteration time” (2.86 out of 5), “Access to modal shift” (2.89 out of 5), “Truck load efficiency” (2.96 out of 5), “Transportation speed” (2.97 out of 5), and “Number of stops required” (2.99 out of 5). These findings are consistent with **(**Baumgartner et al., 2015; Piotrowicz, W., & Cuthbertson, 2015; Bhattacharya et al., 2014; Varsei et al., 2014; Ahi & Searcy, 2015a; Ahi & Searcy, 2015b; Gopal & Thakkar, 2012; Ninlawani et al., 2010; Shang et al., 2010; Aragon-Correa et al., 2008; Zhu et al., 2007; Vachon and Klassen, 2006; Hervani et al., 2005; Gonzalez-Benito, 2005; Rao and Holt, 2005; Zhu and Sarkis, 2011**).**

Table 32 (Appendix F) shows a breakdown of the economic and operational key performance indicators per country. The findings do not show high country related specificity (the SD of each indicator per country is around 10%) in terms of the importance of these KPIs which confirms the homogeneity of the road freight transportation system in SEE.

Additionally, an analysis has been performed in order to observe the distribution of the most important (score above 3 out of 5) operational and economic KPIs against the business sector and the revenue of the companies. The results presented in Table 18 (Appendix F) have been reached.

The findings from Table 33 (Appendix F) show a uniform distribution of the economic and operational KPI measurement both across company size (in terms of revenues) as well as across the business sector which define the companies. An average SD of 6% is noticed in relation to the company size and a SD of 7.2% is noticed in relation to the business sector. These findings denote the homogeneity and linearity of the economic and operational KPIs from the entire sample, making the connection with other findings more and useful and multi-purposed. These findings are, however, at the institutional/stakeholder level only across supply chain related institutions (not including the other quintuple helix actors).

4.3.3.2 Environmental key performance indicators

The environmental key performance indicator variable was tested using a 5 level Likert Scale, where 1 denoted that the tested indicator was not important for the company, while 5 denoted that the indicator was very important for the decision making process of the company.

According to the results, the most important environmental key performance indicators were: "Environmental penalties" (4.01 out of 5), "Total Energy Used" (3.95 out of 5) and "Mileage" (3.18 out of 5). On the other hand, the least important environmental KPIs were: "Land waste" (2.06 out of 5), "Engine standards" (2.88 out of 5), "Total CO2 per TKM" (2.91 out of 5) and "Driver efficiency" (2.96 out of 5) which are in line with Baumgartner et al., 2015; Piotrowicz, W., & Cuthbertson, 2015; Bhattacharya et al., 2014; Varsei et al., 2014; Ahi & Searcy, 2015a; Ahi & Searcy, 2015b; Gopal & Thakkar, 2012; Zhu et al., 2012).

Table 34 (Appendix F) shows a breakdown of the environmental key performance indicators per country. The findings do not show high country related specificity (the SD of each indicator per country is around 9.2%) in terms of the importance of these KPIs which confirms the homogeneity of the road freight transportation system and the related environmental KPIs utilization in SEE binding thus added value to the international context of EMT, DIT, CAST, ST and INT research (Govindan et al., 2015; Tian et al., 2014; Zhu & Geng, 2013; Dornfield et al., 2013; Sarkis et al., 2011; Rivera, 2004).

Additionally, an analysis has been performed in order to observe the distribution of the most important (score above 3 out of 5) environmental KPIs against the business sector and the revenue of the companies. This is very important in order to understand the variance in utilization/implementation of the environmental KPIs as compared with the economic and operational KPIs debated in the previous subsection. The results displayed in Table 20 (Appendix F) have been reached.

The findings from Table 35 (Appendix F) show a uniform distribution of the environmental KPI measurement both across company size (in terms of revenues) as well as across the business sector which define the companies. An average SD of 9.8% is noticed in relation to the company size and a SD of 11.2% is noticed in relation to the business sector. These findings denote the homogeneity and linearity of the environmental KPIs from the entire sample, making the connection with other findings more and useful and multi-purposed.

4.3.3.4 Correlations between KPIs and the business outcomes induced by weather conditions

Basically, the previous two subsections show evidence that both environmental and economic/operational KPIs are homogenous and uniformly distributed over the surveyed sample. Since the KPIs analyzed in the previous tables are of high importance (scoring over 3 out of 5), it is important to identify potential relationships between economic/operational and environmental KPIs in order to establish whether there is a linear correlation between the intersecting/conflicting variables or whether the variables overlap (for example “Total Energy Used” from the environmental KPIs might overall or have linear correlation with “Total fuel consumption” from the economic/operational KPIs. The main rational of this action is to establish the character of each measured KPI as independent variable. Table 14 summarizes the correlations which have been tested for reliability and validity:

Table 14: Stage two - reliability & validity testing for the core KPIs

	Total Energy Used	Mileage	Environmental Penalties
Cost per TKM	(r=-0.06)	(r=-0.04)	(r=-0.04)
Focal Firm Profit	(r=-0.15)	(r=-0.00)	(r=-0.05)
Total Time	(r=-0.02)	(r=0.01)	(r=-0.03)
On Time Deliveries	(r=-0.02)	(r=-0.02)	(r=-0.03)
Service Frequency	(r=-0.02)	(r= 0.06)	(r= 0.03)
Reliability of Transport	(r=-0.05)	(r=-0.06)	(r=-0.02)
Distance to Cover	(r=-0.01)	(r=-0.04)	(r=-0.02)
Efficiency During Disruptions	(r=-0.03)	(r= 0.03)	(r=-0.05)
Efficiency Before Disruptions	(r=-0.08)	(r= 0.02)	(r= 0.11)
Trips Required for Shipment	(r= 0.05)	(r= 0.09)	(r= 0.07)
Total Fuel Consumption	(r= 0.05)	(r= 0.02)	(r= 0.04)
Customer Satisfaction	(r= 0.04)	(r= -0.06)	(r= 0.07)
Safety of Transportation	(r=-0.03)	(r= 0.11)	(r= -0.04)
Corridor Availability and Capacity	(r= 0.12)	(r= -0.01)	(r= 0.03)

After performing a bivariate correlation analysis (Pearson), it has been established that each of the variables above that were measured as having a significant impact on the business performance are totally independent (no linear relation) among them as all the Pearson coefficients were between (-0.19 and 0.19). This finding can be significant since this is a proof that companies give consideration to environmental KPIs as individual/integral parts of their business models and use these KPIs towards achieving the business objectives.

In the previous subchapters, the relation between the negative business outcomes and the weather conditions has been identified based on the most rated variables. To this end, that relation can now be extended to include the KPIs that are tangent to the negative business outcomes identified. Table 36 (Appendix F) integrates these three elements and provides also the rating values (score out of 5 for the KPIs and Weather induced disruptions as well as percentages for the weather conditions disruptions that contribute as a leading party to the disruptions).

4.3.4 Current use of green practices

4.3.4.1 Company related use of green practices analysis

The company related use of green practices variable was tested using a 5 level Likert Scale, where 1 denoted that the tested indicator was not considered to be implemented by the company, while 5 denoted that the indicator was already being implemented by the company. The findings (Table 15) show a surprisingly low implementation of green practices and policies, most of the companies being at the consideration phase. However, the validity of these findings is confirmed through the triangulation with the first stage (fully qualitative).

Table 15: Stage two - current use of green practices

	Not considering/ Unaware	Planning to consider	Currently considering	Initiating implementation	Implemented
EMS	37.5%	26.7%	34.6%	0	0
TQEM	31.4%	32.7%	34.6%	0	0
ISO14001	31.7%	34.6%	32.4%	0	0
Energy Audits	36.5%	30.2%	32.1%	0	0
Products Reduced Consumption	0	29.8%	34.9%	34.0%	0
Products Reduced Waste	32.4%	32.1%	34.3%	0	0
Process Reduced Odor	39.4%	29.2%	30.2%	0	0
Process Reduced Waste	34.6%	35.6%	28.6%	0	0
Process Reduced Hazards	0	30.5%	36.5%	31.7%	0
Process Improved Efficiency	0	32.4%	37.1%	29.2%	0

Redesign Supply Chain	0	29.5%	33.3%	35.9%	0
Environmental Training	30.2%	32.4%	36.2%	0	0
Senior Management Commitment	32.1%	33.3%	33.3%	0	0
Middle Management Commitment	34.0%	34.3%	30.5%	0	0
Environmental Request Suppliers	33.0%	31.7%	34.0%	0	0
Environmental Collaboration Suppliers	34.3%	31.1%	33.3%	0	0
Written Requirements Suppliers	35.2%	33.0%	30.5%	0	0
Supplier Commitment Waste Reduction	33.7%	34.3%	30.8%	0	0
Suppliers Must Implement EMS	29.5%	34.9%	34.3%	0	0
Environmental Evaluations Suppliers	33.3%	31.7%	29.8%	2.2%	1.6%

The above findings denote the following implications:

An average of 29.94% of the companies are wither unaware or not considering the implementation of green practices. This finding points towards the need of proper techniques/tools that would stimulate these companies to adopt green practices, while also feeding them with the necessary information to be aware of the existing green solutions.

An average of 32% of the companies are planning to consider the implementation of green practices. This fraction of the sample is already informed/aware by the existence of such practices and are planning (in the near future) to implement them in their companies. For this sample, it is necessary to provide step by step instructions/training and solutions so that their motivation and ease of implementation of the green solutions is facilitated.

An average of 30.07% of the companies are currently considering the implementation of green practices (or have already done some preliminary implementation facilitations). This means that this specific sample has already all the motivation necessary and is in need for solutions that will facilitate the implementation of green practices in order to ensure a successful adoption of such solution.

An average of 7% of the companies have already started implementing green practices (and they are more than half-way through). This sample requires thus consolidated support and solutions for making sure that they fully take advantage of those practices.

An average of under 1% of the companies have stated that they have successfully managed to implement green practices. This sample needs to be motivated to diversify the range of practices they adopted.

Roughly it can be stated that 30% of the surveyed companies are either unaware or unwilling to implement green practices, 30% of the companies are planning in the near future to adopt green practices while 40% of the companies are either currently considering the implementation of green practices or have already started/finished the implementation of some of such practices.

The findings above have several implications and correlations in relation to the KPIs discussed in the previous section. Overall, the general green practices that were surveyed can be grouped in the following categories: green practices with emerged overall efficiency, green practices that lead to policy compliance and green practices that deliver value to the business partners and to the clients. The green practices with emerged overall efficiency are in line with the environmental and operational KPIs, while the other two categories are in line with the environmental KPIs and partly in line with the economic/operational KPIs that regard delivering client value. Even more, the green practices also cover/integrate properly with the weather induced disruptions in the sense that these practices (which are in the interest of 70% of the sample) can provide good incentives for enabling companies to recover from a disruption in an environmental and economic/operational beneficial way. This status is in coherence with the literature claiming limited information and know-how of companies on these matters (Govindan et al., 2015 Zaabi et al., 2013; Drohomeretsk et al., 2014; Balasubramanian, 2012; Diabat & Govindan, 2011; Sarkis et al., 2010; Soler et al., 2010; Vuro et al., 2009; del Brio et al., 2008; Yu & Hui, 2008; Walker & Preuss, 2008) as well as the leverage of economic gains - and indirectly refered to as green practices by having lower environmental penalties, lower consumption. (Govindan et al., 2015; Tian et al., 2014; Alzaman, 2014; Shi et al., 2012; Eltayeb et al., 2011; Carter & Rogers, 2008; Zhu et al., 2010, Ninlawani et al., 2010; Molina-Azorin et al., 2009; Carter et al., 2007; Chien & Shih, 2007; Mollenkopf et al., 2005).

4.3.4.2 Business partner related use/demands of green practices analysis

The business partner demands towards environmental practices variable was tested using a 5 level Likert Scale, where 1 denoted that the tested indicator was not important for the company, while 5 denoted that the indicator was very important for the business partner of the company.

The findings show that the interest in the implementation of green practices among business partners is very low in the sense that there is no strong intra-supply chain demand in relation to green practice implementation from one partner to another. The following variables have been tested: "Request of overall environmental practice incorporation" (2.07 out of 5), "Implementation of Environmental Management Systems" (2.05 out of 5), "Interest in green supply chain management" (2.15 out of 5), "Provision of inter-partner training" (2.14 out of 5), "Request of environmental compliance info" (2.09 out of 5) and "Provision of detailed environmental specification" (2.04 out of 5). These findings thus, do not fully support the literature claims on meosysstem pressures in the sense in the targeted sample there is no such RGFT/RGSCM coercicve or competitive pressure (Govindan et al., 2015; Tian et al., 2014; Zhu & Geng, 2013; Dornfield et al., 2013; Zhu et al., 2012;Zhu & Liu, 2010; Testa & Iraldo, 2010; Liu & Buck, 2007) that would drive mimetic adaptation/transformation (Dubey et al., 2015; Govindan et al., 2015; Ivanaj et al., 2015; Tian et al., 2014; Chakrabarty & Wang, 2013; Lee, 2008; Chien & Shih, 2007; Papadopoulos & Giama, 2007) (Hu & Hsu, 2010; Zhu & Sarkis, 2006; Widmer et al., 2005; Huang, 2005).

4.3.4.3 Cross-Country and cross-sectoral homogeneity in relation to the adoption of green practices

A cross-country and cross-sectoral has been performed in order to identify the uniformity and variance of the implementation of green practices towards ensuring proper adoption/adaptation of the model to be proposed (Table 37 from Appendix F).

The findings show a moderate/uniform distribution (average SD of 7.67%) of the implementation of green practices across the six countries included in the survey. Additionally, the implementation of green practices across the various industry types is also uniform having a very low standard deviation (SD – 5.21%). The uniform distribution of the implementation of these practices among the countries and business sectors will enable a better adoption of the framework proposed by this research and also confirm the homogeneity of the region in regards to the tested variables.

4.3.5 Drivers and barriers to the use of green practices for RGFT

4.3.5.1 Drivers to the use of green practices

The drivers to the use of green practices variable was tested using a 5 level Likert Scale, where 1 denoted that the tested indicator was not important for the company, while 5 denoted that the indicator was very important for the business partner of the company.

The most important drivers (score of above 3 out of 5) for the companies are the following: "Clients appreciate green certifications" (4.10 out of 5), "This is the next trend in logistics" (4.07 out of 5), "Technology enables green freight transportation" (4.05 out of 5), "We will gain competitive advantages" (4.03 out of 5), "We will pay lower taxes" (4.02 out of 5), "For public acceptance" (3.96 out of 5), "Green resilience is important and is a main driver" (3.94 out of 5), "Governmental support is higher and this motivates us" (3.92 out of 5). As it can be seen these dirvers are primarily economic (either directly or indirectly) supporting thus (Govindan et al., 2015; Ivanaj et al., 2015; Alzaman, 2014; Tian et al., 2014; Hsu et al., 2013; Golicic & Smith, 2013; Eltayeb et al., 2011; Shi et al., 2012; Zhu et al., 2010; Testa & Iraldo, 2010; Ninlawani et al., 2010; Chien & Shih, 2007; Zhu & Sarkis, 2007; King et al., 2005). On the other side, the least important such drivers for the companies were: "Long term revenues" (2.97 out of 5) and "Waste reduction" (2.96 out of 5) – facts which point towards the lack of proper information and know-how on these areas (Dubey et al., 2015; Govindan et al., 2015; Zhu et al., 2012; Delmas & Toffel, 2004; Holt, 2004 and Teuscher et al., 2006).

These results have the following implications:

Firstly, "Clients appreciate green certifications" (4.10 out of 5) – this means the companies are well aware of the growing trend in the market of green products/services and that client demand for such behaviour is becoming higher. Thus, delivering such client service is very important for companies and the KPIs already reflect this element (the customer satisfaction element from the KPIs was rated 4.09 out of 5). However, this contrasts with the previous findings that business partners do not demand green certications (thus it is just a client/society-oriented approach which confirms the literature strand that claims that society should be the key trigger of change (Govindan et al., 2015; Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Hsu et al., 2013; Shi et al., 2012; Rehman & Shrivastava, 2011; Zhu et al., 2010; Testa & Iraldo, 2010; Carter & Rogers, 2008; Chen, 2008; Vachon & Klassen, 2007; Chien & Shih, 2007; Ellen et al., 2006; Capaldi, 2005)).

Secondly, “This is the next trend in logistics” (4.07 out of 5) – this means that companies are aware of the existence/emergence of such trends in the logistics/transportation sector. This fact is also confirmed by the fact that 70% of the respondents are aware or currently considering or already implementing such practices/trends. Additionally, the independent environmental KPIs also confirm these drivers/interests of companies.This contrasta again wti the low scores on peer-demand of green practices which proves that these aspects are still in the early stage in lower income regions as SEE as suggeste by (Bahadur & Doczi, 2015; Vogelstein, 2015; Basu et al., 2013; Radjou et al., 2012; Baresel-Bofinger et al., 2012; Gupta, 2009).

Thirdly, “Technology enables green freight transportation” (4.05 out of 5) – thus, companies believe that technology is a main driver of environmentally sustainable freight transportation. This measurement provides good incentives for the model proposed by this research since companies are prone to see technology as an enabler.

Fourtly, “We will gain competitive advantages” (4.03 out of 5) – companies are aware of the competitive advantage brought by environmental sustainability and this eases/drives their interest for implementing such practices. This finding is not mapped however with any of the KPIs nor is it reflected in the measurement of the green practices adoption. This means that such a vision stated by companies is still in its inception and no capitalized benefits have yet been observed (Govindan et al., 2015; Tian et al., 2014; Alzaman, 2014; Shi et al., 2012; Eltayeb et al., 2011; Carter & Rogers, 2008; Zhu et al., 2010, Ninlawani et al., 2010; Molina-Azorin et al., 2009; Carter et al., 2007; Chien & Shih, 2007; Mollenkopf et al., 2005). **Fifthly**, We will pay lower taxes” (4.02 out of 5) – this financial driver is important for companies and it is also reflected in the environmental KPIs as well as in the environmental practices that companies consider (being consistent with the fourth implication stated before).

Sixthly, “For public acceptance” (3.96 out of 5) – this finding is directly linked with the competitive advantage variable as well as with the client appreciation. It seems that the companies consider the societal value of their operations, linked however with financial outcomes. Nevertheless, considering the stage of implementing green practices, the social value element is still in inception as also debated by (Govindan et al., 2015; Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Hsu et al., 2013; Shi et al., 2012; Rehman & Shrivastava, 2011; Zhu et al., 2010; Testa & Iraldo, 2010; Carter & Rogers, 2008; Chen, 2008; Vachon & Klassen, 2007; Chien & Shih, 2007; Ellen et al., 2006; Capaldi, 2005). Similarly, the **seventh** implication prevails - "Green resilience is important and is a main driver" (3.94 out of 5) – this is in full conformity with the current stage of considering and implementing green practices, as well as in the KPIs (efficiency before and during disruptions 3.15 and respectively 3.08 out of 5). Environmental KPIs also confirm this driver. Basically, despite of the fact that green resilience might still be at a very initial stage of consideration and implementation by companies, the efficiency element (financial and resource mostly) is already included in the KPIs of the companies.

Eightly, "Governmental support is higher and this motivates us" (3.92 out of 5). This driver shows the considerable efforts and pressures made by the involved governments in terms of achieving environmental sustainability from freight transportation. This driver is highly linked with the consideration of implementing environmental sustainability standards as well as it is reflected in the environmental KPIs (Environmental penalties 4.01 out of 5). This result surprisingly contradicts the main literature which usually poses this as a barrier (Govindan et al., 2015; Drohomeretsk et al., 2014;Zaabi et al., 2013; Balasubramaniam, 2012; Diabat & Govindan, 2011; Vuro et al., 2009; Andersen & Larsen, 2009; Walker et al., 2008; Lee, 2008). Stage three part one (focus groups) of the research ammends this issue and provides more insight though.

Lastly, "Long term revenues" (2.97 out of 5) – this driver scored low compared to the others and denotes the lack of belief in long term financial return on investment. This low score points towards the need to devise mechanisms that convince companies about the long term ROI so that they become more eager to implement such practices. A similar approach applies to "Waste reduction" (2.96 out of 5) as well – this driver also scored low compared to the others and denotes the lack of interest of companies in relation to waste reduction/recycling. This issue needs to be addressed so that companies are aware of the importance of proper waste management techniques. This low score is also confirmed by the low scores related to the environmental practice implementation that had to do with products/processes to reduce overheads and wastes. However, despite of these findings, the KPIs related to efficiency and optimization are rated very high, which might point to the fact that companies are not concerned about waste reduction as main driver because they do not encounter major waste issues (as the job focus of the respondents was mostly related to transportation).

A cross country analysis has been performed (Table 38 in Appendix F) in order to identify whether the most important drivers have significant variances in their importance across countries. As in the previous variables, the analysis revealed that the drivers are uniformly rated across all countries and that the sample is SEE homogenous (average SD is 2%) providing thus more insight into the international research setting of the five main theories that drive this research (Govindan et al., 2015; Tian et al., 2014; Zhu & Geng, 2013; Dornfield et al., 2013; Sarkis et al., 2011; Rivera, 2004).

Additionally, a cross-sectoral analysis (Table 39 in Appendix F) has been performed in order to identify whether the most important drivers have significant variances in their importance across the sectors involved. As in the previous variables, the analysis revealed that the drivers are uniformly rated across all sectors and that the sample is SEE homogenous (average SD is 3.1%).

4.3.5.2 Barriers to the use of green practices

The barriers to the use/implementation of green practices variable was tested using a 5 level Likert Scale, where 1 denoted that the tested indicator was not important for the company, while 5 denoted that the indicator was very important for the business partner of the company.

All the barriers that were tested were considered as very important/impeding to the implementation of resilient and green freight transportation. The following criticality order of the barriers was revealed: “Hard to create a staff position responsible for Environmental Management” (4.07 out of 5), “Very bureaucratic to control road/land use and the environmental impact” (4.06 out of 5), “Hard to control our 3PL/4PL partners” (4.07 out of 5), “Limited access to information” (4.03 out of 5), “Untrained staff and low technology adoption” (4.02 out of 5), “Too big initial investment” (4.00 out of 5), “Lack of managerial commitment” (3.99 out of 5), “Limited intermodal facilities” (3.99 out of 5), “Green KPIs are insignificant” (3.99 out of 5) and “Limited green goals for the company” (3.97 out of 5). These findings are generally, in line with the global literature (Govindan et al., 2015 Zaabi et al., 2013; Drohomeretsk et al., 2014; Balasubramanian, 2012; Diabat & Govindan, 2011; Sarkis et al., 2010; Soler et al., 2010; Vuro et al., 2009; del Brio et al., 2008; Yu & Hui, 2008; Walker & Preuss, 2008) as well as with the literature on lower income regions and SEE (Baresel-Bofinger et al., 2012).

These results have the following implications:

Firstly, "Hard to create a staff position responsible for Environmental Management" (4.07 out of 5) – this barrier has a normal occurrence since the whole concept of environmental sustainability in SEE is still new and in the inception stage (from an organizational point of view). Companies might be motivated to create such a work assignment or job position only when capitalized return on investment from environmental sustainability practices will be achieved. This is in line with (GovIvanaj et al., 2015; Zaabi et al., 2013; Diabat & Govindan, 2011; Vuro et al., 2009; Mont & Leire, 2009; Hanna et al., 2000).

Secondly, "Very bureaucratic to control road/land use and the environmental impact" (4.06 out of 5) – this barrier is very relevant in SEE due to the overall heterogeneous policy and bureaucratic settings of the countries involved, however the environmental impact can be calculated at the unit/truck level with proper mechanisms that will be proposed by the model of this research. Companies need to be motivated to identify alternative approached for environmental footprint measurement (independent of country-level policies). Such findings are also debated by (Govindan et al., 2015; Drohomeretsk et al., 2014;Zaabi et al., 2013; Balasubramaniam, 2012; Diabat & Govindan, 2011; Vuro et al., 2009; Andersen & Larsen, 2009; Walker et al., 2008; Lee, 2008). These findings also contrast with the highly rated driver related to the availability of governmental support – which means that such support, even if exists, it is still not sufficient yet.

Thirdly, "Hard to control our 3PL/4PL partners" (4.07 out of 5) – this barrier is a global one, and especially for the surveyed sample, this barrier is very consistent with the variables related to business partner demands of environmental sustainability, which are very low and thus since there is no supply chain level common interest in such practices, it is very hard to track the environmental sustainability value across the entire chain. However, this might be also due since according to the implementation stages of green practices, the targeted sample is still at early stages which means that very limited capitalizations that would diminish this barrier have been achieved. Similar situations have been discussed by (Zaabi et al., 2013; Drohomeretsk et al., 2014; Balasubramanian, 2012; Diabat & Govindan, 2011; Sarkis et al., 2010; Soler et al., 2010; Vuro et al., 2009; del Brio et al., 2008; Yu & Hui, 2008; Walker & Preuss, 2008).

Fourtly, “Limited access to information” (4.03 out of 5) – this barrier is widely confirmed which is in total consistency with the fact that around 30% of the target sample are unaware or unwilling to implement environmental sustainable practices/ (while the rest of 70% are still in the early stages of the implementation); and **fifthly**, “Untrained staff and low technology adoption” (4.02 out of 5) – this barrier is also widely confirmed which is in total consistency with the fact that around 30% of the target sample are unaware or unwilling to implement environmental sustainable practices/ (while the rest of 70% are still in the early stages of the implementation). Additionally, technology adoption is a global barrier/issue and more details regarding such adoption and skill requirement issues will be debated in the next subsections. These findings are consistent with (Govindan et al., 2015; Drohomeretsk et al., 2014;Zaabi et al., 2013; Balasubramaniam, 2012; Diabat & Govindan, 2011; Vuro et al., 2009; Andersen & Larsen, 2009; Walker et al., 2008; Lee, 2008). A similar context resides also for the **sixth** highest rated barrier, “Lack of managerial commitment” (3.99 out of 5) – this barrier is also closely linked with proper access to information, financial incentives and overall organizational resistance to change.

Seventhly, “Too big initial investment” (4.00 out of 5) – this barrier is in close links with the KPIs and also with the specific driver related to financial outcome s(which scored very low). Basically, companies are uncertain about the long term financial sustainability of green practices in order to make an initial investment (Drohomeretsk et al., 2014; Zaabi et al., 2013; Diabat & Govindan, 2011; Connell, 2010; Alkhidir & Zailani, 2009; Walker et al., 2008; Presley et al., 2007; van Hemel & Cramer, 2002). To support this, besides proper access to information, incentives/support for the initial costs should be enabled by the involved governments.

Eightly, “Limited intermodal facilities” (3.99 out of 5) – this barrier, very targeted on resilient and green freight transportation, relates to the lack of such physical infrastructures in SEE (Baresel-Bofinger et al., 2012). As the overall concept of intermodal transportation in SEE and generally in lower-income regions (Bahadur & Doczi, 2015; Vogelstein, 2015; Basu et al., 2013;

Radjou et al., 2012; Gupta, 2009) is lacking many developments, companies must rely on other "soft" mechanisms towards becoming environmentally sustainable.

Ninethly, "Green KPIs are insignificant" (3.99 out of 5) and "Limited green goals for the company" (3.97 out of 5) – these barriers might seem to contradict the previous findings related to the importance of the environmental KPIs, however considering the other variables (such as stage of the green practice implementation, business KPIs and the results from the initial interviews preceding this survey), these barriers seem to reflect the slow pace of organizational change towards adopting a green behaviour in their operations, as well as the slow change/adaptation pace of the top management levels from each partner of the supply chain. These barriers have also to do with the lack or green practice request from the other partners from the supply chain. However, with the highly rated drivers and also the pressure to become green, companies will slowly change their behaviour towards incorporating environmental sustainability at the core of their business mission (Govindan et al., 2015; Drohomeretsk et al., 2014; Zaabi et al., 2013; Diabat & Govindan, 2011; Connell, 2010; Alkhidir & Zailani, 2009; Walker et al., 2008; Presley et al., 2007; van Hemel & Cramer, 2002).

A cross country analysis (Table 40 in Appendix F) has been performed in order to identify whether the most important barriers have significant variances in their importance across countries. As in the previous variables, the analysis revealed that the barriers are uniformly rated across all countries and that the sample is SEE homogenous (average SD is 4.15%).

Additionally, a cross-sectoral analysis (Table 41 in Appendix F) has been performed in order to identify whether the most important barriers have significant variances in their importance across the sectors involved. As in the previous variables, the analysis revealed that the barriers are uniformly rated across all sectors and that the sample is SEE homogenous (average SD is 3.45%).

4.3.5.3 Drivers and Barriers relation with business KPIs and Environmental Practices

The relation between the drivers & barriers to RGFT/RGSCM implementation are presented in Table 16.

Table 16: Stage two - drivers & barriers against KPIs

		DRIVERS								BARRIERS									
DRIVERS and BARRIERS to RESILIENT AND GREEN FREIGHT TRANSPORTATION		Client appreciation	Next trend in logistics	Technology enables RGFT	Competitive advantages	Lower taxes	Public acceptance	Green resilience is important	Governmental support is higher	Lack of Commitment	No Green Goals	Too Big Investment	Green KPI Insignificant	Hard to Control 3PL 4PL	Untrained Staff Low Tech	Hard to Devise Green Job	Limited Information	Bureaucratic to Control Land Use	Limited Intermodal
KEY PERFORMANCE INDICATORS		4.10	4.07	4.05	4.03	4.02	3.96	3.94	3.92	3.99	3.97	4.00	3.99	4.04	4.02	4.07	4.03	4.06	3.99
Cost per TKM	3.97		X																
Focal Firm Profit	3.99	X	X	X	X	X		X				X			X	X			
Total Time	4.00	X		X				X						X					
On Time Deliveries	3.03	X		X				X											

Service Frequency	**3.08**			X				X											X
Reliability of Transport	**3.04**		X	X	X			X						X					X
Distance to Cover	**3.05**							X											
Efficiency During Disruptions	**3.15**	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X
Efficiency Before Disruptions	**3.08**	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X
Trips Required for Shipment	**3.01**			X	X			X											
Total Fuel Consumption	**4.00**		X	X	X	X	X	X		X	X		X	X	X	X	X	X	X
Customer Satisfaction	**4.09**	X	X		X					X	X		X	X	X	X	X	X	X
Safety of Transportation	**3.03**		X	X				X						X					
Corridor Availability and Capacity	**3.11**		X	X				X											X
Total Energy Used	**3.95**	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X
Mileage	**3.18**		X	X	X			X		X	X		X	X	X	X	X	X	X
Environmental Penalties	**4.01**		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X

4.3.6 Resilience mechanisms and strategies

4.3.6.1 Overview on resilience mechanisms and strategies

The resilience mechanisms and strategies for green freight transportation variable was tested using a 5 level Likert Scale, where 1 denoted that the tested indicator was not important for the company, while 5 denoted that the indicator was very important for the company.

According to the results, the following resilience strategies are considered the most important: "Improvements of business inefficiencies" (4.17 out of 5), "Shorter routes" (4.08 out of 5), "Employment of specialized staff" (4.06 out of 5), "Better risk management" (4.03 out of 5), "Reliance on soft technology" (4.01 out of 5), "Relocation of goods" (3.98 out of 5), "Improvement in environmental inefficiencies" (3.95 out of 5) and "Mechanisms to raise awareness" (3.93 out of 5). Oppositely, the strategies which scored the least are the following: "Knowledge management mechanisms" (1.89 out of 5), "Modal shift" (1.95 out of 5), "Real time weather provisioning" (1.99 out of 5), "Reliance on hard technology" (2.41 out of 5), "Interventions in energy consumption" (2.43 out of 5) and "Process alterations" (2.46 out of 5) – overall being being consistent with the related literature (Ambulkar et al., 2015; Kim et al., 2015; Krause et al., 2014; WEF, 2013; Solomon et al., 2012; Holguin-Veras et al., 2012; Christopher & Peck, 2004).

These results have the following implications:

Firsly, "Improvements of business inefficiencies" (4.17 out of 5) – better business monitoring and optimization for cost reduction is required. All the business KPIs are involved in this context and there is a greater need for quantifying these KPIs before, during and after disruptions. This outcome is in line with (Kamalahmadi & Parast, 2016; Fiksel et al., 2015).

Secondly, "Shorter routes" (4.08 out of 5) – this mechanism is linked with the business KPIs and its high rating shows that companies understand the issues that interfere during disruptions and the involved business outcomes. Shorter routes would result in better timing, reduced costs and optimized environmental footprint (Melnyk et al., 2014; Christopher & Peck, 2004).

Thirdly, "Employment of specialized staff" (4.06 out of 5) – this is a key prerequisite for enabling proper resilience during disruptions for a company. It is very important that companies recognize this element as being crucial for their organization despite of the fact that staff training and lack of access to information were previously denoted as one of the main barriers towards resilient and green freight transportation. However, this finding shows that companies are interested in overcoming this barrier. Additionally, by overcoming this barrier, the KPIs (both economic/operational and environmental) will also get optimized (Kim et al., 2015; Durach et al., 2015; Barosso et al., 2015; Perera et al., 2015; Mensah et al., 2015; Gilly et al., 2014; Kristianto et al., 2014).

Fourthly, "Better risk management" (4.03 out of 5) – risk management is a critical part of enabling resilience and disruption management. Overall, from the entire findings of this survey, it appears that companies are somewhat aware of the latest strategies that enable better risk management (such as soft technology, training), however there is still a need to give more access to companies towards understanding and apprehending all the modern risk management solutions and practices so that their resilience strategies can fully benefit from these latest trends (Kamalahmadi & Parast, 2016; Fiksel et al., 2015; Melnyk et al., 2014; Juttner & Maklan, 2011; Christopher & Peck, 2004).

Fifthly, reliance on soft technology" (4.01 out of 5), "Real time weather provisioning" (1.99 out of 5) ,"Knowledge management mechanisms" (1.89 out of 5) - these contrasting scores show a general awareness of the companies towards soft technology as a key enabler of resilience, however it is clear from these findings that the companies are unaware what these technologies actually are. For example, knowledge management mechanisms and real time weather provisioning are examples of soft technologies, however they scored very low as compared to when the generic terminology of "soft technology" was used. Despite this, this opportunity is critical for this research since the proposed model and solution will be fully in line with the "soft technology" concept, while also disclosing, training and getting companies accommodated with very specialized models of such soft technologies (Francis & White, 2016; Choudhury et al., 2015; Akgun & Keskin, 2014; Gogelci & Ponomarov, 2013; Demmer et al., 2011; Christopher & Hollweg, 2011; Pham et al., 2008; Reinmoeller & Van Baardwijk, 2005; Hamel & Valikangas, 2003).

Sixthly, "Relocation of goods" (3.98 out of 5) - this mechanism is linked with the business KPIs and its high rating shows that companies understand the issues that interfere during disruptions and the involved business outcomes. This mechanism is also linked with shorter routes would result in better timing, reduced costs and optimized environmental footprint as well as product availability in a timely and efficient manner. **Seventhly**, “Modal shift” (1.95 out of 5) – this resilience mechanism scored low mostly due to the fact that the inexistence of proper intermodal hubs in the region was rated as a main barrier to enabling resilient and green freight transportation. Basically, the low score for this element is due to the fact that companies are aware they cannot rely on such concepts in their operational geographic area (Bahadur & Doczi, 2015; Vogelstein, 2015; Basu et al., 2013; Radjou et al., 2012; Baresel-Bofinger et al., 2012; Gupta, 2009).

Eightly, “Improvement in environmental inefficiencies” (3.95 out of 5) and “Mechanisms to raise awareness” (3.93 out of 5) – these highly rated resilience strategies show a promising interest of the companies towards enabling resilience in an environmentally sustainable manner. These mechanisms are also in line with the KPIs (both economic and environmental) and with the drivers. However, the specific/related barriers need to be crossed in order to accomplish this strategy. The second element (mechanisms to raise awareness) are a highly rated barrier and also a revealed fact from the part analyzing the implementation of green practices by the targeted companies - where 30% of the companies are either unaware of such practices or unwilling to implement them (Francis & White, 2016; Azevedo et al., 2013; Cabral et al., 2012; Carvalho et al., 2012; Carvalho et al., 2011; Hong et al., 2009; Rosic et al., 2009; Anand & Kodali, 2008; Glickman et al., 2006, Kainuma & Tawara, 2006).

Ninethly, “Reliance on hard technology” (2.41 out of 5) – this mechanism was rated lower mostly because companies perceive such technologies as expensive and hard to maintain (while also being in high need for training and facing adoption issues). In this context, there is no doubt that companies would try to avoid as much as possible buying new equipment for these purposes. **Finally**, in a similar manner, “Interventions in energy consumption” (2.43 out of 5) and “Process alterations” (2.46 out of 5) – these strategies have similar reasons for their scores (as compared to the highly rated strategies. The main reason for these lower scores resides in the early stage in which the companies are in terms of implementing such practices (so they are still not having the proper skills), and also in the lack of information/know-how (which was stated as a main barrier

– being thus consistent with (Dubey et al., 2015; Govindan et al., 2015; Zhu et al., 2012; Delmas & Toffel, 2004; Holt, 2004 and Teuscher et al., 2006).

A cross country analysis (Table 42 in Appendix F) has been performed in order to identify whether the resilience mechanisms have significant variances in their importance across countries. As in the previous variables, the analysis revealed that the resilience mechanisms are uniformly rated across all countries and that the sample is SEE homogenous (average SD is 6.25%).

A cross sectoral analysis (Table 43 in Appendix F) has been performed in order to identify whether the resilience mechanisms have significant variances in their importance across sectors. As in the previous variables, the analysis revealed that the resilience mechanisms are uniformly rated across all sectors and that the sample is SEE homogenous (average SD is 4.82%).

4.3.6.2 Relation with the drivers and barriers and KPIs

The measurements of the resilience strategies show key relations (Table 44 in Appendix F) with the drivers and barriers that the companies encounter when they have to implement resilient and green freight transportation. These consistencies and correlations show the strengths but also the problematic areas that need to be taken into account when devising strategies and solutions for this purpose. Similarly, the measured and collected resilience strategies have the additional relations with the KPIs as shown in Table 45 in Appendix F.

4.3.7 Behavioural analysis for the adoption of RGFT/RGSCM strategies

4.3.7.1 Perceived usefulness of RGFT strategies

The perceived usefulness of resilient and green freight transportations solutions variable was tested using a 5 level Likert Scale, where 1 denoted that the tested indicator was perceived as not useful for the company, while 5 denoted that the indicator was perceived as very useful for the company.

Four main variables have been tested and the following results have been collected: "Perceived Usefulness for Return on Investment" (4.05 out of 5), "Perceived usefulness for Competitive advantage" (4.04 out of 5), "Perceived usefulness for reduced waste" (3.97 out of 5) and "Perceived usefulness for environmental care" (3.96 out of 5).

These results have the following implications:

Firstly, “Perceived Usefulness for Return on Investment ” (4.05 out of 5) and “Perceived usefulness for Competitive advantage” (4.04 out of 5)– these elements are in consistent correlation with the drivers (Competitive advantage - 4.03 out of 5) for implementing such solutions as well as with the KPIs (Focal firm profit – 3.99 out of 5). However, there is an inconsistency with one of the driver for adopting such solutions which refers to the long term financial prospect which scored lower (2.97 out of 5), which means that companies might see benefits on short term rather than on long term. This aspect might also be happening due to lack of information and due to the early stage implementation of such practices – factor confirmed as well by (Dubey et al., 2015; Govindan et al., 2015; Zhu et al., 2012; Delmas & Toffel, 2004; Holt, 2004 and Teuscher et al., 2006).

Secondly, “Perceived usefulness for reduced waste” (3.97 out of 5) – this element is in consistent correlation with the KPIs for environmental issues and overall business efficiency, as well as with the drivers tangent related to delivering client value (4.10 out of 5) and policy compliance (3.92 out of 5). However, it was identified that even though companies believe that such strategies are useful for waste reduction, waste reduction itself is not a key driver (2.96 out of 5) for them to adopt these practices – being more keen on client value and other direct/indirect economic gains (Govindan et al., 2015; Tian et al., 2014; Alzaman, 2014; Shi et al., 2012; Eltayeb et al., 2011; Carter & Rogers, 2008; Zhu et al., 2010, Ninlawani et al., 2010; Molina-Azorin et al., 2009; Carter et al., 2007; Chien & Shih, 2007; Mollenkopf et al., 2005).

Thirdly (similar with the second implication from the previous paragraph), “Perceived usefulness for environmental care” (3.96 out of 5) – this element is in consistent correlation with the KPIs for environmental issues and overall business efficiency through policy compliance, as well as with the drivers tangent related to delivering client value (4.10 out of 5) and policy compliance (3.92 out of 5).

4.3.7.2 Perceived ease of use of RGFT/RGSCM strategies

The perceived ease of use of resilient and green freight transportations solutions variable was tested using a 5 level Likert Scale, where 1 denoted that the tested indicator was perceived as not easy to use/implement for the company, while 5 denoted that the indicator was perceived as very ease to use/implement for the company.

Three main variables have been tested and the following results have been collected: “Implementation of green freight transportation practices” (2.48 out of 5), “Implementation of resilient freight transportation practices” (2.55 out of 5), “Implementation of green and resilient freight transportation practices” (2.59 out of 5). These results show

a general perceived difficulty for implementing such practices, however the slightly higher score for the implementation of green and resilient freight transportation practices provides certain incentive that show that companies view environmental sustainability and resilience and complementary/connected. Such facts are highly consistent with (Govindan et al., 2015 Zaabi et al., 2013; Drohomeretsk et al., 2014; Balasubramanian, 2012; Diabat & Govindan, 2011; Sarkis et al., 2010; Soler et al., 2010; Vuro et al., 2009; del Brio et al., 2008; Yu & Hui, 2008; Walker & Preuss, 2008).

Secondly, these results point to the need of proper training and access to information that is required for companies to get accustomed with such solutions/strategies and to implement them successfully. This requirement is in full consistency with the barriers that were tested in the previous subsections.

4.3.7.3 Intentions to implement/adopt RGFT/RGSCM strategies

The intentions to implement resilient and green freight transportations solutions variable was tested using a 5 level Likert Scale, where 1 denoted that for the tested indicator the intention of the company was low, while 5 denoted that the intention was high for the company.

Throughout the survey, three statements that measured the same variable were used and the following results have been gathered: “If practices/technologies for overcoming and/or mitigating these disasters were available and at low cost, would you use them ?” (3.59 out of 5); “If practices/technologies for overcoming and/or mitigating these disasters were available and at low cost, that would also take into account environmental issues, would you use them ?” (2.98 out of 5); “If practices/technologies for overcoming and/or mitigating these disasters, while improving business efficiency, were available and at low cost, would you use them ?” (3.92 out of 5)

These results are consistent with the previous findings and show that the intention to implement practices of resilient and green freight transportation are the highest when the economic benefit is emphasized, and lowest when the environmental element is introduced. Similarly, these intentions are also in line with the KPIs and with the main drivers as well as with the literature pointing towards the adoption of RGFT/RGSCM strategies (Dubey et al., 2015; Govindan et al., 2015; Ivanaj et al., 2015; Tian et al., 2014; Chakrabarty & Wang, 2013; Lee, 2008; Chien & Shih, 2007; Papadopoulos & Giama, 2007) (Hu & Hsu, 2010; Zhu & Sarkis, 2006; Widmer et al., 2005; Huang, 2005).

4.3.7.4 Cross-country and cross-sectoral analysis

A cross country analysis has been performed (Table 46 in Appendix F) in order to identify whether the intentions, perceived ease of use and perceived usefulness of mechanisms for resilient and green freight transportation have significant variances in their importance across countries. As in the previous variables, the analysis revealed that the behavioural elements are uniformly rated across all countries and that the sample is SEE homogenous (average SD is 4.23%).

Additionally, a cross sectoral analysis (Table 47 in Appendix F) has been performed in order to identify whether the behavioural elements have significant variances in their importance across sectors. As in the previous variables, the analysis revealed that the behavioural elements are uniformly rated across all sectors and that the sample is SEE homogenous (average SD is 7.18%).

4.3.8 Summary of Stage two data analysis

4.3.8.1 Summary of the 2nd stage data analysis and implications for the research objectives

The results of the second stage have the following implications for the following objectives of this thesis (the remaining objectives are being accomplished through the third and fourth methodological stages):

OB1.1: *Understand which weather conditions cause the most impactful disruptions in road freight transportation from SEE (relates to CRQ6)* and **OB2.1**: *Understand what negative business outcomes emerge as a result of such disruptions*. Table 17 shows only the significant items (with score greater than 3.0 out of 5).

Table 17: Stage two - top disruptions against top outcomes

Score (out of 5) N=311	Delays in delivery (4.51)	Overall coordination issues (4.19)	Client complains (4.06)	Loss of revenue (4.05)	Increased fuel consumption (4.03)	Extra cost (3.98)	Decrease of speed (3.85)
Icy Roads (4.16)	85%	70%	52%	83%	74%	67%	85%
Snowfall (4.15)	87%	72%	55%	87%	76%	66%	88%
Fog (3.88)	70%	75%	52%	58%	67%	49%	79%
Blizzards (3.77)	65%	72%	50%	59%	42%	40%	55%
Heavy Rains (3.45)	62%	70%	50%	52%	45%	43%	55%
	Increased CO2 emis-ssion(3.60)	Inventory inconsistencies (3.53)	Congestion (3.46)	Longer distance (3.38)	Missed deliveries (3.21)	Staff complains (3.02)	
Icy Roads (4.16)	50%	**73%**	88%	74%	**75%**	31%	
Snowfall (4.15)	52%	70%	**89%**	**76%**	60%	**45%**	
Fog (3.88)	**62%**	72%	88%	67%	62%	32%	
Blizzards (3.77)	55%	71%	82%	42%	61%	30%	
Heavy Rains (3.45)	55%	68%	82%	45%	58%	35%	

OB2.2: *Understand what (green) key performance indicators do business use and to what extent when dealing with disruptions* and **OB2.3:** *Understand to which extend do businesses implement green practices during their decision making processes* and **OB2.5:** *Understand what resilience mechanisms do businesses implement and to what extent these mechanisms include environmentally sustainable practices.* Table 18 shows only the significant items (with score greater than 3.0 out of 5):

Table 18: Stage two - top KPIs against top resilience strategies

RESILIENCE STRATEGIES AND MECHANISMS / KEY PERFORMANCE INDICATORS		Reliance Soft Technology	Improvements Business Inefficiencies	Improvements Environmental Inefficiencies	Mechanisms To Raise Awareness	Employment Specialized Staff	Relocation Goods	Shorter Routes	Risk Management
		4.01	**4.17**	**3.05**	**3.93**	**4.06**	**3.98**	**4.08**	**4.03**
Cost per TKM	**3.97**		X					X	
Focal Firm Profit	**3.99**	X	X	X	X	X	X	X	X
Total Time	**4.00**	X	X					X	X
On Time Deliveries	**3.03**	X	X					X	X
Service Frequency	**3.08**	X	X	X	X	X	X	X	X
Reliability of Transport	**3.04**	X	X						X
Distance to Cover	**3.05**	X	X	X	X	X	X	X	X
Efficiency During Disruptions	**3.15**	X	X	X	X	X	X	X	X
Efficiency Before Disruptions	**3.08**	X	X	X	X	X	X	X	X
Trips Required for Shipment	**3.01**	X	X	X	X	X	X	X	X
Total Fuel Consumption	**4.00**	X	X	X	X	X	X	X	X
Customer Satisfaction	**4.09**	X	X				X	X	X
Safety of Transportation	**3.03**	X	X						X
Corridor Availability and Capacity	**3.11**	X	X				X	X	X
Total Energy Used	**3.95**	X	X	X	X	X	X	X	X
Mileage	**3.18**	X	X	X	X	X	X	X	X
Environmental Penalties	**4.01**	X	X	X	X	X	X	X	X

OB2.4: *Understand what drivers and barriers do businesses face when aiming to adopt/implement green practices* and **OB3.2:** *Investigate to what extent to businesses respond to ecosystem pressures in order to implement RGFT practices* (relates to CRQ2). Table 19 shows only the significant items (with score greater than 3.0 out of 5):

Table 19: Stage two - top resilience strategies versus top drivers & barriers

	DRIVERS								BARRIERS									
DRIVERS and BARRIERS to RESILIENT AND GREEN FREIGHT TRANSPORTATION	Client appreciation	Next trend in logistics	Technology enables RGFT	Competitive advantages	Lower taxes	Public acceptance	Green resilience is important	Governmental support is higher	Lack of Commitment	No Green Goals	Too Big Investment	Green KPI Insignificant	Hard to Control 3PL 4PL	Untrained Staff Low Tech	Hard to Devise Green Job	Limited Information	Bureaucratic to Control Land Use	Limited Intermodal
RESILIENCE STRATEGIES AND MECHANISMS	4.10	4.07	4.05	4.03	4.02	3.96	3.94	3.92	3.99	3.97	4.00	3.99	4.04	4.02	4.07	4.03	4.06	3.99
Reliance Soft Technology (4.10)		X	X	X							X			X		X		
Improvements Business Inefficiencies (4.17)		X	X	X	X			X	X	X				X		X		
Improvements Environmental Inefficiencies (3.05)	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	
Mechanisms To Raise Awareness (3.93)							X	X						X	X			
Employment Specialized Staff (4.06)							X	X	X	X	X	X			X	X		

Relocation of Goods (3.98)	X			X							X							
Shorter Routes (4.08)	X			X							X		X					
Risk Management (4.03)		X	X	X			X						X			X		

4.3.8.2 Summary of the 2nd stage data analysis and implications for the converged research questions

The results of the second stage have the following implications for the following converged research questions (CRQs) this thesis (the other CRQs are being accomplished through the third and fourth methodological stages):

CRQ2 (relates also to OB2.2, OB2.3, OB 3.2, Pillar 1; Pillar 2 and Pillar 6): Top-down: *How can the modernized ecosystem level (explained by the ST) generate eco-innovation exogenous pressures on the individual institutions (explained by INT) in an international ecosystem and what are the institutional level responses to such induced modernization*: The results of the 2nd stage show a clear relevance and impact of the ST and INT at an international level ecosystem in terms of how institutions respond to such ecosystems pressures. Specifically, the institutional response at this stage clarifies that institutions perceive very high their impact within the quintuple helix mesosystem. For example, the main drivers/reason of implementing eco-innovations such as RGFT/RGSCM resides in: customer appreciation (societal coercive pressure – 4.10/5), adhering to the latest trends in this field (market competitive/mimetic pressure – 4.07/5), direct financial drivers (competitive/inner drive to self-exceed 4.03/5), general public acceptance (societal coercive pressure – 3.96/5), increased governmental support and lower taxes (governmental normative driver – 3.92/5 & 4.02/5). The response to such quintuple helix induced pressures & drivers resides in the adoption of eco-innovations by institutions providing thus insight into the research performed by (Govindan et al., 2015; Tian et al., 2014; Zhu & Geng, 2013; Dornfield et al., 2013; Sarkis et al., 2011; Rivera, 2004).

CRQ3 (relates to OB2.2, OB2.6, OB3.3, Pillar 1 and Pillar 6): Transversal: *What are the local level institutional controlled processes of the CAST driven RGFT microsystem and how do these institutional controlled processes integrate and co-evolve with the ones of other quintuple helix stakeholders in order to enable co-creation and fast eco-innovation adoption (EMT, DIT) towards ensuring RGFT at the quintuple helix mesosystem-level*. The results of the 2nd stage denote the following key controlled processes (top ones) of the CAST driven mesosystem where the sample institutions operate: Cost per TKM (3.97/5); Focal Firm Profit (3.99/5); Total Time (4.00/5); On Time Deliveries (3.03/5); Service Frequency (3.08/5); Reliability of Transport (3.04/5); Distance to Cover (3.05/5); Efficiency During Disruptions (3.15/5); Efficiency Before Disruptions (3.08/5); Trips Required for Shipment (3.01/5); Total Fuel Consumption (4.00/5); Customer Satisfaction (4.09/5); Safety of Transportation (3.03/5); Corridor Availability and Capacity (3.11/5); Total Energy Used (3.95/5); Mileage (3.18/5); Environmental Penalties (4.01/5). However, building upon these key controlled processes is strongly prohibited at the institutional level by: the Institutional level blockers: Lack of green goals (3.97/5); Lack of commitment (3.99/5); Insignificance of green KPIs (3.99/5); and Quintuple helix mesosystem blockers: Limited information/knowledge (4.03/5); Bureaucratic barriers (4.06); Limited infrastructure (3.99/5).

To this end, these findings point towards a strong heterogeneity of the RGFT/RGSCM institutions among the quintuple helix mesosystem and a proven source of inner barriers towards the implementation of the eco-innovations. The second stage did not answer how these KPIs and blockers interfere at the mesosystem level, however the findings may point towards the fact that without the mesosytem pressures explained by ST and INT, eco-innovations (DIT, EMT) would not be triggered and implemented at the institutional level in such a CAST based context. This aspect points towards the fact that the mesosystem is a core driver of eco-innovation demand and implementation being thus consistent with (Baumgartner et al., 2015; Piotrowicz, W., & Cuthbertson, 2015; Bhattacharya et al., 2014; Varsei et al., 2014; Ahi & Searcy, 2015a; Ahi & Searcy, 2015b; Gopal & Thakkar, 2012; Ivanov et al., 2012; Van den Berg, 2011; Folke et al., 2010; Bansal & Mcknight, 2009; Chertow, 2009; Pathak et al., 2007; Holling, 2001).

CRQ6 (relates to OB2.5 and Pillar 2): *Exogenous: How can stochastic externalities induced disruptions (such as environmental conditions) be better overcame in CAST ecosystems through eco-innovation (EMT, DIT).* The results of the 2nd stage show that the following eco-innovations are key enablers of eco-resilience in the CAST based quintuple helix mesosystem where the institutions operate: Reliance on Soft Technology (4.10/5); Improvement of Business Inefficiencies (4.17/5); Improvement of Environmental Inefficiencies (3.05/5); Mechanisms to raise awareness (3.93/5); Employment of specialized staff (4.06/5); Relocation of goods (3.98/5); Shorter routes (4.08/5); Risk management (4.03/5). These findings contribute to the work of (Li & Coates, 2016; Chhetri et al., 2016; Snyder et al., 2015; Loh & Thai, 2015; Mattson & Jenelius, 2015; Global risks, 2015; GAR, 2015; Van der Vegt et al., 2015; Zhu & Ruth, 2013; Linnenluecke et al., 2012; Ergun et al., 2010; Natarajarathinam et al., 2009; Stecke & Kumar, 2009; Nakano, 2009; Sanchez-Rodriguez et al., 2008; Holling, 2001).

CRQ7 (relates to OB3.1, Pillar 3, Pillar 4, Pillar 5 and Pillar 6): *Transversal*: *How does the DIT properly explain the adoption of EMT by CAST based RGFT institutions:* The 2nd stage supports the view of the DIT in terms of explaining the adoption of EMT driven eco-innovations within the RGFT/RGSCM institutions that have been surveyed. For example, a specific part of the survey targeted to test the adoption level of eco-innovations under three main behavioural variables (behavioural intention to adopt eco-innovations (BI), perceived usefulness of eco-innovations (PU) and perceived ease of use of eco-innovations (PEU). More specifically, whether the respondents declare a high PU (4.00/5) of RGFT/RGSCM eco-innovations, the PEU of such eco-innovations is considerably low (2.38/5). Still the BI element (which is the core measurement of the willingness to adopt eco-innovations and thus support the DIT statements) is moderately high (3.53/5). These findings are coherent with the findings from the previous CRQs (especially being coherent with the barriers towards eco-innovation adoption) and provide insights into the matters raised by (Kamalahmadi & Parast, 2016; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Zhu et al., 2012; Carayannis, Barth & Campbell; 2012; Carayannis & Campbell, 2010; Brugge & Van Raak, 2007; Quist, 2007; Sondejker et al., 2006).

4.4 Stage three – (Mesosystem) – Focus groups and Modelling

4.4.1 Summary of the focus groups data analysis

4.4.1.1 Overview

Following the focus group methodology defined in section 3.3.3.1, inductive content analysis (as described in section 4.2.1) has been applied to the transcripts confirmed by the participants to the focus groups. In total, three (3) focus groups have been implemented during 2014- 2015 with the support of the Triple Helix Association Chapter of Greece (THAG). Each focus group contained different participants (as the overall thematic context of the focus group organized by the THAG was different – however – the questions addressed to the audience with regards to this specific research have been the same as shown in Appendix C). Additionally, the composition of each focus group contained (in all cases) representatives from each quintuple helix mesosystem institution. A breakdown of the focus groups can be found below (Table 20):

Table 20: Stage three - focus groups demographics

Focus group	Quintuple helix mesosystem stakeholders that participated
Focus group 1 (During the THAG roundtable on Smart Specialization – 24th February 2014)	• (2) Greek policy makers focused on growth, innovation & development (prefecture) • (2) EU level policy makers focused on innovation & growth • (2) Academics/Innovation producers (public and private) • (1) CEO/Industry representative (manufacturing) • (1) Industry association representative (chamber of commerce) • (1) Environmental & societal actor (association)
Focus group 2 (During the THAG roundtable on Technological Innovation – 25th June 2014)	• (1) policy maker focused on growth, innovation & development (prefecture) • (1) Academics/Innovation producers (public and private) • (1) CEO/Industry representative (manufacturing) • (1) Industry association representative (chamber of commerce) • (1) Environmental & societal actor (association)
Focus group 3 (During the THAG roundtable on Innovation and development – 7th November	• (1) policy maker focused on growth, innovation & development (prefecture) • (2) Academics/Innovation producers (public and private) • (1) Industry association representative (federation)

2015)	• (1) Environmental & societal actor (association)

The chosen sample for each focus groups is representative because the institutions involved are the most widely known/powerful (in the case of associations, industries & innovators) as they are often being involved in my such events publicly, while the policy makers were, in each case, coming from the prefecture level (which is the body specialized in implementing/supporting quintuple helix initiatives). Overall, the outcomes of the focus groups show convergence over the targeted confirmatory and exploratory constructs as it will be shown in the following section.

4.4.1.2 Outcomes and implications

Following the inductive content analysis methodology (from section 4.2.1) the results of the focus group have been categorized against the intended confirmatory & exploratory construct validation/exploration by relying on focus group scientific rigorousness (described in section 3.1.4.1) - specifically in relation to the work of (Kamberelis & Dimitriadis, 2013; Freeman, 2006; Kidd & Parshall, 2000; Stevens, 1996). The overall findings show good convergence among the three focus groups and this also enhances the validity of the findings by having qualitative cross-validation of the findings over several periods of times – but within the same quintuple helix mesosystem context.

The outcome of the **exploratory part** of the focus group and its relation to the CRQs, OBs and TFT Pillars is the following (Tables 21, 22, 23, 24):

CRQ1 (relates to OB3.1, Pillar 3, Pillar 5 and Pillar 6): *Bottom-up: How can local level institutional EMT driven eco-innovations (either transformative or disruptive) diffuse faster under the DIT behaviour and scale-up across the RGFT CAST driven microsystem panarchy during crises towards enabling resilience*? and **CRQ6 (relates to OB2.5 and Pillar 2***): Exogenous: How can stochastic externalities induced disruptions (such as environmental conditions) be better overcame in CAST ecosystems through eco-innovation (EMT, DIT)* ?

Table 21: Stage three - focus group outcomes (first part)

Event	Observations
Focus group 1	The perceived relevance of the topic was very high *("I believe that from a policy perspective […] we are vey keen", "[…] industry is highly interested in this", "[…] as societal and environmental organizations this is our main goal", "for researchers this […] poses as key innovation trend"*) and all participants were actively involved towards emphasizing their institutional aims/goal in seek to emphasize their importance for this mesosystem level challenge which approves related literature (Dubey et al., 2015; Govindan et al., 2015; Zhu et al., 2012; Delmas & Toffel, 2004; Holt, 2004 and Teuscher et al., 2006). Still, there was no convergence among the participants towards explaining how can eco-innovations diffuse faster (EMT, DIT) as each participating institution perceives itself as a key enabler towards ensuring this process (i.e. CAST based panarchy leader). One commonality observed though towards ensuring a solution to this challenge resides in establishing a common "language"/KPIs/goal to be initiated by industry & society/environmentalists – but moderated & governed by the policy makers *("we need […] and a common language", "we do not have […] and common goals, that is why we need to synchronize", "we can align our KPIs […] and goals")* – supporting thus (Bhattacharya et al., 2014; Green et al., 2014; Shen et al., 2013; Hsu et al., 2013; Taticchi et al., 2013; Hitchcock, 2012; Dei & Shefi, 2012; Bai et al., 2012; Shi et al., 2012; Olugu et al., 2010; Tsoulfas & Pappis, 2008, Rao & Holt, 2005; Hervani et al., 2005). Finally, in a crisis induced context, the eco-innovations against resilience have been converged to be transformative/mimetic (as discussed in DIT, INT and ST) across the mesosystem - mostly towards industry alignment for competitive advantage purposes (*"incremental adaptation and transformation to new solutions is […] what we can perform at the moment"*) contributing thus to the theoretical discussion of disruptive versus transformative eco-innovation adoption (Atwell et al., 2008; Walker et al., 2006).
	The second focus group has outcomes in line with the previous focus group (considering that the stakeholders come from the same mesosystem), however one

Focus group 2	key aspect related to the specificity of the eco-innovation (EMT, DIT) – resides in the common agreement that such eco-innovation should be based on the smart specialization axes for the region/country *(“we can provide more support on the smart specialization directions […] and less support in other domains”, “ […] indeed the smart specialization areas could help us to direct our development in products and servides […]”, “[…] even if for a societal association the policy directions are not the core vision, if everybody is keen on it [smart specialization], then we coud adhere as well”, “the smart specialization areas are key guidelines for us, innovation producers to attract EU level and governmental funding”*). This way, there is an increased coherence among the quintuple helix mesosystem stakeholders, and thus everybody will work for the same goal, enabling thus faster diffusion of the eco-innovation across the mesosystem (especially since green growth and technology are key specialization areas for Greece) being thus in coherence with (Ivanaj et al., 2015; Hsu et al., 2013; Hu & Hsu, 2010; Ninlawani et al., 2010; Mont & Leire, 2009; Seuring & Muller, 2008; Walker et al., 2008; Srivastava, 2007; Chien & Shih, 2007; Wright & Elcock, 2006; Tsoulfas & Pappis, 2006; Yalabik et al., 2005; Evans & Johnson, 2005; Eveloy et al., 2005; Handfield et al., 2005; Widmer et al., 2005; WEEE, 2003).
Focus group 3	The third focus group is in line with the first two focus groups, however more emphasis was set on the role of disruptive eco-innovations. The innovation-producer institutions were the most dominant stakeholder at the focus group, while the policy maker institution was the most silent stakeholders and often in conflicting views with the topic of disruptive eco-innovations *(“as policy support, it would be hard to adjust to disruptive innovation […] even if such phenomena would be beneficial”*). Similarly, industry was also very reluctant to disruptive eco-innovations (EMT, DIT) in the current quintuple helix mesosystem context of Greece and argued for transformative innovation as a more financially secured method for enabling RGFT/RGSCM under a fast-track timeline *(“incremental adaptation and transformation to new solutions is […] what we can perform at the moment”*) contributing thus, as well, to the theoretical discussion of disruptive versus transformative eco-innovation adoption (Atwell et al., 2008; Walker et al., 2006).

Final	EMT driven eco-innovations are transformative and should be inner-generated (bottom-up within the mesosystem) rather than top-down, while the government should act as a top-down and horizontal moderator through the smart specialization strategy through which the mesosystem stakeholders align their goals/KPIs and thus enabler a faster eco-innovation diffusion – in line with DIT – under a CAST framework).

CRQ2 (relates to OB2.2, OB2.3, OB 3.2, Pillar 1; Pillar 2 and Pillar 6): *Top-down: How can the modernized ecosystem level (explained by the ST) generate eco-innovation exogenous pressures on the individual institutions (explained by INT) in an international ecosystem and what are the institutional level responses to such induced modernization? **and*** **CRQ3 (relates to OB2.2, OB2.6, OB3.3, Pillar 1 and Pillar 6)**: *Transversal: What are the local level institutional controlled processes of the CAST driven RGFT microsystem and how do these institutional controlled processes integrate and co-evolve with the ones of other quintuple helix stakeholders in order to enable co-creation and fast eco-innovation adoption (EMT, DIT) towards ensuring RGFT at the quintuple helix mesosystem-level?*

Table 22: Stage three - focus group outcomes (second part)

Event	Observations
	Following the findings presented in the previous table for CRQ1, throughout all the three focus groups, there was a good convergence (without any conflicts) over the following sequence which explains how the Greek mesosystem works (or should work): Fristly, more institutions have inner transformational desire towards incorporating/diffusing eco-innovations (DIT) in order to adapt to global standards/trends *("we need and […] we want to change", "following global standards is the key competitive advantage", "[…] Greek society needs innovations and solutions to become upgraded")*. These findings confirm (Dubey et al., 2015; Govindan et al., 2015; Lee & Kim, 2011 and Porter & Reinhardt, 2007) however, the discussion provided limited insight into exploring the hinders to this goal – especially

	the hinders to the impact of all the stkaeholders on eachother in order to support (Dubey et al., 2015; Govindan et al., 2015; Zhu et al., 2012; Delmas & Toffel, 2004; Holt, 2004 and Teuscher et al., 2006).
Final	Secondly, these institutions will perform partnerships/co-create only with institutions with similar values inducing thus a transformational change in other institutions - peer-pressure to adhere to (EMT driven) eco-innovations *("in order to succeed we all need to be at the same level […] and with the same values")*. These findings confirm (Govindan et al., 2015; Tian et al., 2014; Zhu & Geng, 2013; Dornfield et al., 2013; Zhu et al., 2012; Zhu & Liu, 2010; Testa & Iraldo, 2010; Liu & Buck, 2007), however the transformational change insights were very limited in order to fully support (Kamalahmadi & Parast, 2016; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Van der Brugge & Van Raak, 2007; Quist, 2007; Sondejker et al., 2006). Thirdly, the KPI/controlled process alignment during disruptions (towards enabling RGFT/RGSCM through eco-innovations) will be done following the axes of the smart specialization strategy as well as localized inter-institutional co-creations (following thus the CAST view). Due to the high (CAST) complexity of inter-institutional co-creations especially in RGFT/RGSCM this peer-pressure will expand covering a wide area of the mesosystem taking thus all the localized inter-institutional co-creations at a homogenous mesosystem level confirming thus the work of (Ivanaj et al., 2015; Hsu et al., 2013; Hu & Hsu, 2010; Ninlawani et al., 2010; Mont & Leire, 2009; Seuring & Muller, 2008; Walker et al., 2008; Srivastava, 2007; Chien & Shih, 2007; Wright & Elcock, 2006; Tsoulfas & Pappis, 2006; Yalabik et al., 2005; Evans & Johnson, 2005; Eveloy et al., 2005; Handfield et al., 2005; Widmer et al., 2005; WEEE, 2003). Fourtly, this expansion leads to a mesosystem/stakeholder block which will tacitly induce exogenous pressures (INT, ST) to any new individual institution that aims to

	join this network/chain. The remaining issue in this context resides in isolated micro-chains/microsystems within the mesosystem which may serve very localized purposes and may not be affected by such pressures and desires to join the wider stakeholder block – providing thus limited insight into answering the questions raised by (Kamalahmadi & Parast, 2016; de Siqueira et al., 2015; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Blackhurst et al., 2011; Petit et al., 2010; Falasca et al., 2008; Craighead et al., 2007; Tang, 2006, Christopher, 2004) in terms of interconnectedness. Finally, even in this peer – moderated/normalized mesosystem, there still is a drive to be more competitive (for institutional level survival as also described by INT, ST) and to this end, individual institutions will continue to eco-innovate (EMT) and induce peer transformational pressure (ST) that will become mesosystem/stakeholder wide and will generate exogenous pressures on new chain entrants *("at some point […] in isolated cases […] someone will still disrupt with an eco-innovation and then, everybody else will follow and transform")* - confirming thus the work of (Govindan et al., 2015; Tian et al., 2014; Dornfield et al., 2013; Zhu et al., 2012; Rehman & Shrivastava, 2011; Testa & Iraldo, 2010; Vachon & Klassen, 2007; Zhu & Sarkis, 2007; Hervani et al., 2005; Khalid et al., 2004) and the ST and INT theories. Thus, two new concepts have emerged: peer transformational pressure (for institutions already engaged in a stakeholder group) and exogenous pressure for institutions that aim to enter the stakeholder group.

CRQ4 (relates to OB3.4): *Transversal: What are the effects of the interconnectedness of the institutional level stakeholders and the location of the disruption within a quintuple helix CAST based mesosystem on the RGFT process in terms of the effectiveness of the emerged eco-innovation (EMT) diffusion (DIT) ?* and **CRQ7 (relates to OB3.1, Pillar 3, Pillar 4, Pillar 5 and Pillar 6)**: *Transversal: How does the DIT properly explain the adoption of EMT by CAST based RGFT institutions ?*

Table 23: Stage three - focus group outcomes (third part)

Event	Observations
Final	Following the findings presented in the previous tables for the previous CRQs, throughout all the three focus groups, there was a good convergence (without any conflicts) over the following sequence: Firstly, the CAST based interconnectedness plays indeed a critical role – however this is already taken as granted as there are already connections among all quintuple helix stakeholders *("we are all connected […] already but […] with different languages and goals"*) – which does not provide substantial insight into the literature on interconnectedness (Kamalahmadi & Parast, 2016; de Siqueira et al., 2015; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Blackhurst et al., 2011; Petit et al., 2010; Falasca et al., 2008; Craighead et al., 2007; Tang, 2006, Christopher, 2004). The policy institutions are more confident about this matter though rather than the industry and society institutions present at the focus group *("from a policy perspective […] we provide all the platforms to ensure this interconnection, however […] there is a problem in terms of engaging the stakeholders into the platforms"*). To this end, interconnectedness requires improvement in terms of establishing the previously identified concepts: common language, common vision, common KPIs – and all this can be achieved with the support of the smart specialization strategy (with the government as moderator) pending on the triggers launched by industry & society/environmentalists – all this can potentially respond to the aforementioned literature on interconnectedness. Secondly, the DIT based diffusion of the EMT driven eco-innovation follows the DIT based principles and is indeed reliant on the interconnectedness, however the indicators of interconnectivity – beyond the ones mentioned in the previous paragraph– consist of the inner resources & capacity of institutions to adopt and assimilate eco-innovations (capacity to foster the transformation) and then their

	capacity to diffuse further such eco-innovations *("it is more about the inner capacity to transform […] rather than the power of the ecosystem pressures"*) which supports (Dubey et al., 2015; Zhu et al., 2010; Darnall et al., 2008; Hu et al., 2008; Walker et al., 2008; Gonzales et al., 2008; Handfield et al., 2005; Bansal & Hunter, 2003, Sarkis, 2003). Finally, the effectiveness of the diffused eco-innovation should be measured against the KPIs and metrics defined at the mesosystem level – however this requires the necessary homogeneous prerequisites mentioned in the first paragraph supporting thus (Bhattacharya et al., 2014; Green et al., 2014; Shen et al., 2013; Hsu et al., 2013; Taticchi et al., 2013; Hitchcock, 2012; Dei & Shefi, 2012; Bai et al., 2012; Shi et al., 2012; Olugu et al., 2010; Tsoulfas & Pappis, 2008, Rao & Holt, 2005; Hervani et al., 2005).

CRQ5 (relates to OB3.5): Methodologies: What CAST systems modelling and simulation, mixed-methods research and behavioural analysis can be performed within an ecosystem ?

Table 24: Stage three - focus group outcomes (fourth part)

Event	Observations
Final	Following the findings presented in the previous tables for the previous CRQs, throughout all the three focus groups, there was a good convergence (initially there conflicts as every institution aimed to leverage their own methodological interests & know-how, however towards the end of the discussion, there was good convergence) over the following sequence of research methods requires to understand RGFT/RGSCM within a CAST based quintuple helix mesosystem: Firstly, there is a need for high reliance on technology to enable modelling & simulation based on real time big data *("we need ICT solutions that will help us to […] visualize and simulate and replicate reali-life scenarios that would be too costly to test").*

	Secondly, development of integrative multi-stakeholder methods that can capture view plurality in a coherent manner (mixed methods).Thirdly, multidisciplinary bridging of knowledge and expertise to help solve this social challenge. Overall, these findings are in line with the literature that claims as well these gaps (Faisal, 2016; Dubey et al., 2015; Soosay & Hyland, 2015; Smith & Rupp, 2015; Sounders et al., 2015; Power & Gruner, 2015; Deacon et al., 2014; Storer et al., 2014; Soundararajan & Brown, 2014; Iofrida et al., 2014Chouwdhury & Hossan, 2014; Molina-Azorin & Lopez-Gamero, 2014; O'Rourke, 2014; Golicic & Davis, 2012; Zhu et al., 2012; Seuring, 2011; Psychogios and Priporas, 2007; Mangan et al., 2004; Creswell, 2003; Christy and Wood, 1999; Goodman, 1999)

Besides the exploration of the items listed above, the focus groups also targeted the confirmation/validation of the findings emerged from the second stage. The outcome of the **confirmatory part** of the focus group and response to the 2^{nd} stage findings are the following:

The findings of the three focus groups confirm the 2^{nd} stage results summarized in sections 4.2.8.1 and 4.2.8.2, however the key turmoil and debate point within each focus group consisted in the drivers and barriers for the quintuple helix level implementation of RGFT/RGSCM practices. More specifically, the policy stakeholders were defending the blockers stated by the industry, innovation and social stakeholders by revealing that a lot of work/progress has been done to enable such initiatives *("we are providing platforms that can help all the stakeholders to co-create for any societal challenge [...] and platforms targeted at accesign funds and [green] policy guidelines")*. To this extent, the government has revealed the existence of platforms and funds available to support RGFT/RGSCM initiatives, however the common convergence resides in the lack of proper multi-stakeholder information and lack of related skills to access such platforms/funds *("we were not informed [...] about such platforms", "I personally do now know how [...] to use the resources"*). This was perceived as a major breakthrough for all the stakeholders.

Additionally, the role of industry stakeholders (closes actors to the market/society) requires a higher leverage towards initiating the demand for eco-innovation toward complying to social pressures, while also achieving the desired competitive advantage – supporting thus the related literature (Govindan et al., 2015; Tian et al., 2014; Dornfield et al., 2013; Zhu et al., 2012; Rehman & Shrivastava, 2011; Testa & Iraldo, 2010; Vachon & Klassen, 2007; Zhu & Sarkis, 2007; Hervani et al., 2005; Khalid et al., 2004). Still, regardless of the potential solutions for the barriers as well as the feasibility of the drivers that may enable proper implementation of RGFT/RGSCM within the Greek quintuple helix mesosystem, the key mesosystem level issue (besides lack of information and skills) resides in the lack of proactiveness of each stakeholder towards incorporating, transforming and diffusing eco-innovation (which is highly linked with the lack of information and skills). Nevertheless, there is a multilateral commitment and intention to change towards become more proactive and reactive towards RGFT/RGSCM eco-innovation diffusion *("we have to change and co-evolve")*.

Still, in order to understand the entire picture (starting from the institutional level practices and constrains to the entire mesosystem integration and co-creation towards enabling RGFT/RGSCM) a more realistic/industry-specific scenario should be developed. To this end, the next section presents the second part of the third stage which deals with modelling & simulation as well as qualitative consolidation of weather induced disruptions and their proposed RGFT/RGSCM strategies in three different companies from Greece.

4.4.2 Summary of the modelling & simulation – development & data analysis

Modelling and simulation of the supply chain of three representative companies from Greece (after the quintuple helix level consolidation & data collection). In order to achieve this, the Supply Chain Environmental Analysis Tool (SCEnAT) has been utilized. SCEnAT (2016) enables business process modelling and supply chain mapping in an online platform towards establishing the CO2 footprint of supply chain operations and towards the identification of environmentally & financially problematic hotspots within the supply chains (providing thus a suitable framework to model RGFT/RGSCM solutions). In order for this modelling to take place, interviews with the specific companies have been employed (expert convenience sampling) following the qualitative interview methodology described in section 3.1.2 and adapted to the needs of this stage (the main areas asked for the data collection part for this stage can be found in

Appendix D). The rationale of performing modelling & simulation is to bind Stage three part one findings (as well as Stage two) with realistic scenarios that would enable the proposal of a RGFT/RGSCM implementation framework described in section 4.4.2.4. For a methodological oversight please see Figure 33.

In total a number of three (3) series of interviews with the three companies has been performed:

The first series of interviews (Step 1 of the proposed framework from section 4.3.2.4 as a ground-setting step) in order to collect the main data required for modelling. Specifically, the companies have been ensured and informed one month in advance of the interview in order to collect data (samples can be found in Appendix D) regarding their entire operations during normal operational flow as well as during fog and heavy rain disruptions. These interviews with the three companies have been face-to-face with managerial level staff (which had preparedin advance the required documentation/data) and have lasted for about 2 hours each in order to ensure the completeness and accuracy of the required data.

The second series of interviews (Step 4 of the proposed framework from section 4.3.2.4) took place after the modelling & simulation for normal operational flow, for the fog and heavy rain disruptions, as well as for the proposed RGFT/RGSCM strategies took place. The rationale of the second series of interviews (phone based, 35-45 minutes) with the three companies (same managerial level staff as in the previous serie) was for the managers to select their preferred RGFT/RGSCM strategy based on the outcome of the modelling & simulation. The companies have been provided with the results in advance of the individual interviews. After selecting their preferred strategy, a quintuple helix level approach has been performed by mapping to those specific chosen interventions, drivers, barriers and other quintuple helix level consiferations emerged from Stage three part one (focus groups) and Stage two.

The third series of interviews (Step 6 of the proposed framework from section 4.3.2.4) took place (phone based, 40-50 minutes) as final consolidation and exploration mechanism to assess the proposed quintuple helix level considerations related to the chosen RGFT/RGSCM strategies to overcome fog and heavy rain disruptions. The companies have been provided with the results in advance of the individual interviews in order to ensure the required timely input.

The following four sub-sections present the model developed for each company (in form of mini-case studies) as well as the proposed RGFT/RGSCM implementation framework and its feedback/validation from each company. Due to privacy and confidentiality considerations signed with each company during the ethics consent forms, the names of the companies have been anonymized.

4.4.2.1 – Company1 – Global electronics manufacturer during normal operational flow (modelling)

Company1 (size: SME, >1M EUR revenues/year, 3PL reliant) became in full operation in the early 80s. The company is active in developing innovative electronic safety and security systems by using state of the art technology. Currently, the company employs slightly under 200 employees with 10% being involved in R&D. Company1's products are delivered in 72 countries. For the purpose of this exercise, the supply chain involved in manufacturing an emergency light has been modelled into SCEnAT in order to understand/analyse the impact caused by natural/weather induced disruptions (measurement unit: 1 emergency light).

In order to map the SC carbon map, the (high level) primary data (Figure 24) reported in the table below have been retrieved via the interview with the company. The results of the carbon accounting module of the emergency light supply chain estimated using the hybrid methodology of SCEnAT are translated into a supply chain carbon map to identify carbon hot-spots and quantify their impacts. The following scale is used in the ranking: Very High (input box colour coded in red, indicates inputs with emissions greater than 10% of the total lifecycle emissions); High (orange; 5-10%); Medium (yellow; 1-5%); Low (green; below 1%).

Input Name	Amount	Avg. Unit Cost	Emission Intensity	Carbon Emissions	Emission %
Total Monthly Energy	60000kWh	$0.60	0.5600	33,600.0000	100.0%
Plugs and Holds	4kg	$0.15	0.8805	3.5221	0.0%
Connectors	4kg	$0.15	0.8805	3.5221	0.0%
Plastic segments	5kg	$0.98	0.6789	3.3945	0.0%
Battery	2kg	$0.89	1.1289	2.2578	0.0%
PCB Materials	1kg	$0.78	0.9234	0.9234	0.0%
Jumper Segments	1kg	$0.67	0.8805	0.8805	0.0%
Wrapping Paper	1kg	$0.12	0.2390	0.2390	0.0%
Special Cover	1kg	$0.34	0.2380	0.2380	0.0%

Figure 24: Emission modelling of Company1

The Supply Chain Environmental Analysis Tool (SCEnAT) was used to model the emergency light supply chain in order to evaluate the total lifecycle carbon emissions, identify carbon-hotspots and suggest possible low carbon intervention measures to address the hot-spots.

The results of lifecycle (Figure 25) assessment (LCA) undertaken using the Hybrid LCA methodology of SCEnAT are based on the environmental impacts due to global warming potential of the emergency light supply chain. The total lifecycle carbon emissions was estimated to be 33,614.98 kg CO2-eq/kWh. This can further be divided into two main categories: process LCA impacts and indirect impacts. The process LCA impacts contributed 100.00 % of the total lifecycle impacts of the emergency light supply chain. Indirect impacts associated with the supply chain were estimated to be 0.00 %. These indirect impacts arise from emissions associated with indirect inputs from the industries aggregated across 18 sectors namely: Agriculture, Forestry, Mining, Food, Textiles, Wood & Paper, Fuels, Chemicals, Minerals, Metals, Equipment, Utilities, Construction, Trade, Transport & Communication, Business services, Personal Services.

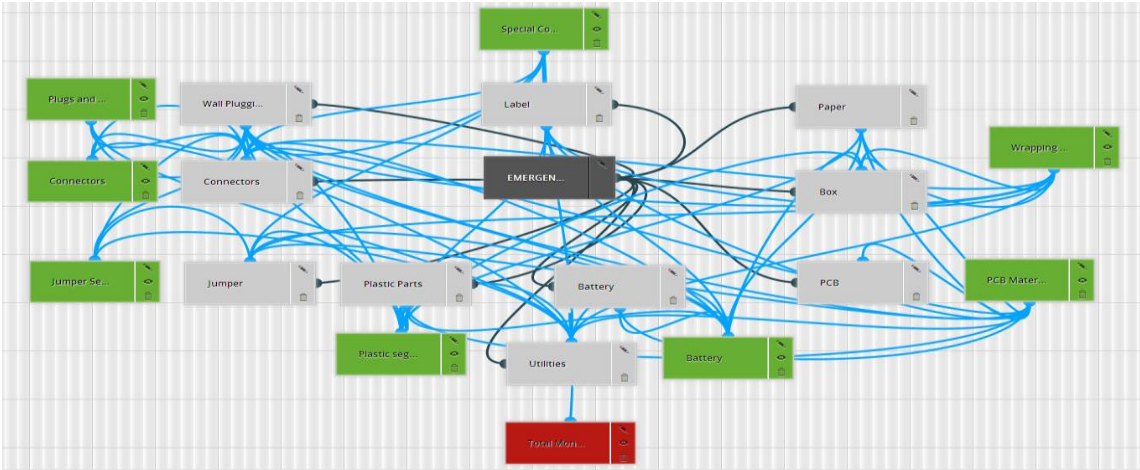

Figure 25: Supply chain modelling of Company1

The use of the robust Hybrid LCA ensures that those inputs that might otherwise be missed in the process LCA system, such as such as construction of commercial buildings (to account for construction of plants and related buildings), service related inputs (such as administration and business related activities), and other special purpose machineries for instance are captured. The lifecycle emissions are presented below in a bar chart. It consists of all direct and indirect inputs into the LCA system, classified into different input categories (Figure 26).

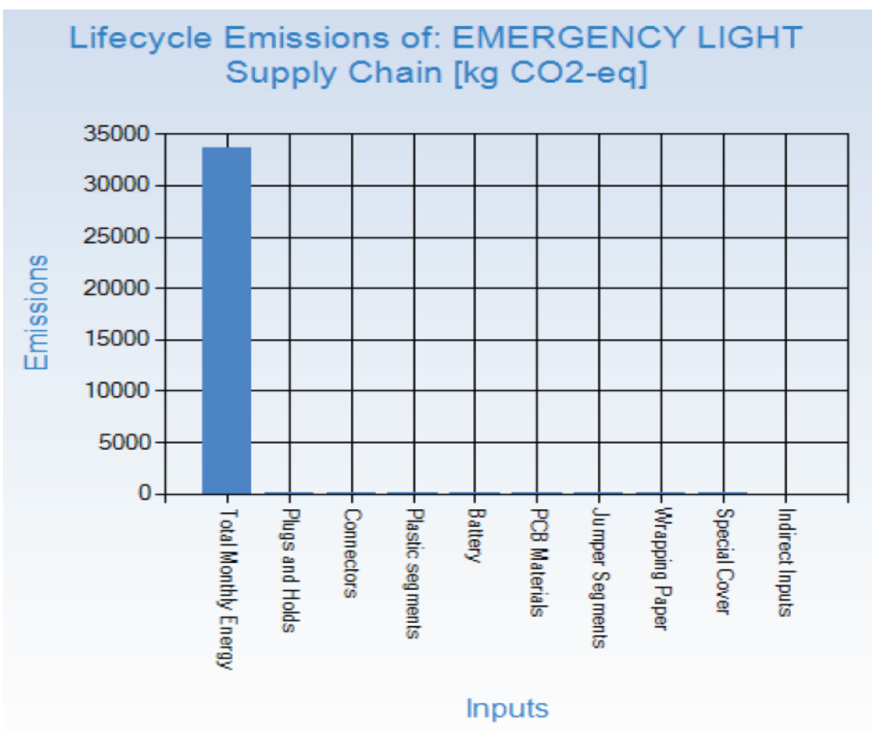

Figure 26: Emission outcomes for Company1

4.4.2.2 – Company2 – Distribution centre for supermarkets during normal operational flow (modelling)

Company2 (size: SME, >1M EUR revenues/year, 3PL reliant) operates in Northern Greece and ensures the distribution of (mainly) food supplies to a national food retailer (chain). The main operations that have been modelled in order to measure the CO2 outputs (as a direct impact of supply/demand caused by natural/weather induced disruptions that affect the company's transportation system) are related to inventory/warehouse propagated imbalances caused by natural/weather disruptions in transportation (measurement unit: 1 hour of distribution centre operation):

- Forklift energy used for picking up/putting down the cargo and any other energy associated to loading and unloading
- Automatic door motors
- Afferent utilities
- Resulted waste (mostly from wrapping, spillage)
- On-site truck transit – KMs, gas consumption and CO2 emissions

In order to map the SC Carbon Map, the primary data (Figure 27) reported in the table below have been retrieved through the initial interview with the company.

Input Name	Amount	Avg. Unit Cost	Emission Intensity	Carbon Emissions	Emission %
Power Supply	5679kWh	$0.80	0.5000	2,839.5000	32.2%
Electricity	4589kWh	$0.80	0.5000	2,294.5000	26.0%
Power supply	2387kWh	$0.80	0.5000	1,193.5000	13.5%
Electricity	2376kWh	$0.80	0.5000	1,188.0000	13.5%
Gas	679litre	$1.40	0.7890	535.7310	6.1%
Gas	679litre	$1.40	0.7890	535.7310	6.1%
Packaging Waste	897kg	$0.12	0.2560	229.6320	2.6%

Figure 27: Emission modelling of Company2

The Supply Chain Environmental Analysis Tool (SCEnAT) was used to model the Distribution Centre Operations Supply Chain in order to evaluate the total lifecycle carbon emissions, identify carbon-hotspots and suggest possible low carbon intervention measures to address the hot-spots.

The results of lifecycle assessment (LCA) undertaken using the Hybrid LCA methodology of SCEnAT (Figure 28) are based on the environmental impacts due to global warming potential of the Distribution Centre Operations Supply Chain. The total lifecycle carbon emissions was estimated to be 8,816.59 kg CO2-eq/kWh. This can further be divided into two main categories: process LCA impacts and indirect impacts. The process LCA impacts contributed 100.00 % of the total lifecycle impacts of the Distribution Centre Operations Supply Chain. Indirect impacts associated with the supply chain were estimated to be 0.00 %. These indirect impacts arise from emissions associated with indirect inputs from the industries aggregated across 18 sectors namely: Agriculture, Forestry, Mining, Food, Textiles, Wood & Paper, Fuels, Chemicals, Minerals, Metals, Equipment, Utilities, Construction, Trade, Transport & Communication, Business services, Personal Services.

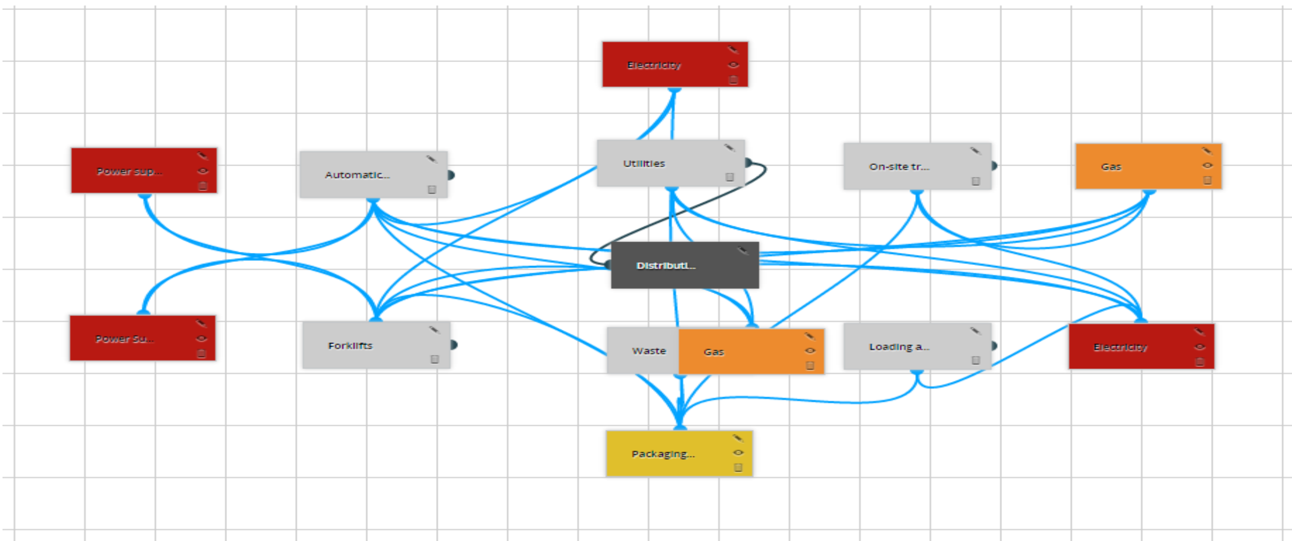

Figure 28: Supply chain modelling of Company2

The use of the robust Hybrid LCA ensures that those inputs that might otherwise be missed in the process LCA system, such as such as construction of commercial buildings (to account for construction of plants and related buildings), service related inputs (such as administration and business related activities), and other special purpose machineries for instance are captured. The lifecycle emissions of the distribution centre operations supply chain are presented below in a bar chart. It consists of all direct and indirect inputs into the LCA system, classified into different input categories (Figure 29).

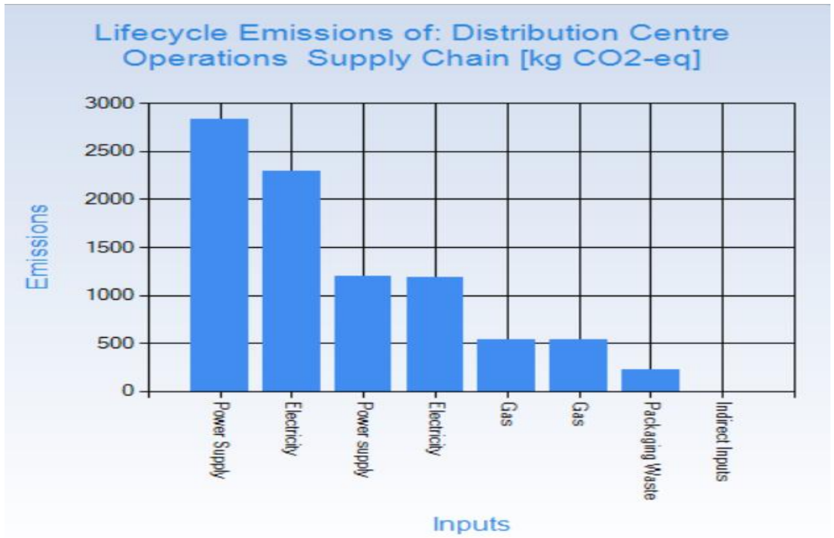

Figure 29: Emission outcomes for Company2

4.4.2.3 – Company3 – Diary food producer during normal operational flow (modelling)

Company3 (size: SME, <1M EUR revenues/year, 3PL reliant) operates in Northern Greece, Greece in one main centre and focuses on dairy products manufacturing. The main operations that have been modelled in order to measure the CO2 outputs are the impact of natural/weather induced disruptions in the transportation infrastructure of the supply/demand on the production process (measurement unit: 1 kg of Cheese):

- Milk processing machineries
- Slicing and intermediary operations
- Packaging
- Storage (including cooling)
- Waste, cleaning, sanitizing and dispensing

In order to map the SC carbon map (Figure 30), the primary data reported in the table below have been retrieved through the initial interview with the company.

Input Name	Amount	Avg. Unit Cost	Emission Intensity	Carbon Emissions	Emission %
Utilities	6792kWh	$0.80	0.5000	3,396.0000	59.6%
Electricity	2326kWh	$0.80	0.5000	1,163.0000	20.4%
Electricity	1678kWh	$0.80	0.5000	839.0000	14.7%
Water	768litre	$0.12	0.1200	92.1600	1.6%
Wrapping individual	192kg	$0.18	0.4500	86.4000	1.5%
Wrapping - Whole	232kg	$0.12	0.2500	58.0000	1.0%
Cleaning additives	92litre	$0.43	0.5600	51.5200	0.9%
Additives	82kg	$0.23	0.1980	16.2360	0.3%

Figure 30: Emission modelling of Company3

The Supply Chain Environmental Analysis Tool (SCEnAT) was used to model the cheese unit supply chain in order to evaluate the total lifecycle carbon emissions, identify carbon-hotspots and suggest possible low carbon intervention measures to address the hot-spots.

The results of lifecycle assessment (LCA) undertaken using the Hybrid LCA methodology of SCEnAT (Figure 31) are based on the environmental impacts due to global warming potential of the Cheese Unit Supply Chain. The total lifecycle carbon emissions (monthly) was estimated to be 5,702.32 kg CO2- eq/kg. This can further be divided into two main categories: process LCA impacts and indirect impacts. The process LCA impacts contributed 100.00 % of the total lifecycle impacts of the cheese unit supply chain. Indirect impacts associated with the supply chain were estimated to be 0.00 %. These indirect impacts arise from emissions associated with indirect inputs from the industries aggregated across 18 sectors namely: Agriculture, Forestry, Mining, Food, Textiles, Wood & Paper, Fuels, Chemicals, Minerals, Metals, Equipment, Utilities, Construction, Trade, Transport & Communication, Business services, Personal Services.

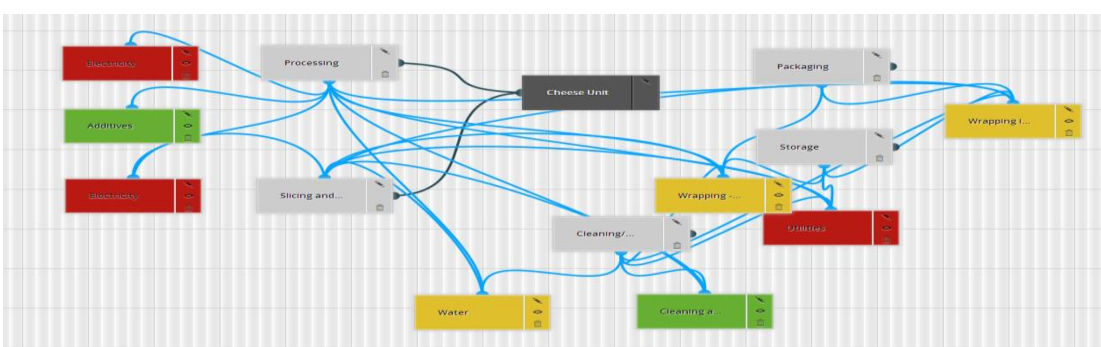

Figure 31: Supply chain modelling of Company3

The use of the robust Hybrid LCA ensures that those inputs that might otherwise be missed in the process LCA system, such as such as construction of commercial buildings (to account for construction of plants and related buildings), service related inputs (such as administration and business related activities), and other special purpose machineries for instance are captured. The lifecycle emissions of the cheese unit supply chain are presented below in a bar chart. It consists of all direct and indirect inputs into the LCA system, classified into different input categories (Figure 32).

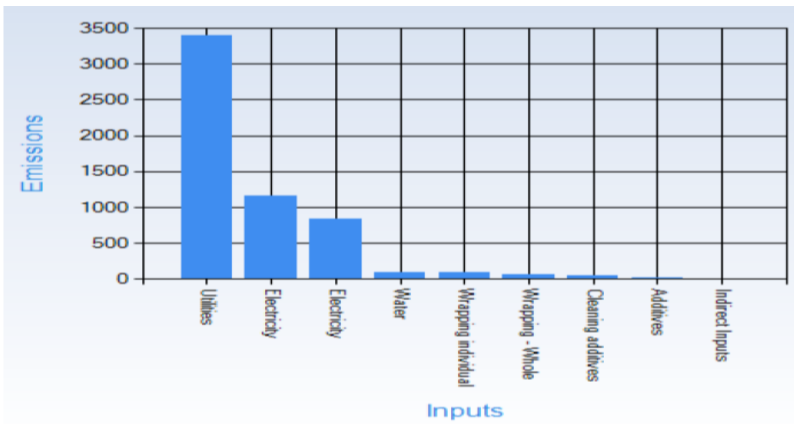

Figure 32: Emission outcomes for Company3

4.4.2.4 – The proposed RGFT/RGSCM implementation framework for the three companies

In order to propose a suitable RGFT/RGSCM implementation framework for the three companies, scenario modelling using SCEnAT has been performed based on the two top-most rated disruptions (fog and heavy rain) in Greece in transportation infrastructures (as confirmed by the 2nd stage and cross-validated by the focus groups from the first part of the third stage). The overall logic of developing the implementation framework is presented in Figure 33. The framework has six main steps:

- Step 1 – Modelling during normal operational flow (explained in details in sections 4.4.2.1, 4.4.2.2 and 4.4.2.3)
- Step 2 – Modelling and simulation during weather-induced disruptions (fog and heavy rain)

- Step 3 – Modelling and simultation of the application of the highest rated RGFT/RGSCM strategies (optimization, decision support and shorter routes)
- Step 4 – Selection of the preferred strategy and assessment/validation (interviews)
- Step 5 – Inclusion of quintuple helix considerations to the selected strategy
- Step 6 – Final consolidation of the proposed quintuple helix consideration (interviews)

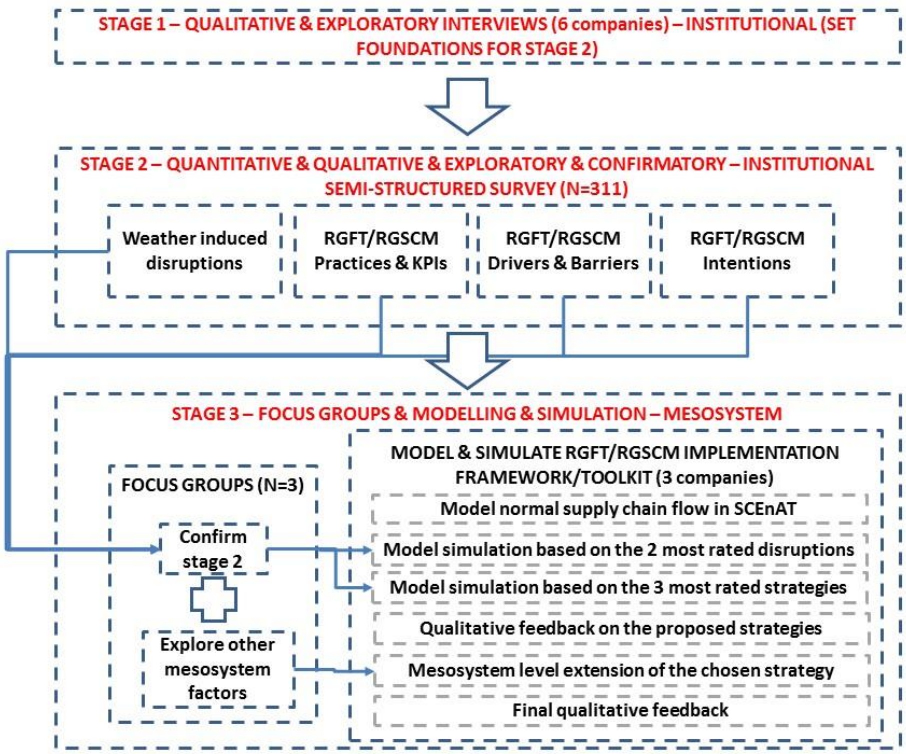

Figure 33: Methodological stages with the quintuple helix framework

Each stage of the RGFT/RGSCM implementation framework modelling and simulation is presented below (Step 1 is the ground-setting activity of initial modelling which is presented in details in sections 4.4.2.1, 4.4.2.2 and 4.4.2.3):

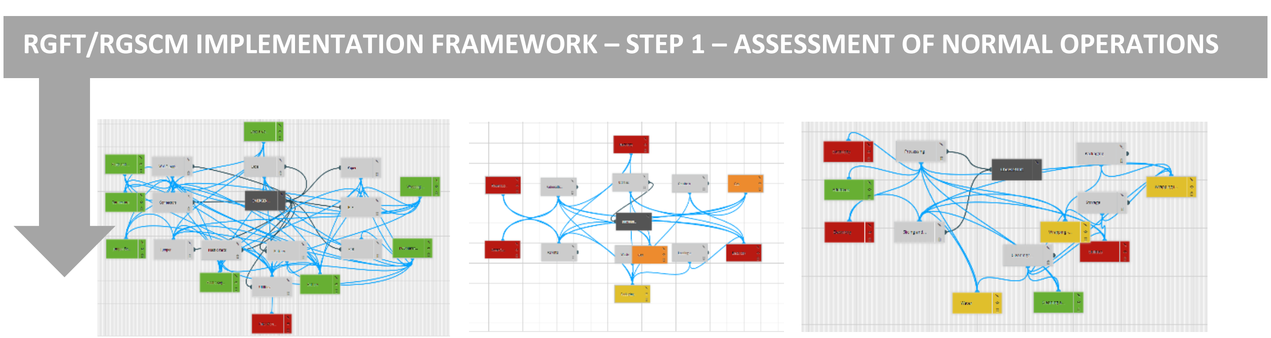

Table 25: Stage three - emissions during normal operations

Company	Emissions during normal operations
Company 1	33,614.98 kg CO2-eq/kWh
Company 2	8,816.59 kg CO2-eq/kWh
Company 3	5,702.32 kg CO2- eq/kg

RGFT/RGSCM IMPLEMENTATION FRAMEWORK – STEP 2 – ASSESSMENT OF DISRUPTED OPERATIONS

INVOLVES SUPPLY CHAIN RE-MODELLING BASED ON THE DISRUPTED STATUS OF THE OPERATIONS

Table 26: Stage three - emissions during fog and heavy rain

Company	Emissions during fog which causes delays	Emissions during heavy rain which causes coordination issues
Company 1	38,212.12 kg CO2-eq/kWh	28,124.22 kg CO2-eq/kWh* (but with stock-out cases)
Company 2	14,637.89 kg CO2-eq/kWh	16,251.12 kg CO2-eq/kWh
Company 3	6,156.35 kg CO2-eq/kg	6,271.90 kg CO2- eq/kg

Based on the interview data collected, several CO2 calculations have been modelled/produced as shown in the above table. As it can be seen, in certain cases, the CO2 footprint increase was not substantially higher during the fog and heavy rain induced disruptions, still, on the long term, even small increase/deviations can bring cost and compliance breach issues. Additionally, one peculiar scenario was noticed in case of the first company during heavy rain disruptions in the sense that the report CO2 output was lower, (though) due to the temporary stop of production (as an outcome) and which leaded to a significant stock-out with financial implications and brand damage.

RGFT/RGSCM IMPLEMENTATION FRAMEWORK – STEP 3 – PROPOSED SOLUTIONS MODELLING

INVOLVES SUPPLY CHAIN RE-MODELLING BASED ON THE PROPOSED RGFT/RGSCM PRACTICES EXPLORED AND CONFIRMED IN STAGE 2 (Survey) and STAGE 3 (Focus groups)

In order to demonstrate this third step of the RGFT/RGSCM implementation framework, the three top most rated RGFT strategies for Greece (improvement of business inefficiencies (waste reduction), reliance on soft technology for real-time decision support and enabling shorter routes) from Stage two (and confirmed in the first part of Stage three) have been used to re-model the three supply chains (what-if scenario modelling) and calculate the CO2 outputs during fog and heavy rain disruptions for the newly modelled supply chains based on the three key strategies/interventions. The results are the following (comprised in Table 27 and illustrated in Figure 34 and Figure 35):

Table 27: Stage three - emissions after modelling the strategies

Company	Fog disruptions which cause delays			Emissions during heavy rains which causes coordination issues		
Company 1 Normal emissions: 33,614.98 kg CO2-eq/kWh	Emissions during fog: 38,212.12 kg CO2-eq/kWh			Emissions during heavy rain: 28,124.22 kg CO2-eq/kWh* (with stock-out cases)		
	Optimization/ Waste reduction	ICT Decision support	Shorter routes	Optimization/ Waste reduction	ICT Decision support	Shorter routes
	24,822.18 kg CO2-eq/kWh	29,167.33 kg CO2-eq/kWh	22,467.81 kg CO2-eq/kWh	29,122.11 kg CO2-eq/kWh	22,821.83 kg CO2-eq/kWh	21,467.81 kg CO2-eq/kWh
Company 2	Emissions during fog: 14,637.89 kg CO2-eq/kWh			Emissions during heavy rain: 16,251.12 kg CO2-eq/kWh		
	Optimization/ Waste reduction	ICT Decision support	Shorter routes	Optimization/ Waste reduction	ICT Decision support	Shorter routes

Normal emissions: 8,816.59 kg CO_2-eq/kWh	8,017.45 kg CO_2-eq/kWh	7,561.89 kg CO_2-eq/kWh	8,215.02 kg CO_2-eq/kWh	8,025.09 kg CO_2-eq/kWh	7,260.80 kg CO_2-eq/kWh	8,301.19 kg CO_2-eq/kWh
Company 3 Normal emissions: 5,702.32 kg CO_2-eq/kg	Emissions during fog: 6,156.35 kg CO_2- eq/kg			Emissions during heavy rain: 6,271.90 kg CO_2-eq/kg		
	Optimization/ Waste reduction	ICT Decision support	Shorter routes	Optimization/ Waste reduction	ICT Decision support	Shorter routes
	2,671.10 kg CO_2-eq/kWh	9,872.78 kg CO_2-eq/kWh	5,567.65 kg CO_2-eq/kWh	2,961.11 kg CO_2-eq/kWh	9,112.66 kg CO_2-eq/kWh	5,522.02 kg CO_2-eq/kWh

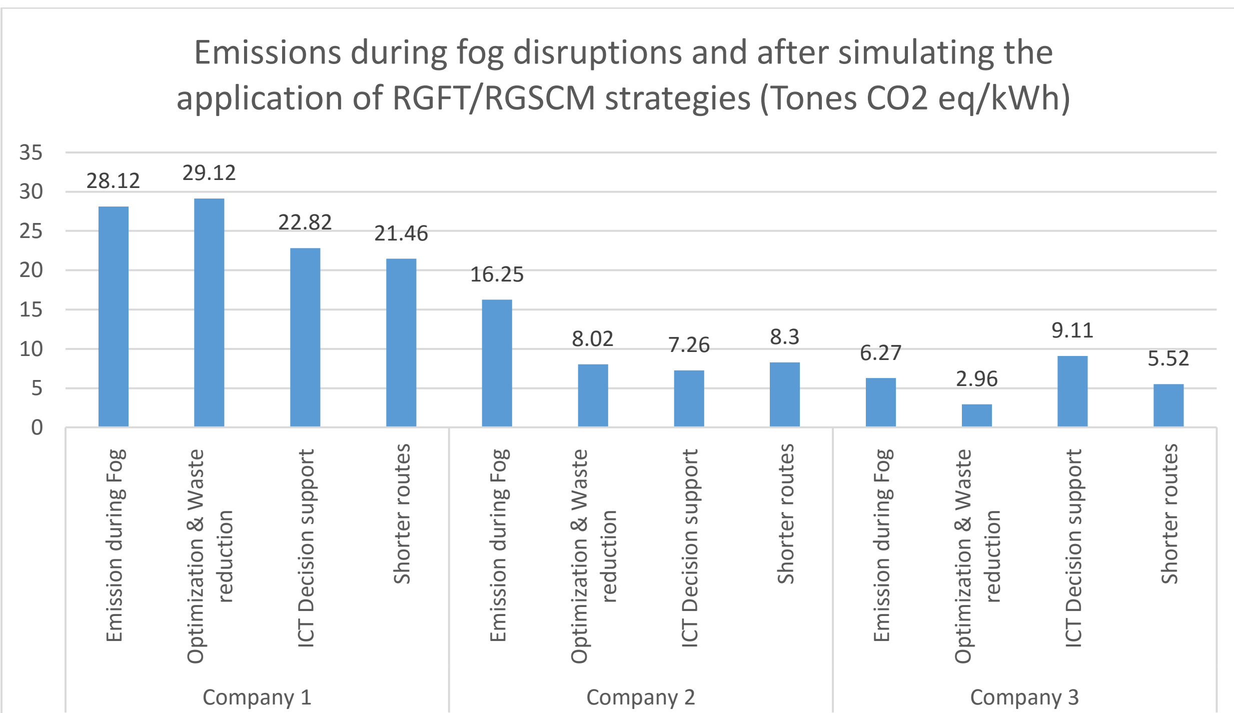

Figure 34: Stage three - Outcomes of fog disruption modelling

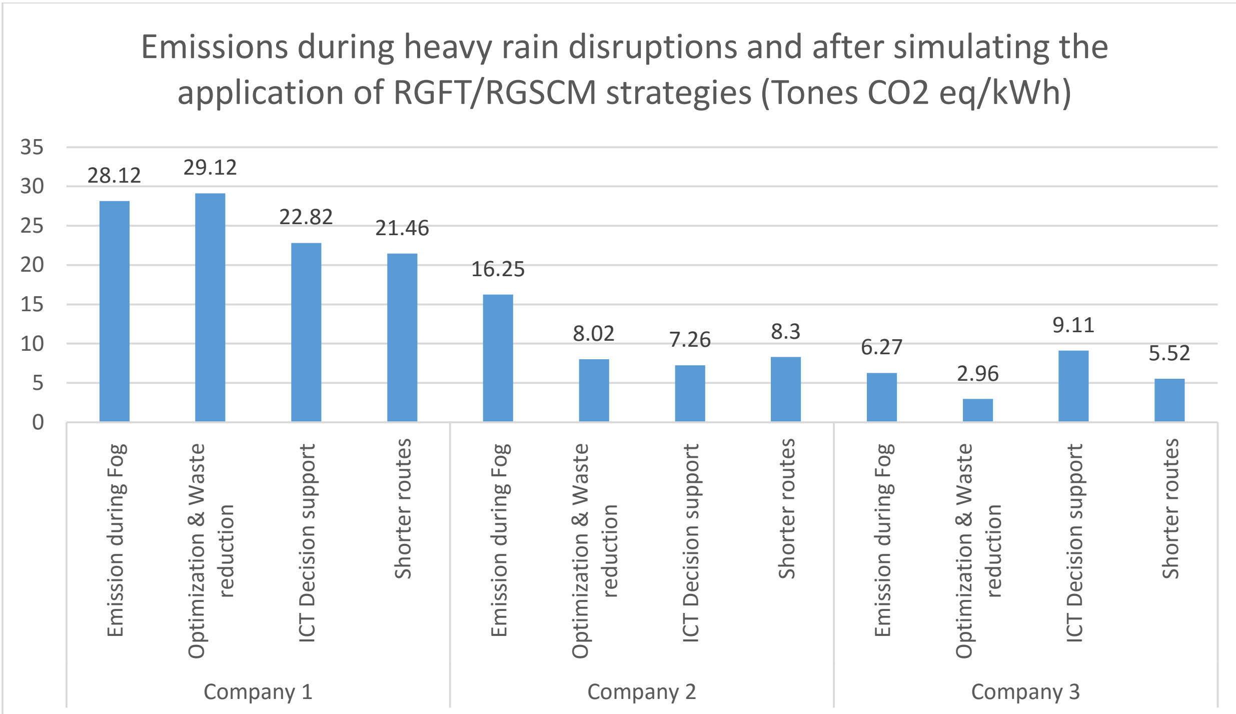

Figure 35: Stage three - Outcomes of heavy rain disruption modelling

RGFT/RGSCM IMPLEMENTATION FRAMEWORK – STEP 4 – INSTITUTIONAL QUALITATIVE FEEDBACK

INVOLVES QUALITATIVE INTERVIEWS WITH THE 3 COMPANIES (MANAGERS) IN ORDER TO GATHER THEIR INSIGHTS INTO THE MODELLING RESULTS AND INTO THEIR PREFERRED SOLUTION/INTERVENTION TO SERVE AS NEXT STEP's INPUT.

In order to assess the suitability/validity of the modelling & simulation outcomes, brief telephone interviews (30-35 minutes) with the involved companies (with related managers) have been performed in order to present the findings and ask the representatives to select their desired RGFT/RGSCM strategy (towards proceeding to the next step).

- **Company 1**: This company (electronics manufacturer) met the best results in the SCEnAT based modelling of the company's supply chain during fog and heavy rain disruptions. After a cost-benefit analysis performed by the operations manager of the company, the preferred RGFT/RGSCM strategy is waste optimization techniques (as it integrates properly with the lean operations model of the company) during both weather induced disruptions specifically because "*our company has a lead thinking approach […] which will make waste optimization techniques much cost-effective to implement by reducing the fixed costs and by expanding to our transportation activities*".

- **Company 2**: This company (distribution centre) had moderate results in the SCEnAT based modelling of the company's supply chain during fog and heavy rain disruptions. The explanation for the moderate sustainability effects after applying the three main strategies during the modelling process resides in the type of operations employed on the spot. Specifically, the waste optimization and shorter route strategies did not produce a substantially low CO2 emission result during disruptions as the distribution centre's operations do not rely primarily on these two aspects. After a cost-benefit analysis performed by the operations manager of the company, the preferred RGFT/RGSCM strategy is ICT for decision support (as it can provide better synchronization and distribution centre optimization/scheduling) during both weather induced disruptions (*"such decision support, even though I am not familiar with such tool, might provide some benefits especially for coordinating with the freight system […] as we cannot implement structural changes (hard)"*).

- **Company 3**: This company (dairy producer) had moderate and negative results in the SCEnAT based modelling of the company's supply chain during fog and heavy rain disruptions. The explanation for the moderate sustainability effects after applying the three main strategies during the modelling process resides in the type of operations employed on the spot. Specifically, shorter routes did not produce a substantially low CO2 emission result during disruptions as the company's operations are in very close proximity to each-other (not requiring thus route optimization). Additionally, the simulation for the introduction of ICT decision support involved substantial changes in the company's workflow and infrastructure which caused increase CO2 output to cope with the simulated disruptions ("*In order to introduce […] ICT in our operations we require a lot of new equipment, and changes especially in the production side in order to integrate better with the freight transportation system*"). After a cost-benefit analysis performed by the operations manager of the company, the preferred RGFT/RGSCM strategy is business/waste optimization (as it can provide more savings and primary resource waste reduction) during both weather induced disruptions.

RGFT/RGSCM IMPLEMENTATION FRAMEWORK – STEP 5 – MESOSYSTEM CONSIDERATIONS

THE CHOSEN STRATEGIES WILL BE MAPPED AGAINST THE DRIVERS & BARRIERS & ADDITIONAL MESOSYSTEM RELATED ASPECTS DISCUVERED IN THE 2nd STAGE OF THE THESIS AS WELL AS IN THE 3rd STAGE (FOCUS GROUPS)

Table 28: Stage three – mesosystem mapping

Company	Selected strategy	Drivers	Barriers	Other aspects
Company 1 and Company 3	Business/ waste optimization	Next trend in RGFT /RGSCM; Competitive advantage; This enables RGFT/RGSCM; Lower taxes	Unskilled staff; Limited information	Lack of information and training; Heterogeneity with business partners; Proactiveness towards eco-innovation and co-modernisation.
Company 2	ICT tools for decision support	Next trend in RGFT/ RGSCM; Competitive advantage; Technology enables RGFT/RGSCM	Big investment; Unskilled staff; Limited information	

RGFT/RGSCM IMPLEMENTATION FRAMEWORK – STEP 6 – MESOSYSTEM INSIGHTS

THE QUINTUPLE HELIX MESOSYSTEM FACTORS (DRIVERS/BARRIERS/OTHER ASPECTS) ATTACHED TO THE CHOSEN STRATEGIES WILL BE QUALITATIVELY EVALUATED BY EACH OF THE 3 COMPANIES IN ORDER TO ASSESS THE MESOSYSTEM LEVEL FEASIBILITY OF THE PROPOSALS.

For assessing the suitability/validity of the mesosystem considerations attributed to the proposed RGFT/RGSCM strategies (Table 46), telephone interviews (40-50 minutes) with the involved companies (with related managers) have been performed in order to present the findings and ask the representatives to consolidate, explain and potentially extend these proposas.

All three companies agree with the drivers and barriers to the chosen RGFT/RGSCM mitigation strategies during fog & heavy rain induced disruptions. Additionally, in terms of the quintuple helix mesosystem level issues such as heterogeneity with other institutions and willingness to engage in eco-innovation diffusion (and/or transformation) through the adoption of such RGFT/RGSCM practices the opinions, in each case, are the following:

Company 1 (electronics manufacturer) has as mission to become an eco-innovation leader (as its stakeholder group resides in similar mind-sets) and diffuser through raising standards within business partnerships and among all the involved quintuple helix stakeholders *("we are part of a leading league of global manufacturers […] and we will always seek to innovate and excel"*), however the general lack of skills and information at the mesosystem level prohibits this action to achieve its maximum potential (*"we are always trying to keep ourselved updated with the latest trainings […] but it is often hard to access governmental support"*). For example, the company would be willing to implement waste optimization to its fullest potential, however, the other mesosystem level stakeholders (i.e municipality, public services, other businesses) are not enabling the required co-creation/synergy to produce the intended outcomes. These aspects seem to partially contradict the policy view emerged from the focus groups (Stage three Part one) and confirm the related literature (Ivanaj et al., 2015; Hsu et al., 2013; Hu & Hsu, 2010; Ninlawani et al., 2010; Mont & Leire, 2009; Seuring & Muller, 2008; Walker et al., 2008; Srivastava, 2007; Chien & Shih, 2007; Wright & Elcock, 2006; Tsoulfas & Pappis, 2006; Yalabik et al., 2005; Evans & Johnson, 2005; Eveloy et al., 2005; Handfield et al., 2005; Widmer et al., 2005; WEEE, 2003). Additionally, the primary objectives of each stakeholder is substantially different and this leads to lack of proper adoption at the mesosystem level of eco-innovations. These findings confirm the initial assumptions of the role of ST, INT, DIT and EMT in explaining the process of eco-innovation diffusion in CAST based mesosystems and are also in line with the focus groups from Stage three part one – while also supporting the literature (Bhattacharya et al., 2014; Green et al., 2014; Shen et al., 2013; Hsu et al., 2013; Taticchi et al., 2013; Hitchcock, 2012; Dei &

Shefi, 2012; Bai et al., 2012; Shi et al., 2012; Olugu et al., 2010; Tsoulfas & Pappis, 2008, Rao & Holt, 2005; Hervani et al., 2005).

Company 2 (distribution centre) and **Company 3** (dairy producer) are less inclined to engage in eco-innovation diffusion and to adopt any required transformations mostly due to the fact that their stakeholder group does not require such measures *("we cannot engage in risky endeavours […]. As long as we can keepy a positive balance and satisfy our customers")*. This brings thus an additional argument for the role of ST and INT when it comes to coercive eco-innovation (EMT) diffusion (DIT) in CAST based mesosystems (Govindan et al., 2015; Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Hsu et al., 2013; Shi et al., 2012; Rehman & Shrivastava, 2011; Zhu et al., 2010; Testa & Iraldo, 2010; Carter & Rogers, 2008; Chen, 2008; Vachon & Klassen, 2007; Chien & Shih, 2007; Ellen et al., 2006; Capaldi, 2005).

4.4.2.5 – Summary of the modelling & simulation stage

The modelling & simulation stage using SCEnAT has been utilized towards subjecting companies to RGFT/RGSCM implementation frameworks under quintuple helix mesosystem considerations. As a core literature claim for understanding RGFT/RGSCM, modelling & simulation enabled to cross-validate in a more realistic scenario the findings of the 2^{nd} stage (primarily) as well as to qualitatively cross-validate the findings of the focus groups from the third stage. The results of the modelling & simulation phase converge with the previous findings (from the previous methodological stages) and strengthen the claims of the TFT Pillars of this thesis by cross-validating the assumptions identified in the literature for each Pillar, as well as answering the CRQs and OBs. A full picture and critical analysis of all the stages is provided in section 5 of the report.

4.5 Summary of the data analysis process

This chapter discussed the data analysis results for the thre main methodological stages employed by this research: **Stage one** - Qualitative exploratory interviews at the institutional level (N=6, one in each different country from SEE) to consolidate the scarce literature findings (from SEE) and to enable a more targeted approach for Stage two. Data has been analyzed via inductive content analysis. **Stage two -** Qualitative (exploratory) and quantitative (confirmatory) semi-structured survey across the six SEE countries (N=311) at the institutional level (test and explore: RGFT/RGSCM practices and their implementation status, drivers & barriers to RGFT/RGSCM implementation, KPIs used to monitor RGFT/RGSCM and wilingness to implement RGFT/RGSCM). Data has been analyzed via quantitative statistical methods as well as inductive content analysis. **Stage three** – **Part one -** Exploratory and confirmatory qualitative focus groups (N=3) to provide more insight into Stage two in Greece only and to leverage the institutional level findings to a stakeholder/quintuple helix mesosystem level (data has been analyzed via inductive content analysis following a proper focus group protocol); and **Stage three** – **Part two** - Modelling and simulation of institutional level supply chains towards proposing a quintuple helix framework (as confirmed/explored in Stage three Part one) for the implementation of RGFT/RGSCM during weather-induced disruptions (data has been quantitatively analyzed in this case via the modelling tool and qualitatively explored via validation interviews).

Overall, the results provide explorations into converging the five theories towards explaining how RGFT/RGSCM can be implemented institutionally and at the mesosystem level (in SEE with the main focus on Greece) under a quintuple helix approach –where the key message that has been revealed is that quintuple helix co-creation, goal an KPI alignment of all stakeholders and capacity to transform (eco-modernize) of institutions are the key enablers of fast eco-innovation (RGFT/RGSCM) diffusion and implementation. A detailed critical discussion about each finding and about the triangulation and validation process is provided in Chapter 5 (Discussion).

Chapter 5: Discussion

5.1 Introduction

This section provides a critical analysis of the primary research findings against the literature derived hypotheses that led to the creation of the converged research questions (CRQs), of the research objectives (OBs) and of the pillars of the proposed theoretical framework of the thesis. Each such item will be discussed in individual subsections.

In order to provide a better understanding on the validity of the triangulation provided below, the following bullet points summarize the key points of each research stage that leaded to the emergence of the following outcomes:

- **Stage one** – Qualitative exploratory interviews at the institutional level (N=6, one in each different country from SEE) to consolidate the literature findings and enable a more targeted approach for Stage two.
- **Stage two** – Qualitative + quantitative exploratory & confirmatory semi-structured survey across the six SEE countries (N=311) at the institutional level.
- **Stage three –** Focus groups, Modelling & Simulation
    - – **Part one** Exploratory & confirmatory qualitative focus groups (N=3) to consolidate Stage two in Greece only and to leverage the institutional level findings to a stakeholder/quintuple helix mesosystem level.
    - – **Part two** Modelling & simulation of institutional level supply chains towards proposing a quintuple helix framework (as confirmed/explored in Stage three Part one) for the implementation of RGFT/RGSCM during weather-induced disruptions.

5.2 Outcomes for the converged research questions

CRQ1 and CRQ3: Bottom-up: How can local level institutional EMT driven eco-innovations (either transformative or disruptive) diffuse faster under the DIT behaviour and scale-up across the RGFT CAST driven microsystem panarchy during crises towards enabling resilience and Transversal: What are the local level institutional controlled processes of the CAST driven RGFT microsystem and how do these institutional controlled processes integrate and co-evolve with the ones of other quintuple helix stakeholders in order to enable co-creation and fast eco-innovation adoption (EMT, DIT) towards ensuring RGFT at the quintuple helix mesosystem-level:

Stage one reveals unilaterally the need for "[…] *quintuple helix co-creation as a core enabler*" of EMT driven eco-innovation diffusion & scale-up (DIT) across the CAST based panarchy/microsystem and thus this informs the literature which sustains CRQ1. From the data collected, the following factors are key enablers of such behaviour: "*mutual support […] and standardisation of practices/policies*"; "*transparency of operations*"; "*technology usage*"; "*better regional planning […]*"; "*[…] enhanced transportation infrastructure*", however very few of these enablers are inner RGFT/RGSCM practices (that would trigger co-creation) as initially suggested by (Bahadur & Doczi, 2016; Dubey et al., 2015; Zhu et al., 2010; Darnall et al., 2008; Hu et al., 2008; Walker et al., 2008; Gonzales et al., 2008; Handfield et al., 2005; Bansal & Hunter, 2003, Sarkis, 2003). **Stage two** did not focus particularly on this aspect, however the impacting factor revealed through this stage resides in the use of technology as a key enabler of fast RGFT/RGSCM adoption & diffusion (N=311, Average: 4.10 out of 5 Likert scale).

Stage three (focus groups part, N=3), though, reveals the critical importance of co-creation towards ensuring faster diffusion of eco-innovations from the institutional level to the mesosystem level and this is achieved through: " *[…] focusing on the smart specialization pillars of Greece*" – which are based on eco-innovation and technology (Ketikidis et al., 2016) – being thus in line with the EMT, DIT & CAST; or *"[…] aligning the incentives, goals and KPIs*" – aspect also highlighted by (Bahadur & Doczi, 2016; Bhattacharya et al., 2014; Green et al., 2014; Shen et al., 2013; Hsu et al., 2013; Taticchi et al., 2013; Hitchcock, 2012; Dei & Shefi, 2012; Bai et al., 2012; Shi et al., 2012; Olugu et al., 2010; Tsoulfas & Pappis, 2008, Rao & Holt, 2005; Hervani et al., 2005); or *"mimetic transformation […] for competitive advantage purposes"* appears to play a critical role in the specific mesosystem's context (the greater the competition, the greater the transformation/diffusion) – aspect also in line with (Govindan et al., 2015; Tian et al., 2014; Zhu & Geng, 2013; Dornfield et al., 2013; Zhu et al., 2012; Zhu & Liu, 2010; Testa & Iraldo, 2010; Liu & Buck, 2007).

Still, according to the results of **Stage three (modelling and simulation**) consolidated by qualitative interviews (N=3), such diffusion would be quite problematic to implement as "*[…] the suitability of such solution for one company may not be the same for another company, or may not be properly integrated with the government and society*". This supports similar claims performed by (Zhu et al., 2012; Carter & Rogers, 2008; Steensma & Corley, 2000). As well, *"disruptive transformation is […] preferred"* was of the innovators' claims during the focus groups, however, industry and government were very reluctant to disruptive eco-innovations in the current quintuple helix mesosystem context of Greece and argued for transformative innovation as a more financially secured method for enabling RGFT/RGSCM under a fast-track timeline. This aspect is also in line with the literature with regards to the financial aspect involved by such investments (Govindan et al., 2015; Drohomeretsk et al., 2014; Zaabi et al., 2013; Diabat & Govindan, 2011; Connell, 2010; Alkhidir & Zailani, 2009; Walker et al., 2008; Presley et al., 2007; van Hemel & Cramer, 2002) as well as with **Stage one** (i.e. *"[…] our main barrier is cost rather than flexibility and willingness to try such practices*") and **Stage two** findings (where the cost aspects were rated as highly problematic – the "Too big investment" item has been rated 4.00/5, N=311).

Finally, the institutionally controlled processes (KPIs) are subjective to the findings mentioned above and are discussed in more details in the next section that focuses on OBs. Still, all three stages converge on the role of co-creation to answer CRQ1 supporting thus the work and claims of (Ivanaj et al., 2015; Hsu et al., 2013; Hu & Hsu, 2010; Ninlawani et al., 2010; Mont & Leire, 2009; Seuring & Muller, 2008; Walker et al., 2008; Srivastava, 2007; Chien & Shih, 2007; Wright & Elcock, 2006; Tsoulfas & Pappis, 2006; Yalabik et al., 2005; Evans & Johnson, 2005; Eveloy et al., 2005; Handfield et al., 2005; Widmer et al., 2005; WEEE, 2003) in relation to co-creation, collaboration and co-modernisation.

CRQ2 and CRQ7: Top-down: How can the modernized ecosystem level (explained by the ST) generate eco-innovation exogenous pressures on the individual institutions (explained by INT) in an international ecosystem and what are the institutional level responses to such induced modernization and Transversal: How does the DIT properly explain the adoption of EMT by CAST based RGFT institutions?

The methodological convergence is described the best through **Stage three (focus groups and modelling & simulation)** which triangulates, consolidates and informs **Stage one** and **Stage two** in the following manner:

More institutions have inner transformational desire towards incorporating eco-innovations in order to adapt to global standards/trends (i.e. *"[...] I am always in seek for new such eco-innovations to be ahead of competition and in trend with societal demands*". Such outcomes are in high coherence with the literature (Bahadur & Doczi, 2016; Dubey et al., 2015; Govindan et al., 2015; Zhu et al., 2012; Zhu et al., 2010; Darnall et al., 2008; Hu et al., 2008; Walker et al., 2008; Gonzales et al., 2008; Handfield et al., 2005; Bansal & Hunter, 2003, Sarkis, 2003). This is also quantitatively confirmed by **Stage two** where, for example, a specific part of the survey targeted to test the adoption level of eco-innovations under three main behavioural variables (behavioural intention to adopt eco-innovations (BI), perceived usefulness of eco-innovations (PU) and perceived ease of use of eco-innovations (PEU). More specifically, whether the respondents declare a high PU (4.00/5) of RGFT/RGSCM eco-innovations, the PEU of such eco-innovations is considerably low (2.38/5). The PEU is linked to the limited information and knowledge on this topic described also by (Govindan et al., 2015 Zaabi et al., 2013; Drohomeretsk et al., 2014; Balasubramanian, 2012; Diabat & Govindan, 2011; Sarkis et al., 2010; Soler et al., 2010; Vuro et al., 2009; del Brio et al., 2008; Yu & Hui, 2008; Walker & Preuss, 2008). Still the BI element (which is the core measurement of the willingness to adopt eco-innovations and thus support the DIT statements) is moderately high (3.53/5). **Stage one** is not related to informing these findings.

These institutions will perform partnerships/co-create only with institutions with similar values inducing thus a transformational change in other institutions (peer-pressure to adhere to eco-innovations) – aspect which is in line with the literature on coercive adoption of EMT driven eco-innovations under the DIT assumptions (Govindan et al., 2015; Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Hsu et al., 2013; Shi et al., 2012; Rehman & Shrivastava, 2011; Zhu et al., 2010; Testa & Iraldo, 2010; Carter & Rogers, 2008; Chen, 2008; Vachon & Klassen, 2007; Chien & Shih, 2007; Ellen et al., 2006; Capaldi, 2005). **Stage two** though, does not add validity to these findings as the instruments that measured (N=311) the requirements in terms of environmental/social sustainability of stakeholders scored very low –such as:

> "Request of overall environmental practice incorporation" (2.07 out of 5), "Implementation of Environmental Management Systems" (2.05 out of 5), "Interest in green supply chain management" (2.15 out of 5), "Provision of inter-partner training" (2.14 out of 5), "Request of environmental compliance info" (2.09 out of 5) and "Provision of detailed environmental specification" (2.04 out of 5).
>
> Even more, besides being in contradiction with **Stage three (focus groups)** as well as in partial contradiction with **Stage three (modelling and simulation** which reveals varied visions of the interviewed companies in terms of the requirements imposed to the institutions from their stakeholder block), **Stage two and Stage three (focus groups) as well as Stage one** confirm the vision/goals in terms of prospective RGFT/RGSCM implementation and reveal the limited implementation of such practices at the moment in SEE and Greece.

Furthermore, the results show that the KPI/controlled process alignment during disruptions (towards enabling RGFT/RGSCM through eco-innovations) will be done following the axes of the smart specialization strategy as well as localized inter-institutional co-creations (as showed in the discussion for CRQ1 and CRQ3) – extending thus the CAST based knowledge under the Greek mesosystem. **Stage one and Stage two** do not impact on this item.

Still, due to the high complexity of inter-institutional co-creations especially in RGFT/RGSCM this peer-pressure will expand covering a wide area of the mesosystem taking thus all the localized inter-institutional co-creations at a homogenous mesosystem level – widely confirming the previous literature on this topic (Bahadur & Doczi, 2016; Dubey et al., 2015; Govindan et al., 2015; Tian et al., 2014; Gobbo et al., 2014; Zhu et al., 2012; Darnall et al., 2008; Andrews et al., 2003; Hoffman & Ventresca, 2002) (Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Golicic & Smith, 2013; Zhu et al., 2010; Testa & Iraldo, 2010; Nawroka, 2008; Walker et al., 2008; Chien & Shih, 2007; Hervani et al., 2005; Ginsberg & Bloom, 2004; Delmas & Toffel, 2004; Gupta &

Pierro, 2003; Rao, 2002; Chan & Lau, 2001; Hoffman, 2000). **Stage one and Stage two** do not impact on this item.

This expansion leads to a mesosystem/stakeholder block which will tacitly induce exogenous pressures to any new individual institution that aims to join this network/chain. Such aspects are in line with the previously identified literature (Govindan et al., 2015; Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Hsu et al., 2013; Shi et al., 2012; Rehman & Shrivastava, 2011; Zhu et al., 2010; Testa & Iraldo, 2010; Carter & Rogers, 2008; Chen, 2008; Vachon & Klassen, 2007; Chien & Shih, 2007; Ellen et al., 2006; Capaldi, 2005) in relation to the mesosystem induced coercive adoption of institutional practices (paving thus the link between INT, ST, EMT and DIT) – as well as the adoption of practices under normative compliance (Govindan et al., 2015; Drohomeretsk et al., 2014; Lee & Kim, 2011; Mann et al., 2010). These findings are partly sustained by **Stage one** as well as largely confirmed by **Stage two** (N=311) under the framework of assessing the drivers of the implementation of eco-innovations imposed from the mesosytem level (for more details see the next section where the drives are being discussed). The qualitative consolidation (N=3) of the modelling & simulation based quintuple helix RGFT/RGSCM implementation framework from **Stage three (second part)** also sustains these findings by arguing that *"[…] if we trigger an eco-innovation which slowly becomes a key market trend, then everybody will adopt it to become competitive […] and the government and other actors will develop mechanisms to support this and thus lagging institutions will have to adapt […]*". The remaining issue in this context resides in isolated micro-chains/microsystems within the mesosystem which may serve very localized purposes and may not be affected by such pressures and desires to join the wider stakeholder block.

Finally, even in this peer – moderated/normalized mesosystem, there still is a drive to be more competitive (for institutional level survival) and to this end, individual institutions will continue to eco-innovate and induce peer transformational pressure that will become mesosystem/stakeholder wide and will generate exogenous pressures on new chain entrants as also proposed by the literature – either as a coercive pressure to eco-innovate/transform/modernize (Bahadur & Doczi, 2016; Dubey et al., 2015; Zhu et al., 2010; Darnall et al., 2008; Hu et al., 2008; Walker et al., 2008; Gonzales et al., 2008; Handfield et al., 2005; Bansal & Hunter, 2003, Sarkis, 2003) or simply as an inner desire to innovate (Govindan et al., 2015; Tian et al., 2014; Dornfield et al., 2013; Zhu et al., 2012; Rehman & Shrivastava, 2011; Testa & Iraldo, 2010; Vachon & Klassen, 2007; Zhu & Sarkis, 2007; Hervani et al., 2005; Khalid et al., 2004) confirming thus the EMT and DIT assumptions within the INT-ST induced framework. **Stage two** strongly confirms this aspect (more details in the next section that presents the discussion on the drivers towards RGFT/RGSCM eco-innovation adoption). Similarly, **Stage three (second part)** also sustains these findings by providing arguments such as: *"[...] the cycle of eco-innovation diffusion is triggered by the constant need of institutions to be more competitive*" – strengthening thus the convergence of the EMT, DIT, ST and INT under a CAST driven context. Still, the debate between transformative and disruptive eco-innovation diffusion towards solving the RGFT/RGSCM challenge is not well sustained.

CRQ4 andCRQ6: Transversal: What are the effects of the interconnectedness of the institutional level stakeholders and the location of the disruption within a quintuple helix CAST based mesosystem on the RGFT process in terms of the effectiveness of the emerged eco-innovation (EMT) diffusion (DIT) and Exogenous: How can stochastic externalities induced disruptions (such as environmental conditions) be better overcame in CAST ecosystems through eco-innovation (EMT, DIT) ?

The methodological convergence is described the best (as in the previous case) through **Stage three (focus groups and modelling & simulation)** which triangulates, consolidates and informs **Stage one** and **Stage two** in the following manner:

The CAST based interconnectedness plays indeed a critical role – however this is already taken as granted as there are already connections among all quintuple helix stakeholders (i.e. *"[...] thinking about connections, yes, there are bridges among all actors"*). However interconnectedness requires improvement in terms of: "*common language*", "*common vision*", "*common KPIs*" – and all this can be achieved with the support of the smart specialization strategy (with the government as moderator) pending on the triggers launched by industry & society/environmentalists. This is also in line with a certain literature strand (Kamalahmadi & Parast, 2016; de Siqueira et al., 2015; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Blackhurst et al., 2011; Petit et al., 2010; Falasca et al., 2008; Craighead et al., 2007; Tang, 2006, Christopher, 2004), however there is no clear insight into whether that too much density increases complexity and disruptions' impact, while isolation may also lead to severe disruptions. This interconnectedness plays a key role (according to **Stage three**) also in how disruptions can capitalize as sources of eco-innovation and triggers of RGFT/RGSCM practices (Kamalahmadi & Parast, 2016; Choudhury et al., 2015; Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Van der Brugge & Van Raak, 2007; Quist, 2007; Sondejker et al., 2006). **Stage one** (N=3) does provide some insight into this matter by arguing for the need of connectivity at the quintuple helix mesosystem level (in the case of Greece), however it does not entire answer this question. **Stage two** does not provide significant insight into this item.

The DIT based diffusion of the EMT driven eco-innovation (under the exogenous stochastic events such as weather induced disruptions) follows the DIT based principles and is indeed reliant on the interconnectedness, however the indicators of interconnectivity – beyond the ones mentioned in the previous bullet point – consist of the inner resources & capacity of institutions to adopt and assimilate eco-innovations (capacity to foster the transformation) and then their capacity to diffuse further such eco-innovations – also in line with (Bahadur & Doczi, 2016; Van der Vegt et al., 2015; Bach, 2015; Tihanyi et al., 2014; Mari & Memon, 2014; De Rosa et al., 2013; Cutter et al., 2013; Derissen et al., 2011; Rose, 2011; Turner, 2010; Lebel et al., 2006; Radjou et al., 2012; Bound & Thornton, 2012; King et al. (2016); Thorpe & Fennel (2012) Pescaroli & Alexander (2016); Winn et al., 2010; Alley et al., 2003; Hulme, 2003; Scheffer et al., 2001; Linnenluecke et al., 2012). This is also strongly supported (quantitatively) by **Stage two** (N=311) under the drivers of RGFT/RGSCM implementation section (more details can also be found in the next section as well) as well as qualitatively supported by the consolidation of the **second part of Stage three (modelling & simulation)** where the need for *"inner […] transformative capacity*" and "*substantial financial […] soundness*" have been reported.

The effectiveness of the diffused eco-innovation should be measured against the KPIs and metrics defined at the mesosystem level to include a wide spectrum of metrics as also reported by (Bhattacharya et al., 2014; Green et al., 2014; Shen et al., 2013; Hsu et al., 2013; Taticchi et al., 2013; Hitchcock, 2012; Dei & Shefi, 2012; Bai et al., 2012; Shi et al., 2012; Olugu et al., 2010; Tsoulfas & Pappis, 2008, Rao & Holt, 2005; Hervani et al., 2005). However, as reported in **Stage one** and in the qualitative exploration of the **second part of Stage three**, the current quintuple helix mesosystem from Greece does not fully resemble these aspects.

CRQ5: Methodologies: What CAST systems modelling and simulation, mixed-methods research and behavioural analysis can be performed within an ecosystem ?

Stage three (first part – focus groups) revealed the following RGFT/RGSCM modelling/methodologies techniques within a CAST based quintuple helix mesosystem which strongly support a specific literature strand such as:

Firstly, high reliance on technology to enable modelling & simulation based on real time big data (Siddhartha & Sachan, 2016; Bruno et al., 2012; Min & Zhou, 2002). Secondly, development of integrative multi-stakeholder modelling methods that can capture view plurality in a coherent manner (mixed methods) as a way to achieve the compromise between complexity and the graspable representation/encapsulation of supply chain structures and behaviours into models (Barbati et al., 2012; Fleisch & Tellkamp, 2003) Thirdly, modelling and assessment & multidisciplinary bridging of knowledge and expertise to help solve this social challenge (i.e. under environmental sustainability considerations such as LCA (Horton et al., 2015; Aquaye et al., 2014; Chourdhary et al., 2013; Genovese et al., 2013; Koh et al., 2011; Lee et al., 2011)).

Finally, the qualitative consolidation of the **second part of Stage three** supports the claim for the use of LCA modelling & simulation tools (such as SCEnAT) as a support mechanism to mixed-method research towards analysing the complex challenge of RGFT/RGSCM (Heckmann et al., 2015; Qazi et al., 2015; Tattichi et al., 2015; Huerta-Barrientos et al., 2015;Soosay & Hyland, 2015; Smith & Rupp, 2015; Sounders et al., 2015; Power & Gruner, 2015; Deacon et al., 2014; Storer et al., 2014; Soundararajan & Brown, 2014; Iofrida et al., 2014, Seuring, 2013).

5.3 Outcomes for the research objectives

OB1.1: Understand which weather conditions cause the most impactful disruptions in road freight transportation from SEE (relates to CRQ6) and **OB2.1**: Understand what negative business outcomes emerge as a result of such disruptions:

Stage one provides an initial qualitative insight (very limited) into the most relevant weather conditions such as "*[…] snow blizzards, storms, icy roads and occasionally floods*", "*winds […] and heat weaves*", "*[…] other hazards*" (pending on the geographical environment of each country) – all these causing institutional impacts such as *"[…] financial losses", "business inefficiencies", "[…] wastes", "infrastructure deterioration", "cargo […] deterioration"*. These findings from **Stage one** cover only a small part of what the systematic literature review and did not reveal any new items providing thus confirmation for a sample of the identified literature (Bahadur & Doczi, 2016; Li & Coates, 2016; Chhetri et al., 2016; Snyder et al., 2015; Loh & Thai, 2015; Mattson & Jenelius, 2015; Global risks, 2015; GAR, 2015; Van der Vegt et al., 2015; Linnenluecke et al., 2012; Ergun et al., 2010; Natarajarathinam et al., 2009; Stecke & Kumar, 2009; Nakano, 2009; Sanchez-Rodriguez et al., 2008; Linnenluecke et al., 2012; Ross, 2003; Hale & Moberg, 2005 Monahan et al., 2003).

To this end, **Stage two (N=311)** explores in a systematic manner a broader number of disruptions and their institutional/mesosystem implications identified through the literature review confirming that icy roads (4.16/5), snowfall (4.15/5), fog (3.88/5), blizzards (3.77/5) and heavy rains (3.45/5) cause the following business outcomes: delays in deliveries (4.51/5), overall coordination issues (4.19/5), client complains (4.06/5), loss of revenue (4.05/5), increased fuel consumption (4.03/5), extra cost (3.98/5), decrease of speed (3.85/5), increased CO2 emissions (3.60/5), inventory inconsistencies (3.53/5), congestion (3.46/5), longer distances (3.38/5), missed deliveries (3.21/5) and staff complains (3.02/5). This institutional impact of weather disruptions is homogenous across all 6 countries, while the disruptions are country specific (due to climate specificity). The findings are in line with the literature mentioned in the previous bullet point.

Stage three (first part - focus groups) with the focus on Greece confirm as well these aspects, however the discussion on whether such disruptions can be seen as a source of eco-innovation was not positive due to the financial constraints of the mesosystem. Specifically *"[…] in order* *for such disruptions to be seen as a source of eco-innovation, this requires a disruptive approach, while the current stage of the country can support only transformative innovation*", thus, this EMT driven approach of DIT based innovation outburst and diffusion is not confirmed for the case of Greece proving thus the limitations of this phenomenon described by (Francis & White, 2016; Choudhury et al., 2015; Akgun & Keskin, 2014; Gogelci & Ponomarov, 2013; Demmer et al., 2011; Christopher & Hollweg, 2011; Pham et al., 2008; Reinmoeller & Van Baardwijk, 2005; Hamel & Valikangas, 2003). Similarly, **Stage three (second part – modelling & simulation)** confirms the criticality of the revealed disruptions & business impact (by focusing on only one sample of the most relevant ones for Greece: fog disruptions which caused delays and heavy rain disruptions that cause overall coordination issues).

OB2.2: Understand what (green) key performance indicators do business use and to what extent when dealing with disruptions and **OB3.3:** Compare the RGFT KPIs of businesses with the ones of the involved mesosystem's stakeholders (relates to CRQ3).

Stage one provides a very limited insight into this matter (as compared to the wide variety of indicators provided by the literature) which denotes the substantial lack of information and knowledge in SEE in this area. To this end, based on the indicators resulted from the systematic literature review, **Stage two (N=311)** confirms the following highest rated indicators: Cost per TKM - 3.97/5; Focal Firm Profit-3.99/5; Total Time 4.00/5; On Time Deliveries - 3.03/5; Service Frequency - 3.08/5; Reliability of Transport - 3.04/5; Distance to Cover - 3.05/5; Efficiency During Disruptions - 3.15/5; Efficiency Before Disruptions - 3.08/5; Trips Required for Shipment - 3.01/5; Total Fuel Consumption - 4.00/5; Customer Satisfaction - 4.09/5; Safety of Transportation - 3.03/5; Corridor Availability and Capacity - 3.11/5; Total Energy Used - 3.95/5;Mileage - 3.18/5; Environmental Penalties - 4.01/5. These findings are in line with (Baumgartner et al., 2015; Piotrowicz, W., & Cuthbertson, 2015; Bhattacharya et al., 2014; Varsei et al., 2014; Ahi & Searcy, 2015a; Ahi & Searcy, 2015b; Gopal & Thakkar, 2012; Ninlawani et al., 2010; Shang et al., 2010; Aragon-Correa et al., 2008; Zhu et al., 2007; Vachon and Klassen, 2006; Hervani et al., 2005; Gonzalez-Benito, 2005; Rao and Holt, 2005; Zhu and Sarkis, 2012), however neither **Stage one** nor **Stage two** provide any specific insight into how these KPIs integrate with the KPIs of the other quintuple helix mesosystem stakeholders. Even more, as it can be seen, only 3 out of these 17 highest rated RGFT/RGSCM KPIs can be considered as environmental sustainability indicators (total fuel consumption, total energy used and environmental penalties) – even though all these three indicators have a clear financial implication - aspect which confirms the views of the literature. Having so few environmental sustainability indicators reveals that also the related RGFT/RGSCM practices are limited as shown in the discussion for OB2.3 and OB2.4.

Stage three (first part - focus groups as well as second part – modelling & simulation) however, attempts to provide an insight into how these SEE –level KPIs integrate at the mesosystem level, however the results of the discussions show a clear heterogeneity (as current status in Greece) especially when it comes to the integration of economic, social and environmental indicators for RGFT/RGSCM. Still the outcomes show a unilateral commitment and vision that KPIs must become homogenous across the mesosystem towards enabling proper RGFT/RGSCM – supporting thus the work of (Bhattacharya et al., 2014; Green et al., 2014; Shen et al., 2013; Hsu et al., 2013; Taticchi et al., 2013; Hitchcock, 2012; Bjorklund et al., 2012; Dei & Shefi, 2012; Bai et al., 2012; Shi et al., 2012; Olugu et al., 2010; Tsoulfas & Pappis, 2008, Rao & Holt, 2005; Hervani et al., 2005).

OB2.3: Understand to which extent do businesses implement green practices during their decision making processes and **OB2.4:** Understand what drivers and barriers do businesses face when aiming to adopt/implement green practices:

All three stages converge on the low implementation of green practices and the clearest picture is provided by **Stage two** which shows the final rating for the current status of implementing green RGFT/RGSCM practices (all practices apart from total fuel consumption, total energy used and environmental penalties have received scores under 3 out of 5 with an average of 2.12). **Stage three (first part - focus groups)** clarifies this even more confirming the lack of information and knowledge on these concepts – reasoning thus the low level of their implementation.

Regarding the drivers & barriers – all three stages converge over the findings of **Stage two**:

Confirmed & highest rated drivers:

Client appreciation - 4.10/5, Next trend in logistics - 4.07/5 and Public acceptance - 3.95/5 as external coercive drivers (mesosystem) which confirm the work of (Govindan et al., 2015; Ivanaj et al., 2015; Chakrabarty & Wang, 2013; Hsu et al., 2013; Shi et al., 2012; Rehman & Shrivastava, 2011; Zhu et al., 2010; Testa & Iraldo, 2010; Carter & Rogers, 2008; Chen, 2008; Vachon & Klassen, 2007; Chien & Shih, 2007; Ellen et al., 2006; Capaldi, 2005) while also proving the mimetic character of EMT driven eco-innovation diffusion (Govindan et al., 2015; Tian et al., 2014; Zhu & Geng, 2013; Dornfield et al., 2013; Zhu et al., 2012;Zhu & Liu, 2010; Testa & Iraldo, 2010; Liu & Buck, 2007).

Competitive advantages - 4.03/5 and Lower taxes - 4.02/5 – as internal financial drivers – in line with (Govindan et al., 2015; Tian et al., 2014; Alzaman, 2014; Shi et al., 2012; Eltayeb et al., 2011; Carter & Rogers, 2008; Zhu et al., 2010, Ninlawani et al., 2010; Molina-Azorin et al., 2009; Carter et al., 2007; Chien & Shih, 2007; Mollenkopf et al., 2005)

Governmental support is higher - 3.92/5 – as normative driver (policy compliance) – confirming thus (Govindan et al., 2015; Drohomeretsk et al., 2014; Lee & Kim, 2011; Mann et al., 2010).

Technology enables RGFT - 4.05/5 and Green resilience is important - 3.94/5 - as internal environmental and operational efficiencies based on technology (Govindan et al., 2015; Ivanaj et al., 2015; Alzaman, 2014; Tian et al., 2014; Hsu et al., 2013; Golicic & Smith, 2013; Eltayeb et al., 2011; Shi et al., 2012; Zhu et al., 2010; Testa & Iraldo, 2010; Ninlawani et al., 2010; Chien & Shih, 2007; Zhu & Sarkis, 2007; King et al., 2005).

Still, these results for the drivers do not show any evidence in Stage two when it comes to the internal need to eco-innovate in order to support the “eco-innovation leaders” driver claims of (Govindan et al., 2015; Tian et al., 2014; Dornfield et al., 2013; Zhu et al., 2012; Rehman & Shrivastava, 2011; Testa & Iraldo, 2010; Vachon & Klassen, 2007; Zhu & Sarkis, 2007; Hervani et al., 2005; Khalid et al., 2004). Still, **Stage three (first part – focus groups)** mitigates this shortcoming (with focus on Greece though) by aiming to explain that in certain cases this driver works (for more details see previous section – the discussion for CRQ2 and CRQ7).

Confirmed & highest rated barriers:

Lack of Commitment - 3.99/5, Untrained Staff Low Tech - 4.02/5, and Limited Information - 4.03/5 as internal + external employee related barriers in full coherence with (Govindan et al., 2015 Zaabi et al., 2013; Drohomeretsk et al., 2014; Balasubramanian, 2012; Diabat & Govindan, 2011; Sarkis et al., 2010; Soler et al., 2010; Vuro et al., 2009; del Brio et al., 2008; Yu & Hui, 2008; Walker & Preuss, 2008).

No Green Goals - 3.97/5 and Green KPI Insignificant - 3.99/5 as internal organizational/institutional barriers in full coherence with (Govindan et al., 2015; Ivanaj et al., 2015; Zaabi et al., 2013; Diabat & Govindan, 2011; Vuro et al., 2009; Mont & Leire, 2009; Hanna et al., 2000). These two barriers can also be seen as resistance to change barriers in the view of (Govindan et al., 2015; Ivanaj et al., 2015; Zaabi et al., 2013; Balasubramaniam, 2012; Diabat & Govindan, 2011; Vachon & Klassen, 2008; Sharfman et al., 2007; Verghese & Lewis, 2007; Hick, 2000).

Too Big Investment - 4.00/5 and Hard to Devise Green Job - 4.07/5 as internal financial barriers also discussed by (Govindan et al., 2015; Drohomeretsk et al., 2014; Zaabi et al., 2013; Diabat & Govindan, 2011; Connell, 2010; Alkhidir & Zailani, 2009; Walker et al., 2008; Presley et al., 2007; van Hemel & Cramer, 2002).

Hard to Control 3PL 4PL - 4.04/5, Bureaucratic to Control Land Use - 4.06/5 and Limited Intermodal Facilities- 3.99/5 as lack of proper environmental regulations, infrastructure and stakeholder communication means (Govindan et al., 2015; Drohomeretsk et al., 2014;Zaabi et al., 2013; Balasubramaniam, 2012; Diabat & Govindan, 2011; Vuro et al., 2009; Andersen & Larsen, 2009; Walker et al., 2008; Lee, 2008).

In contrary with the following literature, *top management support* barriers have not been rated as critical (Govindan et al., 2015; Zaabi et al., 2013; Hoejmose et al., 2012; Balasubramanian, 2012; Diabat & Govindan, 2011; Vuro et al., 2009; D'Amato &

Roome, 2009; Sarkis, 2009; Ravi & Shanker, 2005). Similarly, the *uncertainty of RGFT/RGSCM practice development* barrier as discussed by (Ivanaj et al., 2015; Schotter & Goodsite, 2013) has not been rated (in any stage) as critical.

Still, as discussed in the previous section for CRQs, co-creation, co-modernization. goal- and KPI alignment of all quintuple helix mesosystem is the only long-term solution to solve the challenge of RGFT/RGSCM (Ivanaj et al., 2015; Hsu et al., 2013; Hu & Hsu, 2010; Ninlawani et al., 2010; Mont & Leire, 2009; Seuring & Muller, 2008; Walker et al., 2008; Srivastava, 2007; Chien & Shih, 2007; Wright & Elcock, 2006; Tsoulfas & Pappis, 2006; Yalabik et al., 2005; Evans & Johnson, 2005; Eveloy et al., 2005; Handfield et al., 2005; Widmer et al., 2005; WEEE, 2003).

OB2.5: Understand what resilience mechanisms do businesses implement and to what extent these mechanisms include environmentally sustainable practices and **OB2.6:** Understand how (to what extent) businesses interact with the RGFT stakeholders.

Stage one did not provide any substantial insight into this matter (most answers relating to resource consumption efficiency – strengthening thus the argument of a clear lack of information and knowledge on these matters), however **Stage two (N=311)** provides the following primary quantitative insights in terms of what RGFT/RGSCM mechanisms are being preferred: Reliance on Soft Technology (4.10); Improvements Business Inefficiencies (4.17); Improvements Environmental Inefficiencies (3.05); Mechanisms To Raise Awareness (3.93); Employment Specialized Staff (4.06); Relocation of Goods (3.98); Shorter Routes (4.08) and Risk Management (4.03). These results are in full coherence with the work performed by Govindan et al. (2015) which discuss the paradigms of lean, green and resilient supply chains in an effort to fill the literature gaps towards overcoming isolated researches on these topics (Francis & White, 2016; Azevedo et al., 2013; Cabral et al., 2012; Carvalho et al., 2012; Carvalho et al., 2011; Hong et al., 2009; Rosic et al., 2009; Anand & Kodali, 2008; Glickman et al., 2006, Kainuma & Tawara, 2006). The authors (Govindan et al., 2015) position green and resilient supply chains under the core drivers of improving supply chain performance (during resilience mechanisms) while reducing material waste and improving resource efficiency/consumption – and this is what Stage two has confirmed.

Even more, **Stage three (first part – focus groups)** confirms these findings and stresses out the need for integrating the quintuple helix mesosystem when applying these strategies. Still, **the qualitative assessment of Stage three (second part – modelling & simulation)** addresses the core limitation at this stage which is also stressed out in the literature by a recent study of Francis & White (2016) which demonstrates that a green and resilient supply chain requires strong individual cultures of both environmental sustainability and resilience (in order to ensure proper integration) – which is also in line with Burnard & Bharma (2011). Furthermore, Gogelci & Ponomarov (2013) establish how the increased capacity of an institution to foster eco-innovations influences the ability to incorporate resilience which becomes a key argument towards relating EMT and DIT in a closer manner towards explaining eco-innovation (RGFT/RGSCM) adoption within CAST based systems from institutions to mesosystem level (with further insight from INT and ST) – which is discussed more in the previous section during the argumentation for each CRQ.

Finally, the discussion on mesosystem level interaction and interconnection is discussed in the previous section (the debate on the research outcomes for CRQ4 and CRQ6).

OB3.1: Investigate how can the resilience mechanisms of businesses be supported/fostered faster by other stakeholders from the ecosystem (relates to CRQ1, CRQ7), **OB3.2:** Investigate to what extent to businesses respond to ecosystem pressures in order to implement RGFT practices (relates to CRQ2) and **OB3.4:** Establish the importance of business partnerships interconnectedness in terms of enabling fast RGFT (relates to CRQ4).

These outcomes are fully described in the previous section (5.2) in the discussions for CRQ1, CRQ2, CRQ4 and CRQ7.

OB3.5: Use modelling tools (SCEnAT) to show practical underpinnings of implementing suitable RGFT (relates to CRQ5) and **OB4:** Develop several case studies to test the proposed model with RGFT mesosystem stakeholders (qualitative)

Following the research gap towards the need for modelling & simulation under a multi-stakeholder approach in the field of RGFT/RGSCM highlighted by (Siddhartha & Sachan, 2016; Horton et al., 2015; Aquaye et al., 2014; Chourdhary et al., 2013; Genovese et al., 2013; Bruno et al., 2012; Barbati et al., 2012; Koh et al., 2011; Lee et al., 2011; Fleisch & Tellkamp, 2003; Min & Zhou, 2002), **Stage three (second part – modelling & simulation)** has adopted such an approach towards modelling realistic scenarios of RGFT/RGSCM practice implementation at the institutional and mesosystem level. The qualitative assessment (N=3) interviews denote a positive approach by institutions (industry in this case) towards relying on SCEnAT's outputs when it comes to the decision making processes required to potentially adopt and implement RGFT/RGSCM strategies.

5.4 Outcomes for the proposed theoretical framework of the thesis

The theoretical framework of the thesis (TFT) developed after the systematic literature review revealed the following pillars that served as hypotheses in terms of how the proposed framework operates. The outcomes after the three main primary research stages confirm in most of the cases (with certain variations) these pillars as it will be shown below (the full discussion of the primary & secondary research on this aspect can be found in sections 5.1 and 5.2 as these Pillars are sustained by the CRQs and OBs):

Pillar 1: The RGFT microsystem is CAST based and must emphasise the following core elements: adaptability, flexibility, capacity to foster resilience and well defined key controlled processes at the (supply chain) microsystem level.

The results confirm the complexity of the RGFT/RGSCM microsystem under the quintuple helix mesosystem governance supporting the adaptability and capacity to foster resilience based on KPIs – however – the microsystem level KPIs should be homogeneous with the mesosystem level KPIs.

Pillar 2: Having these elements with core fundamental infusions from the EMT, during a disruption, the RGFT microsystem will eco-innovate and based on the well defined key controlled processes (with core support from flexibility, adaptability) a green resilience strategy will emerge.

The results partially confirm this pillar showing that the eco-innovation producers (in a disruptive manner) are only few within the mesosystem and that most of the other stakeholders are primarily adapting (transformative innovation) by steadily incorporating the eco-innovations, while also adjusting their KPIs.

Pillar 3: However, in the best case, this green resilience strategy will be implemented at the institutional (INT) or RGFT microsystem level without any direct impact measurement and implementation oversight at the wider ecosystem level (quintuple helix mesosystem) which has wider implications for the environment.

The current status of RGFT/RGSCM practice implementation in Greece confirms this pillar, however, the results show that there is high willingness to leverage eco-innovations at the mesosystem level through co-creation and goal and KPI alignment.

Pillar 4: To this end, based on the CAST and DIT, the propagation of the green resilience strategy and the necessary quintuple helix co-creation processes should be devised in order to leverage the impact of the green resilience strategy from microsystem, to mesosystem and finally to the ecosystem.

This pillar was confirmed (as a prospective future vision) – with specific mentioning that the eco-innovations will be based on the smart specialization areas of the country/region. The mesosystem leverage was confirmed, however there was no discussion (explicitly) about the environmental ecosystem (just implicitly – by having an environmentally sustainable and socially conscious quintuple helix mesosystem which will impact positively indeed on the environmental ecosystem).

Pillar 5: Thus, the DIT propagates eco-innovations from institutions to ecosystem inducing thus change at the ecosystem/stakeholder level (ST) which will later on put more exogenous pressure to institutions (INT) to induce further modernization (cycle).

This pillar was one of the core confirmations of this research (unilaterally at all stages) confirming thus the relationships among all the theoretical foundations driving this sector with their practical implementation. Basically, having the inner desire to excel, institutions will continue to eco-innovate (mostly through steady transformation) – ensuring thus the sustainable change at the mesosytem level (as the remaining lagging institutions will have pressures to adapt/transform).

Pillar 6: This way, green resilience propagation is not isolated in a remote microsystem location of the environment and it will impact and induce modernization and transformation throughout all social systems by relying on EMT, CAST and DIT.

This pillar was also confirmed as shown in the previous sections (5.1 and 5.2), however a concerning element in this area resides in the existence of very isolated chains/networks (i.e. institutions that do not take part in any stakeholder group or that are in very isolated mesosystems) which may not be subjected to the driving forces of the leading mesosystem pressures. Still, these case are expected to form a very small percentage of the entire mass.

Pillar 7: The meaning of green resilience in this case is the capacity of the RGFT microsystem to recover in an environmentally sustainable (resource efficient and negative impact reduction) manner after an environmentally induced disruption took place by properly propagating the recovery throughout all social systems that are involved.

The primary research confirms this definition – sustaining the previous efforts in this emerging field. Additionally, the primary research induces the need for a proper integration of EMT, DIT, CAST, INT and ST in studying environmentally sustainable resilience under true co-creation at the quintuple helix mesosystem level.

5.5 Summary

To conclude the critical discussion part, it is of core importance to mention that the main research outcomes are: firstly, the complexity of the RGFT/RGSCM microsystem under the quintuple helix mesosystem governance supporting the adaptability and capacity to foster resilience based on KPIs is confirmed – however – the microsystem level KPIs and goals should be homogeneous with the mesosystem level KPIs and goals. Secondly, the results show that the eco-innovation producers (in a disruptive manner) are only few within the mesosystem and that most of the other stakeholders are primarily adapting (transformative innovation) by steadily incorporating the eco-innovations, while also adjusting their KPIs.

Thirdly, the current status of RGFT/RGSCM practice implementation in Greece confirms the assumptions (of such limited implementation), however, the results show that there is high willingness to leverage eco-innovations at the mesosystem level through co-creation and goal & KPI alignment (especially considering the drivers & barriers that have been confirmed). Even more, eco-innovations will be based on the smart specialization areas of the country/region. The mesosystem leverage was confirmed, however there was no discussion (explicitly) about the environmental ecosystem (just implicitly – by having an environmentally sustainable and socially conscious quintuple helix mesosystem which will impact positively indeed on the environmental ecosystem).

Fourtly, by having the inner desire to excel, institutions will continue to eco-innovate (mostly through steady transformation) – ensuring thus the sustainable change at the mesosytem level (as the remaining lagging institutions will have pressures to adapt/transform). However a concerning element in this area resides in the existence of very isolated chains/networks (i.e. institutions that do not take part in any stakeholder group or that are in very isolated mesosystems) which may not be subjected to the driving forces of leading mesosystem pressures. Still, these case are expected to form a very small percentage of the entire mass. Lastly, the primary research induces the need for a proper integration of EMT, DIT, CAST, INT and ST in studying environmentally sustainable resilience under true co-creation at the quintuple helix mesosystem level.

Chapter 6: Conclusions

6.1 Introduction

This thesis investigated the area of resilient green supply chain management (RGSCM) and its subfield - resilient and green freight transportation (RGFT) - as core enablers of growth with tremendously increased societal, environmental normative and coercive pressures that demand innovative approaches for eco-innovations RGSCM and RGFT decision making and impact measurement processes towards ensuring resource efficiency and environmental footprint mitigation at the stakeholder level rather than individually at the institutional level (by proper and uniform adoption/implementation of RGSCM/RGFT during weather-induced disruptions in SEE). This matters comes into the context of the unpredictable nature of extreme weather-induced disruptions (heavy rain, blizzards, snow, icy roads, fog, heat weaves) which is posing tremendous pressure on nowadays supply chains. Longer transports, increased fuel consumption, hazardous wastes, unsatisfied clients, social unrest and risks, damage to the environment, infrastructure and assets are only few of the pressuring outcomes of such disruptions. As social and environmental concerns are growing in importance through normative and coercive pressures, supply chain management (especially transportation) must fastly adapt to such requirements when aiming to become resilient to such disruptions towards enabling proper RGFT/RGSCM.

This demand for leveraging RGSCM/RGFT from institutional level to stakeholder level is one of the key gaps of the related literature. In order to counteract this, the main ideology of this research consisted in developing a convergence among five main organizational theories (EMT, DIT, CAST, INT, ST) utilized in individual areas of environmental sustainability and resilience research in order to demonstrate how these theories inform each-other under the core patronage of the quintuple helix model (innovation, industry/, market, government, society and environment) developed by Carayannis, Barth & Campbell (2012) – and how all-together enable the required mechanism to support the implementation of RGSCM/RGFT at the quintuple helix mesosystem level. Such convergence has been achieved by proposing a theoretical framework of RGFT/RGSCM eco-innovation flow and adoption at the institutional and stakeholder/mesosystem level.

Within the proposed theoretical framework, the environment is considered as the main ecosystem layer which integrates within the quintuple helix mesosystem (which, accordingly integrates the RGFT microsystem). The environment, through the EMT, imposes ecological modernization (ideology, discourse, technological adjustment and strategic management) throughout all its subsystems (thus throughout quintuple helix mesosystem and RGFT microsystem). The environment generates environmental risks and vulnerabilities that cause disruptions that impact directly the RGFT microsystem, which, in order to preserve itself, leverages (traditionally and problematically) economic and business oriented goals, propagating the disruption damages to the outer system (quintuple helix mesosystem) and finally to the environmental ecosystem by causing severe environmental damage. When an environmental disruption takes place – at least one RGFT microsystem institution is affected. In order to counteract this, the seven-pillar theoretical framework proposed by this research can be employed in order to analyse how mesosystems adopt RGFT/RGSCM innovations (rather than focusing solely on economic outcomes).

In order to support this convergence and the theoretical framework assumptions, a three-stage mixed-method approach has been adopted. Stage one consisted of six exploratory qualitative interviews (SEE level) which covered basic exploratory inquiries in terms of what RGFT/RGSCM practices do supply chain institutions implemented, what drivers and barriers they encounter, what KPIs they use, intentions to implement new RGFT/RGSCM eco-innovations (all these governed by the EMT, CAST, DIT, ST and INT). The items explored in Stage one have resulted from the systematic literature review. Stage two adopted a quantitative and qualitative approach through semi-structured surveys (N=311) across SEE (Romania, Bulgaria, Serbia, FYROM, Slovenia and Greece) and further explored and also confirmed the elements utilized in Stage one. The level of inquiry of Stage two was institutional as well, however certain questions (i.e. drivers/barriers) have mesosystem level implications. Finally, Stage three explored and consolidated even more the findings (however on Greece only) by employing three focus groups at the quintuple helix mesosystem level in order to (besides confirming the findings of Stage two) understand how these already existing findings can be leveraged at the stakeholder/mesosystem level and how can all the stakeholders contribute to the implementation of RGFT/RGSCM. In addition, a quintuple helix framework for the implementation of RGFT/RGSCM has been proposed and through the use of modelling and simulation, pre and post-disruption scenarios (based on the findings) have been developed for three companies in Greece in order to assess how these companies perceive such RGFT/RGSCM strategies and quintuple helix level mesosystem considerations.

The primary research outcomes towards the exploration and consolidation of the CRQs and assumptions are:

The complexity of the RGFT/RGSCM microsystem under the quintuple helix mesosystem governance supporting the adaptability and capacity to foster resilience based on KPIs are confirmed – however – the microsystem level KPIs should be homogeneous with the mesosystem level KPIs.

The results show that the eco-innovation producers (in a disruptive manner) are only few within the mesosystem and that most of the other stakeholders are primarily adapting (transformative innovation) by steadily incorporating the eco-innovations, while also adjusting their KPIs.

The current status of RGFT/RGSCM practice implementation in Greece confirm the assumptions (of such limited implementation), however, the results show that there is high willingness to leverage eco-innovations at the mesosystem level through co-creation and goal & KPI alignment.

Eco-innovations will be based on the smart specialization areas of the country/region. The mesosystem leverage was confirmed, however there was no discussion (explicitly) about the environmental ecosystem (just implicitly – by having an environmentally sustainable and socially conscious quintuple helix mesosystem which will impact positively indeed on the environmental ecosystem).

Furthermore, by having the inner desire to excel, institutions will continue to eco-innovate (mostly through steady transformation) – ensuring thus the sustainable change at the mesosytem level (as the remaining lagging institutions will have pressures to adapt/transform).

However, a concerning element in this area resides in the existence of very isolated chains/networks (i.e. institutions that do not take part in any stakeholder group or that are in very isolated mesosystems) which may not be subjected to the driving forces of leading mesosystem pressures. Still, these case are expected to form a very small percentage of the entire mass.

Finally, the primary research induces the need for a proper integration of EMT, DIT, CAST, INT and ST in studying environmentally sustainable resilience (RGFT/RGSCM) under true co-creation at the quintuple helix mesosystem level.

Overall, this research provided a pioneering insight into converging EMT, DIT, CAST, INT and ST towards explaining how RGFT/RGSCM can be implemented institutionally and at the mesosystem level (in SEE with the main focus on Greece) under a quintuple helix approach – where the key message that has been revealed is that quintuple helix co-creation, goal an KPI alignment of all stakeholders and capacity to transform (eco-modernize) of institutions are the key enablers of fast eco-innovation (RGFT/RGSCM) diffusion and implementation.

6.2 Implications

This research has multilateral implications (within the context of SEE with specialization on Greece) as shown below:

Implications for academia

ACADEMIA-01: This research proposed a new theoretical convergence in the field of RGFT/RGSCM by binding the EMT, DIT, CAST, INT and ST into explaining the behaviour of the multi-stakeholder environment of quintuple helix mesosystems when it comes to diffusing/absorbing RGFT/RGSCM strategies derived from the inner RGFT/RGSCM microsystems.

ACADEMIA-02: Besides answering the CRQs, the following research gaps have been filled by extending the theory for the EMT, DIT, CAST, INT and ST (as the CRQs focused on the convergence among all these theories):

EMT: *How does the following consolidated EMT pillar apply to and explain RGFT ? (Berger et al., 2001; Zhu et al., 2012): EMT as innovation or technological adjustment (research, transformation) ? – also debated by* (Francis

& White, 2016; Choudhury et al., 2015; Akgun & Keskin, 2014; Gogelci & Ponomarov, 2013; Demmer et al., 2011; Christopher & Hollweg, 2011; Pham et al., 2008; Reinmoeller & Van Baardwijk, 2005; Hamel & Valikangas, 2003).

EMT: *What transformations and co-creation are required to help stakeholders overcome EMT implementation for* RGFT (Horlings & Marsden, 2011; Carayannis & Campbell, 2010) ?   - also debated by (Kamalahmadi & Parast, 2016; Nooraie & Parast, 2016; Mari et al., 2015; Rajesh & Ravi, 2015; Kim et al., 2015; Durach et al., 2015; Barosso et al., 2015; Perera et al., 2015; Mensah et al., 2015; Gilly et al., 2014; Kristianto et al., 2014; Scholten et al., 2014; Carvalho et al., 2012; Lengnick-Hall et al., 2011; Burnard & Bharma, 2011; Christopher & Peck, 2004).

EMT: *To what extent do stakeholders modernize & transform themselves (is there a correlation between ecological modernization implementation and institutional modernization) ? (York & Rosa, 2003)*

EMT: *What is the effect of EMT implementation on the entire ecosystem, rather than on individual stakeholders ? (York & Rosa, 2003; Carayannis & Campbell, 2010; Carayannis, Barth & Campbell, 2012)*

EMT: *How does the DIT properly explains the adoption of EMT by RGFT stakeholders ? (Zhu et al., 2012; Carayannis, Barth & Campbell, 2012).*

DIT: *How can eco-innovation (either disruptive or transformative) scale-up across the ecosystem levels/panarchy (Jacobsson & Brgek, 2008)?*

DIT: *How can transformative (eco)-innovation driven by the EMT (to solve resilience crises) diffuse faster based on core controlled processes at the institutional level (Moore & Westley, 2011)?*

DIT: *How can disruptive (eco) innovation (to solve resilience crises) respond better to the need of the entire ecosystem (Moore & Westley, 2011; Atwell et al., 2008; Walker et al., 2006)?*

CAST: *How can the EMT infuse the ecological modernisation view and how can the DIT explain the innovation outburst during crisis (disruption) resolution (resilience) which provide a novel opportunity for self-adaptation of a CAST ecosystem (Folke et al., 2010)?*

CAST: *How can stochastic externalities (such as environmental disruptions) induced crises (disasters) be better/faster overcome (Holling , 2001; Zhu & Ruth, 2013) ?*

CAST: *How can the exogenous ecosystem influence and foster better co-creation for the CAST-based SCM microsystem (Pathak et al., 2007; Folke et al., 2010) ?*

CAST: *What are the key RGFT/RGSCM decision making factor at the institutional level and how do they match with the decision making factors at the ecosystem level in order to ensure prosperity and stability within a CAST framework under uncertainty (Pathak et al., 2007; Ivanov et al., 2012; Chertow, 2009) ?*

CAST: *What systems modelling and simulation, mixed-methods research and behavioural experiments can be performed within a CAST ecosystem for resilient supply chains (Pathak et al., 2007) ?*

CAST: *What are the effects of the interconnectedness of the actors and the location of the disruption within a CAST ecosystem on the self-adaptation(resilience) process as well as on the ecological innovation capacity (Zhu & Ruth, 2013; Petit et al., 2010; Wagner & Bode, 2006) – also debated by* (Kamalahmadi & Parast, 2016; de Siqueira et al., 2015; Choudhury et al., 2015;

Kim et al., 2015; Cardoso et al., 2015; Brandon-Jones et al., 2014; Wieland & Walenburg, 2013; Mandal, 2012; Blackhurst et al., 2011; Petit et al., 2010; Falasca et al., 2008; Craighead et al., 2007; Tang, 2006, Christopher, 2004).

INT: *How both exogenous and endogenous pressures promote the adoption of GSCM (RGFT) practices (Sarkis et al., 2011; Hall, 2001)* ?

INT: *Which stakeholders are the drivers of GSCM (RGFT) implementation within an ecosystem (Sarkis et al., 2011; Rivera, 2004)* ?

ST: *How does the innovation diffusion theory explain the adoption of GSCM practices at the ecosystem level based on the ST's emerged exogenous pressures (Sarkis et al., 2011; Vachon, 2007) ? – also debated by* (Ivanaj et al., 2015; Hsu et al., 2013; Hu & Hsu, 2010; Ninlawani et al., 2010; Mont & Leire, 2009; Seuring & Muller, 2008; Walker et al., 2008; Srivastava, 2007; Chien & Shih, 2007; Wright & Elcock, 2006; Tsoulfas & Pappis, 2006; Yalabik et al., 2005; Evans & Johnson, 2005; Eveloy et al., 2005; Handfield et al., 2005; Widmer et al., 2005; WEEE, 2003).

ST: *How can the ST be implemented at an international/multicultural setting (Sarkis et al., 2011)*?

ACADEMIA-03: This research analyzed and explored the quintuple helix concept of Carayannis, Barth & Campbell (2012) with specific application within the RGFT/RGSCM field by introducing a new approach towards researching RGFT/RGSCM (ecosystem – mesosystem – microsystem) arguing that the environment is encapsulating the entire quintuple helix mesosystem (and its inner RGFT/RGSCM microsystem).

ACADEMIA-04: Filling the demand for mixed methods research in the field of RGFT/RGSCM (qualitative interviews, quantitative approaches, focus groups, modelling & simulation) highly acclaimed by:

Responding to the research claiming for the need for mixed methods research in GSCM/GFT (Faisal, 2016; Dubey et al., 2015; Chouwdhury & Hossan, 2014; Molina-Azorin & Lopez-Gamero, 2014; O'Rourke, 2014; Golicic & Davis, 2012; Zhu et al., 2012; Seuring, 2011; Psychogios and Priporas, 2007; Mangan et al., 2004; Creswell, 2003; Christy and Wood, 1999; Goodman, 1999).

Responding to the research claiming for the need of mixed methods research in relation to analysing resiliency performance in supply chains with tangency to RGFT/RGSCM (Hohenstein et al., 2015; Qazi et al., 2015; Kilubi et al., 2015; Tabrizi & Razmi, 2013; Pettit et al., 2013; Cadden et al., 2013).

Responding to the research claiming for the need of quantitative based modelling & decision support in GSCM/GFT (Heckmann et al., 2015; Qazi et al., 2015; Tattichi et al., 2015; Huerta-Barrientos et al., 2015; Seuring, 2013; Wu & Olson, 2008; Craighead et al., 2007; Srivastava et al., 2007; Chan & Chan, 2006; Fleisch & Tellkamp, 2003; Lee et al., 2002; Simchi-Levi, 2000).

Responding to the research claiming for the need of mixed methods when analysing systems that include environment, society and cross-system innovation/practice diffusion – quintuple helix (Soosay & Hyland, 2015; Smith & Rupp, 2015; Sounders et al., 2015; Power & Gruner, 2015; Deacon et al., 2014; Storer et al., 2014; Soundararajan & Brown, 2014; Iofrida et al., 2014).

Implications for industry

INDUSTRY-01: List of confirmed weather induced disruptions at the SEE level and their business implications which can help industries to better plan resilience strategies and to perform risk assessment for their operations (with focus on road transportation).

INDUSTRY-02: List of confirmed RGFT/RGSCM practices at the SEE level and their business implications (including drivers & barriers) which can help industries to better plan the implementation of such strategies – as well as help them get informed and skilled in these emerging trends/technologies.

INDUSTRY-03: Access to a quintuple helix level framework for the implementation of RGFT/RGSCM through SCEnAT (in Greece) and the primary research findings which will ensure a suitable implementation roadmap (economically, environmentally and socially) under a quintuple helix mutual understanding. This also provides networking opportunities with all the leading companies that already use SCEnAT.

INDUSTRY-04: Through the quintuple helix focus groups, a bridge among a key sample of quintuple helix mesosystem actors from Greece has been triggered which (if maintained) can ensure a long term engine of co-creation among the stakeholders, leading to a more fostering environment for RGFT/RGSCM practice implementation and co-growth (as all stakeholders aim to develop a common vision, mutual understanding and compatible KPIs).

Implications for policy

POLICY – 01: Through the quintuple helix focus groups, policy makers from Greece gained a clearer understanding of the other actors (in terms of their needs, knowledge, issues) and can thus enable more supportive policies to foster the required co-creation and KPIs integration – while also solving the global requirements of multi-actor participation in the decision makings of sustainable development. The results of the focus groups are also publicly available in order to influence policy change.

POLICY – 02: Through the confirmed drivers and barriers for the RGFT/RGSCM practice implementation, policy makers from Greece can properly guide/tailor the smart specialization strategy axes towards fostering a better and targeted action plan towards its implementation (as the funding for the smart specialization is already set – having a clear direction will lead to more optimized spending).

POLICY – 03: Through the necessary co-creation at the quintuple helix mesosystem, policy makers from Greece can ensure (if they enable this co-creation) a long term sustainable societal co-evolution/co-modernization in a true inter-discuplinary and cross-sectoral manner which will help to achieve the policy targets (together with efficienc spending and return on investment) while achieving an enhanced quality of life and satisfaction from the citizens involved.

POLICY – 04: Having this clear status of RGFT/RGSCM in Greece, policy makers can enhance their capacity of R&D fund attraction to support their sustainable development strategies/action – and launch new niche markets (reducing thus unemployment).

POLICY – 05: By enabling RGFT/RGSCM visions, the government will face less pressures from environmental/societal organizations and will enable to maintain Greece's (also applicable in SEE) carbon cap limits.

Implications for society

SOCIETY-01: Enhanced active participation and social voice inclusion in the decision making process of the government and industry (considering that industry – supported by the government – will engage more and more with society towards solving the RGFT/RGSCM challenges by ensuring that the strategies taken are in line with the increasing social voice).

SOCIETY-02: Enhancement of the labour market from Greece with a new specialization niche. Specifically, with proper quintuple helix co-creation, Greece can become an international leader in ICT driven eco-innovation producer/initiator and that could serve global markets, ensuring thus employment and education of the local society in a sustainable manner.

SOCIETY-03: By taking a socially and environmentally approach towards RGFT/RGSCM, society will benefit from a friendlier developmental context with reduced risks and an enhanced quality of life.

Implications for the environment

ENVIRONMENT-01: By properly relying on RGFT/RGSCM, the first impact for the environment resides in less resource consumption which will mitigate the damaged caused by the extraction sector and will push global R&D towards developing more efficient & eco-friendly solutions.

ENVIRONMENT-02: Additionally, by relying on such strategies proposed in this research, there will be less waste and hazardous materials generated during the resilience process of supply chains, leading thus to a substantially reduced CO2 footprint (as also shown through the modelling & simulation phases).

ENVIRONMENT-03: Through the active engagement of all quintuple helix stakeholders into the future roadmap of RGFT/RGSCM, the awareness raising of environmental aspects will be enhanced leading to a sustainable mechanism of acknowledging the importance of environmental sustainability.

6.3 Impact and dissemination

Up to date, the following practical impact of this PhD research has been monitored (2012-2016):

Journal Publications: One (1) paper pre-selected for publication in the Journal of Cleaner Production (Impact factor 3.844)

- *Solomon, A., Koh, S.C.L., Ketikidis, P.H. 2016. Towards a new Theoretical Foundation Convergence as a Key Enabler of a Low Carbon Economy: Practical evidence for Quintuple Helix Co-Creation Towards Solving the Challenge of Low Carbon and Resilient Supply Chains. Journal of Cleaner Production.*

New research funding: Based on the findings of this research, the two sponsoring institutions, the South East European Research Centre (SEERC) and the University of Sheffield have been successfully acquired (having the research student as principal investigator) of two new EU funded projects (TrainERGY – EU/ERASMUS+ Training for Energy Efficient Operations – Total value 360.000 EUR and REINVEST – EU/EUROPEAID on enhancing India's knowledge in environmentally sustainable transportation – 340 000 EUR). Additionally, the findings of the PhD have contributed (and have also been enhanced) through the already ongoing project – PrESS (Promoting environmentally sustainable SMEs). Finally, three other recently submitted funded proposals based on the findings of this research are awaiting evaluation.

Establishment of the Triple Helix Association Chapter of Greece (THAG): Triggered by the multi-stakeholder co-creation requirement identified through this PhD research, the sponsoring organization (SEERC) has established in 2013 a local branch of the global Triple Helix Association. THAG has enabled the organization of the focus groups and has triggered triple helix co-creation (as well as recently quintuple helix co-creation) among the main actors in Greece. Additionally, based on the quintuple helix co-creation required to solve the RGFT/RGSCM challenge in Greece, currently, THAG and SEERC are working on establishing a local branch of the Advanced Resource Efficiency Centre (AREC) initiated by the University of Sheffield (UK) with the purpose of bridging the stakeholders of environmental sustainability and resource efficiency.

Dissemination and sharing of best practices of the research: This has been achieved in two ways:

- *Enhancement of the related teaching curriculum as well as the development of industry based course-works (following the mesosystem co-creation through the focus groups)* at the University of Sheffield International Faculty, CITY College, based on the revealed findings of this research (both at undergraduate and masters level).
- *Constant dissemination at global (13) conferences*: (provided in Appendix E)

6.4 Limitations of the study

Regardless of the relevance of the emerged findings, the research framework that has been proposed (TFT) to derive these findings has certain limitations acknowledged by the literature. Specifically, the following limitations prevail at the following levels:

Overall research design: The ideology of mixed method research that sustains the true validity of the findings implies parallel research experiments (integral) by using different research methods (i.e. qualitative and quantitative) and then performing the triangulation to consolidate the findings (Faisal, 2016; Dubey et al., 2015; Chouwdhury & Hossan, 2014; Molina-Azorin & Lopez-Gamero, 2014; O'Rourke, 2014; Golicic & Davis, 2012; Greene, 2008; Bergman, 2008; Bazeley et al., 2004).

However, this research utilized mixed-methods mostly as an exploratory approach to consolidating theory. For example, Stage one utilized a very small sample of qualitative interviews to build/expand the theory revealed after the systematic literature review (which was used to derive the TFT), however the results of these interviews provided very limited insight that can be used to ensure the scientific consolidation of the TFT.

Subsequently, Stage two adopted a quantitative and qualitative approach (semi-structured survey) towards confirming and extending the TFT. Regardless of the fact that this has been performed at a wider scale, the claims for triangulation with the first stage cannot be fully sustained (since the first stage provided a very limited insight into the TFT).

Furthermore, Stage three (first part - focus groups) confirmed indeed the findings of Stage two and Stage one and provided as well further exploration over this aspect, however this has been done for Greece only (limiting thus the findings for the case of Greece as opposed to the previous two stages which covered the entire SEE area). Still since the quantitative analysis showed very close means and small standard deviations at the cross-country analysis, the focus on Greece in Stgae 3 stage does not create a big discrepancy. Additionally, even though Stage three confirmed the previous two stages, the overall concerns over the composition of the focus groups (i.e. heterogeneity of the stakeholders) can lead to a sceptical view on the validity and reliability of the converged discussions/solutions.

As well, Stage three (second part – modelling & simulation) builds upon the previously confirmed findings, however the results of the evaluation/feedback provided by the three interviewees gives in certain cases conflicting views over the focus group findings that they have been subjected to (regardless of their positive feedback over the modelling & simulation approach).

Finally, regardless of the fact that the literature pushes towards the utilization of the methods adopted by this research, there is no other research that utilizes exactly the same combination of methods (in order to provide more validity for this research's method design). However, the test-retest approach adopted through all these stages mitigates to some extent such limitations.

Sampling: Stage two (quantitative) has a well-balanced sample across SEE in terms of the targeted respondents, however, Stage one and Stage three (first part – focus groups) consist of expert based sample selection which triggers result bias concerns. This aspect is even more critical for Stage three (first part – focus group) where stakeholders such as policy makers, societal/environmental actors, industries and innovators have been engaged – as each individual stakeholder is deemed to have directed the discussion in such a way that would accommodate their own objectives/goals – rather than the overall common goal.

Analysis: Qualitative analysis (inductive content analysis) which was utilized in Stage one and Stage three (first part – focus groups) is always subjected to potential transcription misinterpretations, data gaps as well as induction bias by the primary researcher, however this aspect has been mitigated as much as possible, following scientific guidelines, by asking the interviewees and focus group participants to cross-check the transcript summaries before inductive content analysis took place. Quantitative analysis is subjected to data coding misinterpretation Heckmann et al., 2015; Qazi et al., 2015; Tattichi et al., 2015; Huerta-Barrientos et al., 2015; Seuring, 2013; Wu & Olson, 2008; Craighead et al., 2007; Srivastava et al., 2007; Chan & Chan, 2006; Fleisch & Tellkamp, 2003; Lee et al., 2002; Simchi-Levi, 2000, however, the main limitation of the quantitative part for this research resides in their moderate to low significance according to the reliability & internal consistency analysis results (ANOVA & Cronbach Alpha). This low significance is considered (as in previous case with the survey instrument that has been utilized) to be due to the lack of proper information & knowledge of the respondents. This lack of information and knowledge has been confirmed as well through Stage one and Stage three (first part – focus groups). Still, the findings of Stage two have been indeed triangulated by Stage three (first part – focus groups), however the limitations of Stage two should be addressed in any future study.

Conceptual framework assumptions: When defining the TFT (as well as during the testing phase), this research adopts a very high level approach aiming to integrated EMT, DIT, CAST, ST and INT concepts in order to respond to the identified research gap which claims multi-sectoral and multi-stakeholder integration (Soosay & Hyland, 2015; Smith & Rupp, 2015; Sounders et al., 2015; Power & Gruner, 2015; Deacon et al., 2014; Storer et al., 2014). Regardless of the positive outcome of the primary research (which confirm the TFT), in order to validate this framework, a more in-depth analysis is required at a unitary level (for example testing the assumptions of each of the five theories in integration with the others). Additionally, the conceptual framework assumptions are also biased on the limitations of the systematic literature review which could include substantial omissions of relevant literature.

6.5 Recommendations and proposed further research

Finally, based on related gap and on the advancements achieved through this research, the following recommendations and further research are deemed to be relevant:

ACADEMIA – further research on the unanswered or newly discovered gaps:

EMT: How can the quintuple helix ecosystem for growth (including RGFT) foster more “strong” EMT implementation rather than “weak” (Zhu et al., 2012; Horlings & Marsden, 2011; Carayannis & Campbell, 2010) ?
EMT: Does the EMT implementation lead to dematerialization or supermaterialization ? (York & Rosa, 2003) and how does this link with the recent advancements in the field of LCA based circular economy (Govindan et al., 2015; Genovese et al., 2015; Koh at al., 2015)?

EMT+DIT: How can eco-innovations in GSCM be diffused faster from innovators and early adopters to laggards (Zhu et al., 2012)?

EMT: How can eco-innovations be diffused within the mesosystem by relying on the environmental flows ideology (Moland & Spaargaren, 2005) ?

CAST: How can localized interactions (symbiosis) based on controlled processes scale-up and co-create to enable self-adaptation of a CAST based system at the mesosystem level (Holling, 2001; Bansal and Mcknight, 2009; Folke et al., 2010; Van den Berg et al., 2011) ?

CAST: How can the concept of "Panarchy" (Holling, 2001) can be applied based on the three CAST pillars and explain how co-creation within the mesosystem takes place (Walker et al., 2004; Van den Berg et al., 2011; Chertow, 2009) ?

CAST: How do various cross-tier supply chain microsystems interaction among each-other within the wider ecosystem (Ivanov, 2012; Pathak et al., 2007) ?

CAST: Strengthen the claim that resilient GSCM (and implicitly RFGT) are cycle based industrial microsystems based on CAST in the context on the most recent trends in this document (Wong et al., 2016, Fallah et al., 2015, Torabi et al. 2015, Cardoso et al., 2015) and how this can be integrated in the context of the circular economy concept ?

Methodology: Replicate the methodology utilized by this research on other (or similar) quintuple helix mesosystems in order to cross-validate the findings and build up scientific value for this approach.

Methodology: Replicate the methodology utilized by this research at a higher granularity level in order to properly assess (via integrally performed mixed-methods) the validity and influence of each of the five theories (EMT, DIT, CAST, DIT, INT, ST) when it comes to explaining RGFT/RGSCM within quintuple helix mesosystems.

Methodology: Develop and validate methodologies to support multi-stakeholder analysis (i.e. quintuple helix) in the field of RGSCM/RGFT towards extending the existing theory to more socially/mesosystem aware considerations that could have immediate transferability to the mesosystem stakeholders.

INDUSTRY – recommendations and next steps

Get accustomed with the smart specialization areas of their operating region/country in order to properly understand the areas where governmental support will be offered.

Get accustomed with the concepts of RGFT/RGSCM (in terms of practices, drivers, barriers, policies & regulations) and provide adequate training for their staff. Society is steadily pushing for a better inclusion of the environmental sustainability factor and thus, industry will face an even greater pressure (besides their inner desire to reduce costs and stay competitive). Additionally, as supply chains leverage to the global level, Greek industries need to be aware of their global markets, where the demands for such environmental sustainability practices are even higher.

Be more open towards the co-creation with universities/innovation centers and society in order to develop mutually beneficial pathways (under true governmental compliance). It is often the fact that society is the final customer of industries, thus, an early engagement of society into such practices will lead to a greater and more satisfied pool of clients.

Appoint an environmental manager that will be in charge to provide such strategies for each company, ensuring thus a constant up to date-ness with the global practices. Where the possibility of such a position is not available, environmental sustainability (through RGFT/RGSCM) can be integrated in the quality assurance mechanisms of the industry.

Become more technology friendly: adopt decision support tool, LCA tools (i.e. SCEnAT) and forecasting mechanisms (i.e. weather prediction tools) to be able to plan in real-time RGFT/RGSCM strategies in order to achieve the intended efficiency.

POLICY – recommendations

Enable an open dialog among all the quintuple helix involved stakeholders to support better focusing & targeting of the RGFT/RGSCM related policies and investments (i.e. infrastructure, open training centres, support for technology transfer offices, co-creation platforms for crowdsourcing and mass-dialogues). A specific focus should be set on the barriers identified through this research.

Enable enhanced access points for competitive funding in terms of R&D projects for RGFT/RGSCM based on quintuple helix consortia that wish to access any national/EU level funding to support these endeavours.

Develop partnerships with similar peers worldwide in order to keep the local sustainable development connected to the latest global trends and to support transnational exchanges of experience & knowledge.

Support a systemic skill intervention and development strategy in the field of RGFT/RGSCM in order to ensure a sustainable skill provision mechanism that will enable the advancing society to cope with the challenges & trends in this field.

SOCIETY & ENVIRONMENTAL ORGANIZATIONS – recommendations

Get more involved in inclusive events promoted by local organizations (policy makers) in terms of widening the voice of civil society for sustainable development activities.

Get informed about the development in the field of RGFT/RGSCM and crowdsource ideas/suggestions for improvement during any co-creation initiative provided by industry.

Adopt a constructive approach towards the sustainable development movement by equally balancing the requirements of all quintuple helix stakeholders.

6.6 Summary

Overall, this research provides (as main outcome) insight into converging the five theories (EMT, DIT, CAST, INT and ST) towards explaining how RGFT/RGSCM (for weather induced disruptions) can be implemented institutionally and at the mesosystem level (in SEE with the main focus on Greece) under a quintuple helix approach –where the key message that has been revealed is that quintuple helix co-creation, goal an KPI alignment of all stakeholders and capacity to transform (eco-modernize) of institutions are the key enablers of fast eco-innovation (RGFT/RGSCM) diffusion and implementation. The detailed findings of this research (three staged mixed methods: qualitative (six interviews), quantitative (311 semi-structured questionnaires) and modelling and simulation (three focus groups and three modelling scenarios)) have core implications for academia, industry, policy society and for the environment (as presented in the previous subsections). The core limitations of this thesis which should be addressed in future studies consist in the high level approach in terms of converging the five theories as well as in the manner in which the triangulation is being performed (the three stages are not performed integrally and then triangulated – being rather integrated as means of one stage informing another). Nevertheless, the proposed framework could serve as a step forward towards the integration of the quintuple helix model with EMT, DIT, CAST, INT and ST in relation to RGFT /RGSCM implementation.

References

Acquaye, A. A., Sherwen, T., Genovese, A., Kuylenstierna, J., Koh, S. L. and McQueen-Mason, S. (2012) Biofuels and their potential to aid the UK towards achieving emissions reduction policy targets. *Renewable and Sustainable Energy Reviews*, 16(7), pp. 5414-5422.

Acquaye, A., Genovese, A., Barrett, J. and Koh, S. C. L. (2014) Benchmarking carbon emissions performance in supply chains. *Supply Chain Management: An International Journal*, 19(3), pp. 306-321.

ADVANCE-LOGISTICS Project (2013) *Advanced predictive-analysis-based-decision-support engine for logistics*. [online]. Available from: http://www.advance-logistics.eu/ [Accessed 25th October 2013].

Agranoff, R. (2006) Inside collaborative networks: Ten lessons for public managers. *Public Administration Review*, 66, pp. 56–65.

Ahi, P. and Searcy, C. (2013) A comparative literature analysis of definitions for green and sustainable supply chain management. *Journal of Cleaner Production*, 52, pp. 329-341.

Ahi, P. and Searcy, C. (2015a) An analysis of metrics used to measure performance in green and sustainable supply chains. *Journal of Cleaner Production*, 86, pp. 360-377.

Ahi, P. and Searcy, C. (2015b) Measuring social issues in sustainable supply chains. *Measuring Business Excellence*, 19(1), pp. 33-45.

Aifadopoulou, G. (2004) *Tranportation and logistics chains in South East Europe (CADSES area and Ten network).* Thessaloniki, Greece: Hellenic Institute of Transport.

Akgün, A. and Keskin, H. (2014) Organisational resilience apacity and firm product innovativeness and performance. *International Journal of Production Research*, 52(23), pp. 6918–6937.

Akinola, A. A. (1986) An application of the Bass model in the analysis of diffusion of coco-spraying chemicals among Nigerian cocoa farmers. *Journal of Agricultural Economics*, 37(3), pp. 395-404.

Akyuz, G. A. and Erkan, T. E. (2010) Supply chain performance measurement: a literature review. *International Journal of Production Research*, 48(17), pp. 5137–5155.

Al Zaabi, S., Al Dhaheri, N. and Diabat, A. (2013) Analysis of interaction between the barriers for the implementation of sustainable supply chain management. *International Journal Advanced Manufacturing Technology*, 68(1-4), pp. 895-905.

Albuquerque, P., Bronnenberg, B. J. and Corbett, C. J. (2007) A Spatiotemporal Analysis of the Global Diffusion of ISO 9000 and ISO 14000 Certification. *Management Science*, 53(3), pp. 451-468.

Alexander, A., Walker, H. and Naim, M. (2014) Decision Theory in Sustainable Supply Chain Management: A Literature Review. *Supply Chain Management: An International Journal*, 19(5/6), pp. 504-522.

Alfaro, J., A. Ortiz and R. Poler (2007) "Performance Measurement System for Business Processes." *Production Planning & Control*, 18 (8), pp. 641–654.

Alkadi, I., Alkadi, G. and Totaro, M. (2003) Effects of Information Technology on the Business World. *Human Systems Management* , 22(3), pp. 99-103.

AlKhidir, T. and Zailani, S. (2009) Going green in supply chain towards environmental sustainability. *Global Journal of Environmental Research*, 3(3), pp. 246-251.

Alley R. B., Marotzke J., Nordhaus W. D., Overpeck J. T., Peteet D. M., Pielke R. A., Pierrehumbert R. T., Rhines P. B., Stocker T.F., Talley L.D. and Wallace J. M. (2003) *Abrupt Climate Change Science*, 299(5615), pp. 2005–2010.

Ambrosini, V. and Bowman, C. (2009) What are dynamic capabilities and are they a useful construct in strategic management? *International Journal of Management Reviews*, 11(1), pp. 29–49.

Ambulkar, S., Blackhurst, J. and Grawe, S. (2015) Firm's resilience to supply chain disruptions: Scale development and empirical examination. *Journal of Operations Management*, 33, pp. 111-122.

Anand G. and Kodali R. (2008) A conceptual framework for lean supply chain and its implementation. *International Journal Value Chain Management*, 2, pp. 313–357.

Andersen, M. and Skjoett-Larsen, T. (2009) Corporate Social Responsibility in Global Supply Chains. *Supply Chain Management: An International Journal* , 14(2), pp. 75-86.

Andrews, R. N. L., Amaral, D., Darnall, N., Gallagher, D., Edwards, D., Jr, Hutson, A., D'Amore, C. and Zhang, Y. (2003) Environmental Management Systems: Do They Improve Performance? *Project Final Rep., National Database on Environmental Management Systems*.

Antonelli, C. (2006) Diffusion as a process of creative adoption. *The Journal of Technology Transfer*, 31(2), pp. 211-226

Aragón-Correa, J. A., Hurtado-Torres, N., Sharma, S., García-Morales, V. J. (2008) Environmental strategy and performance in small firms: a resource-based perspective. *Journal of Environmental Management*, 86 (1), pp. 88–103.

Archer, M., Bhaskar, R., Collier, A., Lawson, T. and Norrie, A. (2013) *Critical realism: Essential readings*. Routledge.

Argenti, P. (2004) Collaborating with activists: how Starbucks works with NGOs. *California Management Review*, 47(1), pp. 91–116.

Arimura, T. H., Darnall, N. and Katayama, H. (2011) Is ISO 14001 a gateway to more advanced voluntary action? The case of green supply chain management. *Journal of environmental economics and management*, 61(2), pp.170-182.

Arimura, T., Hibiki, A. and Katayama, H. (2008). Is a voluntary approach an effective environmental policy instrument? A case for environmental management systems. *Journal of Environmental Economics and Management*, 55, pp. 281-295.

Arnold, V., Benford, T. S., Hampton, C. and Sutton, S. G. (2012) Enterprise Risk Management as a Strategic Governance Mechanism in B2B-Enabled Transnational Supply Chains. *JOURNAL OF INFORMATION SYSTEMS*, 26(1), pp. 51–76.

Ashton, W.S. (2009) The structure, function, and evolution of a regional industrial ecosystem. *Journal of Industrial Ecology*, 13, pp. 228-246.

Atwell, R. C., Schulte, L. A. and Westphal, L. M. (2008) Linking resilience theory and diffusion of innovations theory to understand the potential for perennials in the U.S. Corn Belt. *Ecology and Society*, 14 (1), pp. 30.

Azevedo, S., Kannan, G., Carvalho, H. and Cruz-Machado, V. (2013a) Ecosilient index to assess the greenness and resilience of the upstream automotive supply chain. *Journal of Cleaner Production*, 56(1), pp.131–146.

Bach, R. (2015) *Strategies for supporting community resilience: Multinational experiences*. Multinational Resilience Policy Group. CRISMART, the Swedish Defence University. Stockholm.

Bacharach, S. B. (1989) Organizational Theories: Some Criteria for Evaluation. *Association of Management Review*, pp. 486-515.

Bahadur, A., & Doczi, J. (2016). Unlocking resilience through autonomous innovation.

Bai, C., Sarkis, J., Wei, X. and Koh, S. C. L. (2012) Evaluating ecological sustainable performance measures for supply chain management. *Supply Chain Management: An International Journal*, 17(1), pp. 78-92.

Bakshi, N. and Kleindorfer, P. (2008) Co-opetition and Investment for Supply-Chain Resilience. *INSEAD Working Paper Series*.

Balasubramanian, S. (2012) A hierarchical framework of barriers to green supply chain management in the construction sector. *Journal of Sustainable Development*, 5(10), pp.15.

Ball, A. and Craig, R. (2010) Using neo-institutionalism to advance social and environmental accounting. *Critical Perspectives on Accounting*, 21(4), pp. 283–293.

Ballou, R. H. (2007) The Evolution and Future of Logistics and Supply Chain Management. *European Business Review*, 19(4), pp. 332-348.

Banerjee, S. B., Lyer, E. S. and Kashyap, R. K. (2003) Corporate environmentalism: Antecedents and influence of industry type. *Journal of Marketing*, 67(2), 106-122.

Bansal, P. and Hunter, T. (2003) Strategic explanations for the early adoption of ISO 14001. *Journal of Business Ethics*, 46, pp. 289–299.

Bansal, P. and Mcknight, B. (2009) Looking forward, pushing back and peering sideways: analyzing the sustainability of industrial symbiosis. *Journal of Supply Chain Management*, 45, pp. 26-37.

Bansal, P. and Roth, K. (2000) Why Companies Go Green: A Model of Ecological Responsiveness. *Academy of Management Journal*, 43(4), pp. 717-736.

Barbati, M., Bruno, G. and Genovese, A. (2012) Applications of agent-based models for optimization problems: A literature review. *Expert Systems with Applications*, 39(5), pp. 6020-6028.

Baresel-Bofinger, A. C. R., Ketikidis, P. H., Koh, S. C. L. and Cullen, J. (2011) Role of 'green knowledge' in the environmental transformation of the supply chain: The case of Greek manufacturing. *International Journal of Knowledge-Based Development*, 2(1), pp. 107-128.

Barroso, A. P., Machado, V. H., Carvalho, H. and Machado, V. C. (2015) Quantifying the Supply Chain Resilience. *Applications of Contemporary Management Approaches in Supply Chains*.

Bask, A. and Kuula, M. (2011) Measuring Supply Chain Level Environmental Sustainability – Case Nokia. *IJBIT*, pp. 16-26.

Basu, R. R., Banerjee, P. M. and Sweeny, E. G. (2013) Frugal innovation: core competencies to address global sustainability. *Journal of Management for Global Sustainability*, 2, pp. 63-82.

Baumgartner, R. J., Fritz, M. M. and Schöggl, J. P. (2015) Sustainability and Supply Chain Management Aspects, Indicators and Performance Measurement. *Innovation und Nachhaltigkeit: Strategisch-operatives Energie-und Ressourcenmanagement*, 31.

Bayraktar, E., Demirbag, M., Koh, S. C. L., Tatoglu, E. and Zaim, H. (2009) A causal analysis of the impact of information systems and supply chain management practices on operational performance: evidence from manufacturing SMEs in Turkey. *International Journal of Production Economics*, 122(1), pp. 133-149.

Bazeley, Pat (2004) Issues in mixing qualitative and quantitative approaches to research. *In*: R. Buber, J. Gadner and L. Richards (eds.) *Applying qualitative methods to marketing management research*. Basingtoke, pp. 141-156.
Beck, U., Giddens, A. and Lash, S. (eds.) (1994) *Reflexive modernization theory*. Policy, Cambridge.

Bedia, J., Herrera, S., Camia, A., Moreno, J. M. and Gutiérrez, J. M. (2014) Forest fire danger projections in the mediterranean using ENSEMBLES regional climate change scenarios. *Climatic Change*, 122, pp. 185–199.

Bedia, J., Herrera, S., Gutiérrez, J. M., Benali, A., Brands, S., Mota, B. and Moreno, J. M. (2015) Global patterns in the sensitivity of burned area to fire-weather: Implications for climate change. *Agricultural and Forest Meteorology*, 214, pp. 369-379.

Bell, J. E., Autry, C. W., Mollenkopf, D. A. and Thornton, L. M. (2012) A natural resource scarcity typology: Theoretical foundations and strategic implications for supply chain management. *Journal of Business Logistics*, 33(2), pp. 158-166.

Bendell, Jem (2003) Talking for change? reflections on effective stakeholder dialogue. *In*: J. Andriof *et al*. (eds) *Unfolding Stakeholder Thinking 2: Relationships, Communication, Reporting and Performance*. Greenleaf, Sheffield.

Berger, G., Flynn, A., Hines, F. and Johns, R. (2001). Ecological modernization as a basis for environmental policy: Current environmental discourse and policy and the implications on environmental supply chain management. *Innovation: The European Journal of Social Science Research*, 14(1), pp. 55-72.

Bergman, Manfred Max (2008) The straw men of the qualitative - quantitative divide and their influence on mixed methods research. *In*: M. M. Bergman (eds) *Advances in mixed methods research: Theories and applications*. London, UK, pp. 11-22.

Berkes, F. (1999) Sacred ecology: traditional ecological knowledge and management systems. Philadelphia and London: Taylor & Frances.

Berkes, F., Colding, J. F. and Folke, C. (eds) (2003) *Navigating nature's dynamics: building*.

Berkhout, F., Hertin, J. and Gann, D. M. (2006) Learning to adapt: organizational adaptation to climate change impacts. *Climatic Change*, 78, pp. 135–156.

Beske, P., Koplin, J. and Seuring, S. (2008) The Use of Environmental and Social Standards by German First-Tier Suppliers of the Volkswagen AG. *Corporate Social Responsibility and Environmental Management*, 15, pp. 63–75.

Beuthe, M., Degrandsart, F., Geerts, J. F. and Jourquin, B. (2002) External costs of the Belgian interurban freight traffic: a network analysis of their internalisation. *Transportation Research Part D*, 7, pp. 285–301.

Bhagwat, R. and Sharma, M. K. (2009) An Application of the Integrated AHP-PGP Model for Performance Measurement of Supply Chain Management. *Production Planning & Control*, 20 (8), pp. 678–690.

Bhamra, R. (2012) Sustainable outsourcing: a practice survey and research opportunities. *International Journal of Sustainable Engineering*, 5(4), pp. 304-311.

Bhaskar, R. (2013) *A realist theory of science*. Routledge.

Bhattacharya, A., Mohapatra, P., Kumar, V., Dey, P. K., Brady, M., Tiwari, M. K. and Nudurupati, S. S. (2014) Green supply chain performance measurement using fuzzy ANP-based balanced scorecard: a collaborative decision-making approach. *Production Planning & Control*, 25(8), pp. 698-714.

Bhattacherjee, A. (2012) *Social Science Research: Principles, Methods, and Practices.* Florida: Tampa Bay Open Access Textbooks Collection. Book 3.

Björklund, M., Martinsen, U. and Abrahamsson, M. (2012) Performance Measurements in the Greening of Supply Chains. *Supply Chain Management: An International Journal*, 17 (1), pp. 29–39.

Blackhurst, J., Craighead, C. W., Elkins, D and Handfield, R. B. (2005) An Empirically Derived Agenda of Critical Research Issues for managing Supply-Chain Disrupions. *International Journal of Production Research*, 43(19), pp. 4067-4081.

Bode, C. and Wagner, S. (2006) An empirical investigation into supply chain vulnerability. *Journal of Purchasing & Supply Management*, 12 (6), pp. 301–312.

Bound, K. and Thornton, I. (2012) Our frugal future: lessons from India's innovation system. London, UK: Nesta.

Bourlakis, M., Maglaras, G., Aktas, E., Gallear, D. and Fotopoulos, C. (2014a). Firm size and sustainable performance in food supply chains: Insights from Greek SMEs. *International Journal of Production Economics*, 152, pp. 112-130.

Bourlakis, M., Maglaras, G., Gallear, D. and Fotopoulos, C. (2014b) Examining sustainability performance in the supply chain: The case of the Greek dairy sector. *Industrial Marketing Management*, 43(1), pp. 56-66.

Boyer, K. K., Prud'homme, A. M. and Chung, W. (2009) The last mile challenge: evaluating the effects of customer density and delivery window patterns. *Journal of Business Logistics*, 30(1), pp. 185-202.

Brandon-Jones, E., Squire, B., Autry, C. W. and Petersen, K. J. (2014) A Contingent Resource-Based Perspective of Supply Chain Resilience and Robustness. *Journal of Supply Chain Management*, 50(3), pp. 55-73.

Brito, M. P., Carbone, V. and Blanquart, C. M. (2008) Towards a sustainable fashion retail supply chain in Europe: organisation and performance. *International Journal of Production Economics*,114 (2), pp. 534–553.

Bruno, G., Esposito, E., Genovese, A. and Passaro, R. (2012) AHP-based approaches for supplier evaluation: Problems and perspectives. *Journal of Purchasing and Supply Management*, 18(3), pp. 159-172.

BTS (2010) *Transportation Statistics Annual Report*. [online]. Available from: http://www.bts.gov/publications/transportation_statistics_annual_report/2010/ [Accessed October 14th 2013].

Buhman, C., Sunder, K. and Singhal, J. (2005) Interdisciplinary and interorganizational research:Establishing the science of enterprise networks. *Production and Operations Management*, 14 (4), pp. 493–513.

Burnard, K. and Bharma, R. (2011) Organisational Resilience: Development of a Conceptual Framework for Organisational Responses. *International Journal of Production Research*, 49(18), pp. 5581-5599.

Buttel, F. H. (2000) Ecological modernization as social theory. *Geoforum*, 31(1), pp. 57-65.

Byrd, T. A. and Davidson, N. W. (2003) Examining Possible Antecedents of IT Impact On the Supply Chain and Its Effect on Firm Performance. *Information and Management*, 41(2), pp. 243-255.

Cabral, I., Grilo, A. and Cruz-Machado, V. (2012) A decision-making model for Lean, Agile, Resilient and Green supply chain management. *International Journal of Production Research*, 50(17), pp. 4830–4845.

Cadden, T., Marshall, D. and Cao, G. (2013) Opposites attract: organisational culture and supply chain performance. *Supply Chain Management: An International Journal*, 18(1), pp. 86-103.

Cagnazzo, L., Taticchi, P. and Brun, A. (2009) The role of performance measurement systems to support quality improvement initiatives at supply chain level. *The International Journal*.

Cai, W., Borlace, S., Lengaigne, M., Van Rensch, P., Collins, M., Vecchi, G., Timmermann, A., Santoso, A., McPhaden, M. J., Wu, L. and England, M. H. (2014) Increasing frequency of extreme El Niño events due to greenhouse warming. *Nature Climate Change*, 4(2), 111-116.

Capaldi, N. (2005) Corporate social responsibility and the bottom line. *International Journal of Social Economics*, 32(5), pp. 408-23.

Carayannis, E. G. and Campbell, D. F. J. (2010) Triple Helix, Quadruple Helix and Quintuple Helix and how do knowledge, innovation and the environment relate to each other? A proposed framework for a trans-disciplinary analysis of sustainable development and social ecology. *International Journal of Social Ecology and Sustainable Development*, 1(1), pp. 41–69.

Carayannis, E. G., Barth, T. D. and Campbell, D. F. (2012) The Quintuple Helix innovation model: global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship*, 1(1), pp. 1-12.

Carbon Trust. (2008) *The Carbon Trust Standard.* Formal report.

Cardoso, S. R., Barbosa-Póvoa, A. P., Relvas, S. and Novais, A. Q. (2015) Resilience metrics in the assessment of complex supply-chains performance operating under demand uncertainty. *Omega*, 56, pp. 53-73.

Cardoso, S.R., Barbosa-Póvoa, A.P.,Relvas, S.,Novais, A.Q., (2015). Resilience metrics in the assessment of complex supply-chains performance operating under demand uncertainty. Omega56, 53–73.

Cargo Domino EU Project (2013) *Cargo Domino EU project*. [online]. Available from: http://www.sbbcargo.com/ [Accessed October 15th 2013].

Carpenter S. R. (2003) *Regime shifts in lake ecosystems*. Ecology Institute, Germany: Oldendorf/Luhe.

Carpenter, S. R., Westley, F. and Turner, M. G. (2005) Surrogates for resilience of social–ecological systems. *Ecosystems*, 8(8), pp. 941-944.

Carter, C. and Dresner, M. (2001) Purchasing's role in environmental management: cross-functional development of a grounded theory. *Journal of Supply Chain Management*, 37(3), pp.12–23.

Carter, C. and Rogers, D. S. (2008) A Framework of Sustainable Supply Chain Management: Moving Toward New Theory. *International Journal of Physical Distribution & Logistics Management*, 38(5), pp. 360-387.

Carter, C. R., Ellram, L. M. and Tate, W. L. (2007) Structure and influence: a logistics management application of social network analysis. *Journal of Business Logistics*, 28(1), pp. 137-68.

Carter, C. R., Kale, R. and Grimm, C. M. (2000) Environmental purchasing and firm performance: an empirical investigation. *Transportation Research Part E: Logistics and Transportation Review*, 36 (3), pp. 219–228.

Carvalho, H., Azevedo, S. G. and Cruz-Machado, V. (2012) Agile and resilient approaches to supply chain management: influence on performance and competitiveness. *Logistics research*, 4(1-2), pp. 49-62.

Carvalho, H., Barroso, A. P., Machado, V. H., Azevedo, S. and Cruz-Machado, V. (2012) Supply chain redesign for resilience using simulation. *Computers & Industrial Engineering*, 62(1), pp. 329-341.

Carvalho, H., Duarte, S. and Cruz-Machado, V. (2011) Lean, agile, resilient and green: divergencies and synergies. *International Journal of Lean Six Sigma*, 2(2), pp.151–179.

Carvalho, H., Duarte, S. and Cruz-Machado, V. (2011) Lean, agile, resilient and green: divergencies and synergies. *International Journal of Lean Six Sigma*, 2 (2), pp. 151-179.

CASAGRAS Project (2013) *CASAGRAS Project*. [online]. Available from: http://www.iot-casagras.org [Accessed October 13th 2013].

Cashin, P. A., Mohaddes, K. and Raissi, M. (2015) Fair weather or foul? the macroeconomic effects of El Niño.

Chakrabarty, S. and Wang, L. (2013) Climate change mitigation and internationalization: the competitiveness of multinational corporations. *Thunderbird International Business Review*, 55 (6), pp. 673-688.

Chakravarthy, B. (1997) A new strategy framework for coping with turbulence. *Sloan Management Review* , 38(4), pp. 69-82.

Chan, F. T., Bhagwat, R. and Wadhwa, S. (2009) Study on suppliers' flexibility in supply chains: is real-time control necessary? *International Journal of Production Research* , 47(4), pp. 965–987.

Chan, H. and Chan, F. T. (2009) Effect of information sharing in supply chains with flexibility. *International Journal of Production Research* , 47(1), pp. 213–232.

Chan, R. Y. K. and Lau, L. B. Y. (2001). Explaining green purchasing behavior: a cross-cultural study on American and Chinese consumers. *Journal of International Consumer Marketing*, 14 (2/3), pp. 9-41.

Chase, R., Jacobs, F. and Aquilano, N. (2004) *Operations Management for Competitive Advantage.* Boston: McGraw-Hill.

Chen, C. (2005) Incorporating Green Purchasing into the Frame of ISO 14000. *Journal of Cleaner Production*, 13(9), pp. 927–933.

Chen, I. J. and Paulraj, A. (2004) Towards a theory of supply chain management: the constructs and measurements. *Journal of operations management*, 22(2), pp. 119-150.

Chen, Y. S. (2008) The driver of green innovation and green image — Green core competence. *Journal of Business Ethics*, 81(3), pp. 531–543.

Chertow, M.R. (2009). Dynamics of geographically based industrial ecosystems. Final report.

Chhetri, P., Jayatilleke, G. B., Gekara, V. O., Manzoni, A. and Corbitt, B. (2016) Container terminal operations simulator (CTOS)–Simulating the impact of extreme weather events on port operation. *EJTIR*, 16(1), pp. 195-213.

Chiarini, A. and Douglas, A. (2015) The impact of logistics solutions on customer satisfaction: an exploratory qualitative study of manufacturing companies. *Sinergie Italian Journal of Management*, pp. 255-270.

Chien, M. K. and Shih, L. H. (2007) An empirical study of the implementation of green supply chain management practices in the electrical and electronic industry and their relation to organizational performances. *International Journal of Environmental Science and Technology*, 4 (3), pp. 383–394.

Chin, H. E., Li, R. K. and Tsai, C. H. (2012) Designing a Supply Chain System to Maximize Replenishment Efficiency: A Simulation Exercise. *International Journal of Management*, 29 (2/1), pp. 492-503.

Choudhary, A. K., Harding, J., Camarinha-Matos, L. M., Koh, S. C. L. and Tiwari, M. K. (2013) Knowledge management and supporting tools for collaborative networks. *International Journal of Production Research*, 51(7), pp. 1953-1957.

Chow, W. et al. (2008) Supply chain management in the US and Taiwan: an empirical study. *Omega*, 36 (5), pp. 665–679.

Chowdhury, M. and Hossan, M. (2014) Supply chain sustainability and resilience: The case of apparel industry in Bangladesh.

Chowdhury, M. H. and Quaddus, M. A. (2015) A multiple objective optimization based QFD approach for efficient resilient strategies to mitigate supply chain vulnerabilities: the case of garment industry of Bangladesh. Omega 0305-0483.

Christmann, P. and Taylor, G. (2001) Globalization and the environment: determinants of firm self-regulation in China. *Journal of International Business Studies*, 32(3), pp. 439-58.

Christoff, P. (1996) Ecological modernisation, ecological modernities. Environmental Science.

Christopher, M. (2004) Creating resilient supply chains. *Logistics Europe*, 11, pp. 18-19.

Christopher, M. and Peck, H. (2004) Building the Resilient Supply Chain. *International Journal of Logistics Management*, 15(2), pp. 1-14.

Christopher, M., Holweg, M., (2011). Supply Chain 2.0': managing supply chains in the era of turbulence. Int.J.Phys.Distrib.Logist.Manag.41(1),63–82.

Clemens, B. and Douglas, T. J. (2006) Does coercion drive firms to adopt 'voluntary' green initiatives? Relationships among coercion, superior firm resources, and voluntary green initiatives. *Journal of Business Research*, 59 (4), pp. 483–491.

COFRET EU Project (2013) *COFRET EU Project*. [online]. Available from: http://www.cofret-project.eu/ [Accessed October 14th 2013].

Coglianese, C. and Nash, J. (2001) *Regulating from the Inside: Can Environmental Management Systems Achieve Policy Goals?* Washington: Resources for the Future.

Cognizant. (2008) *Creating a Green Supply Chain - ICT as an Enabler* .

Connell, K. Y. H. (2010) Internal and external barriers to eco-conscious apparel acquisition. *International Journal of Consumer Studies*, 34 (3), pp. 279-286.

Connelly, B., Ketchen, D. and Slater, S. (2010) Toward a “theoretical toolbox” for sustainability research in marketing. *Journal of the Academy of Marketing Science* .

Connelly, J. and Smith, G. (1999) Politics and the Environment: From Theory to Practice, London, Routledge.

Connolly, C. and Hyndman, N. (2013) Towards charity accountability: narrowing thegap between provision and needs? *Public Management Review*, 15, pp. 945–968.

Contestabile, M. (2013) Energy Policy: China's green jobs. *Nature Climate Change*, 3(6), pp. 536-536.

Cooper, D. R. and Schindler, P. S. (2008) Business Research Methods, McGraw-Hill, New York, NY.

Cornell, S., Berkhout, F., Tuinstra, W., Ta, J. D., Chabay, I., de Wit, B., Langlais, R., Mills, D., Moll, P., Otto, I. M., Petersen, A., Pohl, C. and Kerkhoff, L. Van. (2013). Opening up knowledge systems for better responses to global environmental change. *Environmental Science & Policy*, 8.

Cousins, P. D. and Menguc, B. (2006) The implications of socialization and integration in supply chain management. *Journal of operations management*, 24(5), pp. 604-620.

Cousins, P. D., Lamming, R. C. and Bowen, F. (2004) The role of risk in environment-related supplier initiatives. *International Journal of Operations & Production Management*, 24(6), pp. 554-565.

Craglia, M., Bie, K. De, Jackson, D., Pesaresi, M., Bian, L., Campbell, F., Ehlers, M., van Gendeeren, J., Goodchild, M., Guo, H., Lewis, A., Simpson, R., Skidmore, A. and Woodgate, P. (2012) Digital Earth 2020 : towards the vision for the next decade. *International Journal of Digital Earth*, 5(1), pp. 4–21.

Craighead, C. W., Blackhurst, J., Rungtusanatham, J. M. and Handfield, R. B. (2007) The Severity of Supply Chain Disruptions: Design Characteristics and Mitigation Capabilities. *Decision Sciences*, 38(1), pp. 131-156.

Cruz, J. and Matsypura, D. (2009) Supply chain networks with corporate social responsibility through integrated environmental decision-making. *International Journal of Production Research*, 47(3), pp. 621 - 648.

Curkovic, S. and Sroufe, R. (2011) Using ISO 14001 to Promote a Sustainable Supply Chain Strategy. *Business Strategy and the Environment*, 20, pp. 71–93.

Cutter, S. L. (2013) Building Disaster Resilience: Steps toward Sustainability. *Chall.* Sustain, 1, pp. 72–79.

Danese, P. (2011) Towards a contingency theory of collaborative planning initiatives in supply networks. *International Journal of Production Research*, 49(4), pp. 1081–1103.

Darnall, N., Jolley, G. J. and Handfield, R. (2008) Environmental management systems and green supply chain management: complements for sustainability? *Business Strategy and the Environment*, 17(1), pp. 30-45.

Darnall, N., Jolley, J., & Handfield, R. (2008) Environmental Management Systems and Green Supply Chain Management: Complements for Sustainability? *Business Strategy and the Environment* , 18, 30–45.

Dasari, H. P., Salgado, R., Perdigao, J. and Challa, V. S. (2014) A Regional Climate Simulation Study Using WRF-ARW Model over Europe and Evaluation for Extreme Temperature Weather Events. *International Journal of Atmospheric Sciences*.

Dasgupta, P. and Mäler, K. G. (eds) (2004) *The economics of non-convex ecosystems.* Kluwer Academic, Dordrecht, The Netherlands.

Dattaa, P. P. and Christopher, M. G. (2011) Information sharing and coordination mechanisms for managing uncertainty in supply chains: a simulation study. *International Journal of Production Research*, 49(3), pp. 765–803.

De Rosa, V., Gebhard, M., Hartmann, E. and Wollenweber, J. (2013) Robust sustainable bi-directional logistics network design under uncertainty. *International Journal of Production Economics*, 145, pp. 184–198.

de Siqueira, B. S., Grijalvo, M., & Morales-Alonso, G. (2015). Improving Resilience and Performance of Organizations Using Environment, Health and Safety Management Systems. An Empirical Study in a Multinational Company. In *Enhancing Synergies in a Collaborative Environment* (pp. 275-282). Springer International Publishing.

Deacon, A., Bennet, A., & Shukla, M. (2014). A Model to Study What Knowledge Based Practices Successfully Facilitate Innovation in Supply Chains. In Proceedings of the 2nd International Conference on Innovation and Entrepreneurship: ICIE 2014 (p. 38). Academic Conferences Limited.

Defee, C. C., Esper, T. and Mollenkopf, D. (2009) Leveraging closed loop orientation and leadership for environmental sustainability. *Supply Chain Management: An International Journal*, 14(2), pp. 87-98.

Dekker, R., Bloemhof, J. and Mallidis, I. (2012) Operations Research for green logistics–An overview of aspects, issues, contributions and challenges. *European Journal of Operational Research*, 219(3), pp. 671–679.

del Brio, J.A., Junquera, B. and Ordiz, M. (2008) Human resources in advanced environmental approaches: a case analysis. *International Journal of Production Research*, 46 (21), pp. 6029-6053.

Delbufalo, E. (2012) Outcomes of inter-organizational trust in supply chain relationships: a systematic literature review and a meta-analysis of the empirical evidence. *Supply Chain Management: An International Journal*, 17(4), pp. 377-402.

Delloite. (2012) *Supply Chain Resilience:A Risk Intelligent approach to managing global supply chains.* Delloite Consulting.

Delmas, M. and Toffel, M. W. (2004) Stakeholders and environmental management practices – an institutional framework. *Business Strategy and the Environment*, 13(4), pp. 209–222.

Demir, E., Bektas, T. and Laporte, G. (2011) A comparative analysis of several vehicle emission models for road freight transportation. *Transportation Research Part D* , 16, pp. 347–357.

Demmer, W.A.,Vickery, S.K., Calantone, R., (2011). Engendering resilience in small- and medium-sized enterprises (SMEs):a case study of Demmer Corporation. Int. J.Prod.Res.49(18),5395–5413.

Derissen, S., Quaas, M. F. and Baumgärtner, S. (2011) The relationship between resilience and sustainability of ecological-economic systems. *Ecological Economics*, 70, pp. 1121–1128.

Dey, P. K. and W. Cheffi. (2012) Green Supply Chain Performance Measurement using the Analytic Hierarchy Process: A Comparative Analysis of Manufacturing Organisations." Production Planning & Control. doi: 10.1080/09537287.2013.798088.

Diabat, A. and Govindan, K. (2011) An analysis of the drivers affecting the implementation of green supply chain management. *Resources, Conservation and Recycling*, 55(6), pp. 659-667.

Diabat, A., Kannan, D. and Mathiyazhagan, K. (2014) Analysis of enablers for implementation of sustainable supply chain managementeA textile case. *Journal of Cleaner Production*, 83, pp. 391-403.

Distrivaart EU Project (2013) *Distrivaart EU Project*. [online]. Available from: http://www.transport-research.info/web/projects/project_ details.cfm?ID=3988 [Accessed October 10th 2013].

Dobers, K., Klukas, A., Lammers, W., Laux, M., Mauer, G. and Schneider, M. (2013) Green Logistics: Optimisation approaches for resource-efficient logistics services. *Efficiency and Logistics*, pp. 149–161.

Donnellan, B., Larsen, T. J. and Levine, L. (2007) Editorial introduction to the special issue on: transfer and diffusion of IT for organizational resilience. *Journal of Information Technology*, 22(1), pp. 3-4.

Dornfeld, D., Yuan, C., Diaz, N., Zhang, T. and Vijayaraghavan, A. (2013) Introduction to Green manufacturing. In: Green Manufacturing. Springer US, pp. 1-23.

Drohomeretski, E., Gouvea da Costa, S. and Pinheiro de Lima, E. (2014) Green supply chain management: Drivers, barriers and practices within the Brazilian automotive industry. *Journal of Manufacturing Technology Management*, 25(8), pp. 1105-1134.

Dubey, R., Gunasekaran, A. and Ali, S. S. (2015) Exploring the relationship between leadership, operational practices, institutional pressures and environmental performance: A framework for green supply chain. *International Journal of Production Economics*, 160, pp. 120-132.

Dubey, R., Gunasekaran, A., Papadopoulos, T. and Childe, S. J. (2015) Green supply chain management enablers: Mixed methods research. *Sustainable Production and Consumption*, 4, pp. 72-88.

Durach, C. F., Wieland, A. and Machuca, J. A. (2015) Antecedents and dimensions of supply chain robustness: a systematic literature review. *International Journal of Physical Distribution & Logistics Management*, 45(1/2), pp. 118-137.

Dynes, S., Johnson, M. E., Andrijcic, E. and Horowitz, B. (2007) Economic Costs of Firm-Level Information Infrastructure Failures. *International Journal of Logistics Management* , 18(3), pp. 420-442.

Easterby-Smith, M., Thorpe, R. and Lowe, A. (2002) *Management Research – An Introduction.* London: Sage Publications.

Ehrenfeld, J. R. (2007) Would industrial ecology exist without sustainability in the background? *Journal of Industrial Ecology*, 11, pp. 73-84.

Eisenhardt, K. M. (1989) Building theories from case study research. *Academy of Management Review*, 14(4), pp. 532-50.

Ellen, P. S., Webb, D. J. and Mohr, L. A. (2006) Building corporate associations: consumer attributions for corporate social responsibility programs. *Journal of the Academy of Marketing Science*, 34(2), pp. 147-57.

Elo, S. and Kyngäs, H. (2008) The qualitative content analysis process. *Journal of advanced nursing*, 62(1), pp. 107-115.

Eltayeb, T. K., Zailani, S. and Ramayah, T. (2011) Green supply chain initiatives among certified companies in Malaysia and environmental sustainability: Investigating the outcomes. *Resources, conservation and recycling*, 55(5), pp. 495-506.

Ergun, O., Karakus, G., Keskinocak, P., Swann, J. and Villarreal, M. (2010) Operations research to improve disaster supply chain management. *Wiley Encyclopedia of Operations Research and Management Science*.

Etzion, D. (2007) Research on organizations and the natural Environment, 1992-present: A review. *Journal of Management*, 33(4), pp. 637-664.

EU Circular Economy Act (2015) http://ec.europa.eu/environment/circular-economy/index_en.htm

EU Digital Agenda. (2013) EU Digital Agenda (online), Available from: http://s3platform.jrc.ec.europa.eu/digital-agenda [Accessed on october 2013]

EU2020 . (2013). *European Comission - EU 2020* (online), Available from: http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/targets/index_en.htm [Accessed on October 2013]

EURIDICE Project (2013) *Euridice Website*. [online]. Available from: http://www.euridice-project.eu/ [Accessed November 13th 2013].

Evans, H. and Johnson, J. (2005). “10 Steps toward RoHS directive compliance’’. *Circuits Assembly*, 16(2), pp. 68-70.

Eveloy, V., Ganesan, S., Fukuda, Y., Wu, J. and Pecht, M. G. (2005) ‘‘Are you ready for lead-free electronics?’’ *IEEE Transactions on Components and Packaging Technology*, 99, pp. 1-11.

Fahimnia, B., Sarkis, J., Boland, J., Reisi, M. and Goh, M. (2015) Policy insights from a green supply chain optimisation model. *International Journal of Production Research*, 53(21), pp. 6522-6533.

Faisal, M. (2016) Research Analysis on Barriers to Green Supply Chain Management in Pharmaceutical Industries. *Review of Public Administration and Management*.

Faisal, M., Banwet, D. and Shankar, R. (2006) Mapping supply chain on risk and customer sensitivity dimensions. *Industrial Management and Data Systems*, 106(6), pp. 878–895.

Falasca, M., Zobel, C. W. and Cook, D. (2008) A decision support framework to assess supply chain resilience. In: Proceedings of the 5th International ISCRAM Con- ference, Washington.

Fallah, H., Eskandari, H. and Pishvaee, M. S. (2015) Competitive closed-loop supply chain network design under uncertainty. *Journal of Manufacturing Systems*, 37, pp. 649-661.

Farjoun, M. (2010) Beyond dualism: Stability and change as a duality. *Academy of Management Review*, 35(2), pp. 202-225.

Fatemi, M. (2010) Supply Chain Flexibility: Definition and Review. *European Journal of Economics, Finance and Administrative Sciences*, 20, pp. 1450-2887.

Fiksel, J. (2003) Designing resilient, sustainable systems. *Environmental science & technology*, 37(23), pp. 5330-5339.

Fiksel, J., Polyviou, M., Croxton, K. L. and Pettit, K. J. (2015) From risk to resilience: learning to deal with disruption. *MIT Sloan Management Review*.

Firth, D. R., Lawrence, C. and Clouse, S. F. (2006) Predicting Internet-based online community size and time to peak membership using the Bass model of new product growth. *Interdisciplinary Journal of Information, Knowledge, and Management*, 1, pp. 1-12.

Fisher, D. R. and Freudenburg, W. R. (2001) Ecological modernization and its critics: Assessing the past and looking toward the future. *Society & natural resources*, 14(8), pp. 701-709.

Fleetwood, S. and Ackroyd, S. (2004) Critical realist applications in organisation and management studies. *Psychology Press*, 11.

Fleisch, E. and Tellkamp, C. (2003) *The Impact of Inventory Inaccuracy on Retail Supply Chain Performance: AS imulation Study*. Auto-ID Center, Wniversity of St. Gallen, Institute of Technology Management.

Fleischmann, M., Beullens, P., Bloemhof-Ruwaard, J. M. and Van Wassenhove, L. N. (2001) The impact of product recovery on logistics network design. *Production & Operations Management*, 10, pp. 156–173.

Florida, R., Atlas, M. and Cline, M. (2000) “What makes companies green? Organizational Change.

Flynn, B. and Flynn, E. (2005) Synergies between supply chain management and quality management: emerging implications. *International Journal of Production Research*, 43 (16), pp. 3421–3436.

Folke C., Berkes F. and Colding J. (1998) Ecological practices and social mechanisms for building resilience and sustainability. In: Berkes F, Folke C, editors. Cambridge (UK): Cambridge Uni-versity Press. in press

Folke, C., S. R. Carpenter, B. Walker, M. Scheffer, T. Chapin, and J. Rockstrom. 2010. Resilience thinking.

Foster, S. (2008) Towards an understanding of supply chain quality management. *Journal of Operations Management*, 26 (4), pp. 461–467.

Foster, T., Wallina, C. and Ogden, J. (2011) Towards a better understanding of supply chain quality management practices. *International Journal of Production Research*, 49(8), pp. 2285–2300.

Fowler, F. J. (2009) Survey Research Methods (Applied Social Research Methods), 4th ed., Sage, Newbury Park, CA.

Francis, A. T. P. B. M. and White, R. F. G. R. (2016) Profiling the resiliency and sustainability of UK manufacturing companies. *Management*, 27(1), pp. 82-99.

Freeman, R. E. (1984) Strategic Management: A Stakeholder Approach. Pittman, Marshfield.
Freeman, T. (2006) Best practice'in focus group research: making sense of different views. *Journal of advanced nursing*, 56(5), pp. 491-497.

FreightVision. (2009) *Relevance of European policy on long distance freight transport in Europe.* FreightVision.

Frissen, P. H. A. (2007) De Staat van Verschil – Een Kritiek van de Gelijkheid. Van Gennep, Amsterdam.

Frondel, M., Horbach, J. and Rennings, K. (2008) What triggers environmental management and innovation? Empirical evidence for Germany. *Ecological Economics*, 66, pp. 153-160.

Fullerton, R. R., Kennedy, F. A. and Widener, S. K. (2014) Lean manufacturing and firm performance: The incremental contribution of lean management accounting practices. *Journal of Operations Management*, 32(7), pp. 414-428.

GAR (2015). *Global Assessment Report on Disaster Risk Reduction*. UNISDR. www.preventionweb.net/gar.

Geldermann, J., Treitz, M. and Rentz, O. (2007) Towards sustainable production networks. *International Journal of Production Research*, 45(18–19), pp. 4207–4224.

Genchev, S. E., Glenn Richey, R. and Gabler, C. B. (2011) Evaluating reverse logistics programs: a suggested process formalization. *The International Journal of Logistics Management*, 22(2), pp. 242-263.

Genovese, A., Koh, S. C. L. and Acquaye, A. (2013) Energy efficiency retrofitting services supply chains: Evidence about stakeholders and configurations from the Yorskhire and Humber region case. *International Journal of Production Economics*, 144(1), pp. 20-43.

Genovese, A., Koh, S. C. L., Kumar, N. and Tripathi, P. K. (2014) Exploring the challenges in implementing supplier environmental performance measurement model: A case study. *Production Planning and Control*.

Ghadge, A. (2013). A systems thinking approach for modelling supply chain risk propagation (Doctoral dissertation, © Abhijeet Ghadge).

Giddens, A. (1994) Beyond Left and Right. Stanford University Press, Stanford, CA.

GIFTS EU Project (2013) GIFTS EU Project (online) Available from: [Accessed on November 2013]

Gilly, J. P., Kechidi, M. and Talbot, D. (2014) Resilienceoforganisationsandterritories: the roleofpivot firms. Eur.Manag.J.32,596–602.

Ginsberg, J. M. and Bloom, P. N. (2004) Choosing the right green marketing strategy. *Sloan Management Review*, 46, pp. 79–84.

Giunipero, L. C., Hooker, R. E., Joseph-Matthews, S. M., Yoon, T. E. and Brudvig, S. (2008) 'A

Glickman, T. and White, S. (2006) Security, visibility and resilience: the keys to mitigating supply chain vulnerabilities. *International Journal of Logistics Systems and Management*, 2(2), pp. 107–119.

Global Reporting Initiative (2013) The external assurance of sustainabilityreporting. Stitching Global Reporting Initiative (GRI), Amsterdam, TheNetherlands, http://www.globalreporting.orgGonzález-Benito, J., Lannelongue, G., Queiruga, D., 2011. Stakeholders andenvironmental management systems: a synergistic influence onenvironmental imbalance. J. Cleaner Prod. 19, 1622–1630.

Global Risks (2015), *10th Edition*. World Economic Forum. Geneva.

Gobbo, S. C. D. O., Fusco, J. P. A. and Junior, J. A. G. (2014) An analysis of embeddedness in the value creation in interorganisational networks: an illustrative example in Brazil. *International Journal of Advanced Operations Management*, 6 (2), pp. 178-198.

Goel, A. (2010) *A Roadmap for Sustainable Freight Transport.* Zaragoza: Zaragoza Logistics Center.

Gold, S., Seuring, S. and Beske, P. (2010) Sustainable Supply Chain Management and Inter-Organizational Resources: A Literature Review. *Corporate Social Responsibility and Environmental Management*, pp. 230–245.

Golgeci, I., Ponomarov, S.Y., (2013). Does firm innovativeness enable effective responses to supply chain disruptions? An empirical study. Supply Chain Manag.: Int.J.18(6),604–617.

Golicic, S. L. and Davis, D. F. (2012) Implementing mixed methods research in supply chain management. *International Journal of Physical Distribution & Logistics Management*, 42(8/9), pp. 726-741.

Golicic, S. L. and Mentzer, T. J. (2005) "Exploring the drivers of interorganizational relationship magnitude". *Journal of Business Logistics*, 26(2), pp. 47-71.

Golicic, S. L. and Smith, C. D. (2013) A meta-analysis of environmentally sustainable supply chain management practices and firm performance. *Journal of Supply Chain Management*, 49(2), pp. 78-95.

Gonza´lez-Benito, J., Gonza´lez-Benito, O´ , (2005) Business performance: an empirical analysis. Omega: The *International Journal of Management Science*, 33 (1), pp. 1–15.

Gonzalez, P., Sarkis, J. and Adenso-Diaz, B. (2008) Environmental management system certification and its influence on corporate practices: evidence from the automotive industry. *International Journal of Operations and Production Management*, 28, pp. 1021-1041.

González-Benito, J. and González-Benito, Ó. (2006) The role of stakeholder pressure and managerial values in the implementation of environmental logistics practices. *International Journal of Production Research*, 44(7), pp. 1353-1373.

Gopal, P. R. C. and Thakkar, J. (2012) A review on supply chain performance measures and metrics: 2000-2011. *International Journal of Productivity and Performance Management*, 61(5), pp. 518-547.

Gorton, M., Dumitrashko, M. and White, J. (2006),"Overcoming supply chain failure in the agri-food sector: a case study from Moldova". *Food Policy*, 31(1), pp. 90-103.

Govindan, K., Azevedo, S. G., Carvalho, H. and Cruz-Machado, V. (2014) Impact of supply chain management practices on sustainability. *Journal of Cleaner Production*, 85, pp. 212-225.

Govindan, K., Diabat, A. and Shankar, K. M. (2015) Analyzing the drivers of green manufacturing with fuzzy approach. *Journal of Cleaner Production*, 96, pp. 182-193.

Green, K. W., Inman, R. A., Birou, L. M. and Whitten, D. (2014) Total JIT (T-JIT) and its impact on supply chain competency and organizational performance. *International Journal of Production Economics*, 147, pp. 125-135.

Greene, J. C. (2008) Is mixed methods social inquiry a distinctive methodology? *Journal of Mixed Methods Research*, 2(1), pp. 7–22.

Grossmann, I. (2004) Challenges in the new millennium: product discovery and design, enterprise and supply chain optimization, global life cycle management. *Computing and Chemical Engineering* , 29, pp. 29–39.

Grote, C. A., Jones, R. M., Blount, G. N., Goodyer, J. and Shayler, M. (2007) ''An approach to the EuP Directive and the application of the economic eco-design for complex products''. *International Journal of Production Research*, 45(18/19), pp. 4099-117.

Grove, J. M., Chowdhury, R. R. and Childers, D. (2015) Co-design, co-production, and dissemination of social-ecological knowledge to promote sustainability and resilience: urban experiences from the US.

Gualandris, J., Klassen, R. D., Vachon, S. and Kalchschmidt, M. (2015) Sustainable evaluation and verification in supply chains: Aligning and leveraging accountability to stakeholders. *Journal of Operations Management*, 38, pp. 1-13.

Guang Shi, V., Koh, S. C. L., Baldwin, J. and Cucchiella, F. (2012) Natural resource based green supply chain management. *Supply Chain Management: An International Journal*, 17(1), pp. 54 67.

Gunasekaran, A. and Kobu, B. (2007) Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995–2004) for research and applications. *International Journal of Production Research,* 45 (12), pp. 2819–2840.

Gunasekaran, A., Patel, C. and McGaughey, R. E. (2004) "A Framework for Supply Chain Performance Measurement." *International Journal of Production Economics*, 87(3), pp. 333–347.

Gunasekaran, A., Patel, C. and Tirtiroglu, E. (2001) Performance measures and metrics in a supply chain environment. *International Journal of Operations and Production Management*, 21, pp. 71–87.

Gunasekaran, A., Williams, H. and McGaughey, R. (2005) Performance measurement and costing system in new enterprise. *Technovation*, 25 (5), pp. 523–533.

Gunderson, L. H., Holling, C. S., Eds. 2002. Panarchy: understanding transformations in human and natural systems. Washington, DC: Island Press.

Gunther, E. and Scheibe, L. (2005) The hurdles analysis as an instrument for improving environmental value chain management. *Progress in Industrial Ecology, an International Journal*, 2(1), pp. 107 - 131.

Gupta, A. K. (2009) 'Seduce the scientist'. Farming Matters, December.

Gupta, M. and Piero, T. (2003) Environmental management is good business. *Industrial Management*, 45, pp. 14–19.

Hale, T. and Moberg, C. R. (2005) "Improving supply chain disaster preparedness: a decision process for secure site location". *International Journal of Physical Distribution & Logistics Management,* 35 (3), pp. 195-207.

Hall, J. (2001) Environmental supply-chain innovations. *Greener Management International*, 35, pp. 105–119.

Hall, J. (2006) Environmental supply chain innovation. In J. Sarkis (Ed.). Greening the Supply Chain, Springer, London. http://dx.doi.org/10.1007/1-84628-299-3_136

Hamel, G. and Välikangas, L. (2003)The quest for resilience. *Harvard Business Review,* 81(9), pp. 52–63.

Handfield, R. and Lawson, B. (2007) Integrating suppliers into new product development. *Research Technology Management*, 50(5), pp. 44–51.

Handfield, R. and Nichols, E. (2002) *Supply chain redesign: transforming supply chains into integrated value systems.* Upper Saddle River New Jersey: Financial Times Prentice-Hall.

Handfield, R., Sroufe, R. and Walton, S. (2004) Integrating environmental management and supply chain strategies. *Business Strategy and the Environment*, 14, pp. 1–19.

Handfield, R., Sroufe, R. and Walton, S. (2005) Integrating environmental management and supply chain strategies. *Business Strategy and the Environment*, 14, pp. 1-19.

Handfield, R., Walton, S. V., Sroufe, R. and Melnyk, S. A. (2002) Applying environmental criteria to supplier assessment: a study in the application of the analytical hierarchy process. *European Journal of Operational Research*, 141(16), pp. 70-87.

Hansen, S., Großmann, J. and Abele, E. (2005) ''The Directive on Energy using Products – an approach for an efficient implementation in industry''. Proceedings of the 4th International Symposium on Environmentally Conscious Design and Inverse Manufacturing, Tokyo, pp. 642-48.

Hanson, J. D., Melnyk, S. A. and Calantone, R. J. (2004) Core values and environmental management. *Greener Management International*, 46, pp. 29-40.

Harland, C. M., Caldwell, N. D., Powell, P. and Zheng, J. (2007) Barriers to supply chain information integration: SMEs adrift of eLands. *Journal of Operations Management*, 25(6), pp. 1234-1254.

Harris, P. G. (2006) Environmental perspectives and behavior in China: synopsis and bibliography. *Environment and Behavior*, 38 (1), pp. 5–21.

Hartmann, J. and Moeller, S. (2014) Chain liability in multitier supply chains? Responsibility attributions for unsustainable supplier behavior. *Journal of Operations Management*, 32(5), pp. 281-294.

Heckmann, I., Comes, T. and Nickel, S. (2015) A critical review on supply chain risk–Definition, measure and modeling. *Omega*, 52, pp. 119-132.

Henderson, J. C. and Lentz, C. M. A. (1996) Learning, working, and innovation: A case study in the insurance industry. *Journal of Management Information Systems*. 12(3), pp. 43-64.

Hennink, M. M. (2007) *International focus group research: a handbook for the health and social sciences*. Cambridge University Press.

Hervani, A. A., Helms, M. M. and Sarkis, J. (2005) Performance measurement for green supply chain management. *Benchmarking: An international journal*, 12(4), pp. 330-353.

Hick, S. (2000) Morals Make the Money. *Austrian CPA*, 70, pp. 72-73.

Hill, R. and Omar, M. (2006) Another look at the single-vendor single-buyer integrated production inventory problem. *International Journal of Production Research*, 44 (4), pp. 791–800.

Hirsch, P. M. (1975) Organizational effectiveness and the institutional environment. *Administrative Science Quarterly*, 20(3), pp. 327–344.

Hitachi Consulting (2009) *Six Key Trends Changing Supply Chain Management Today*. USA: Hitachi Consulting.

Hitchcock, T. (2012) Low Carbon and Green Supply Chains: The Legal Drivers and Commercial Pressures. *Supply Chain Management: An International Journal*, 17 (1), pp. 98–101.

Hitt, M. A., Xu, K. and Carnes, C. M. (2015) Resource based theory in operations management research. *Journal of Operations Management*.

Hoejmose, S., Brammer, S. and Millington, A. (2012) "Green" supply chain management: The role of trust and top management in B2B and B2C markets. *Industrial Marketing Management*, 41(4), pp. 609-620.

Hoek, R. I., Harrison, A. and Christopher, M. (2001) Measuring Agile Capabilities in the Supply Chain. *International Journal of Production and Operations Management* , 21(1/2), pp. 126-147.

Hoffman A. (2000) Competitive Environmental Strategy: a Guide to the Changing Business Landscape. Island: Washington, DC.

Hoffman, A. and Ventresca M. J. (eds). (2002). Organization, Policy and the Natural Environment: Institutional and Strategic Perspectives. Stanford University Press: Stanford, CA.

Hofmann, E. and Locker, A. (2009) "Value-based Performance Measurement in Supply Chains: A Case Study from the Packaging Industry." *Production Planning & Control*, 20 (1), pp. 68–81.

Hohenstein, N. O., Feisel, E., Hartmann, E. and Giunipero, L. (2015) Research on the phenomenon of supply chain resilience: a systematic review and paths for further investigation. *International Journal of Physical Distribution & Logistics Management*, 45(1/2), pp. 90-117.

Holguín-Veras, J., Jaller, M., Van Wassenhove, L. N., Pérez, N. and Wachtendorf, T. (2012) On the unique features of post-disaster humanitarian logistics. *Journal of Operations Management*, 30(7), pp. 494-506.

Holling, C. S. (1973) Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, 4, pp. 1–23.

Holling, C. S. (2001) Understanding the complexity of economic, ecological, and social systems. *Ecosystems*, 4(5), pp. 390-405.

Holt, D. (2004) Managing the interface between suppliers and organizations for environmental responsibility – an exploration of current practices in the UK. *Corporate Social Responsibility and Environmental Management*, 11(2), pp. 71–84.

Holt, D. and Ghobadian, A. (2009) An empirical study of green supply chain management practices amongst UK manufacturers. *Journal of Manufacturing Technology Management*, 20(7), pp. 933–56.

Hong, P., Kwon, H-B. and Roh, J. (2009) Implementation of strategic green orientation in supply chain: An empirical study of manufacturing firms. *European Journal of Innovation Management*, 12(4), pp. 512–532.

Hoque, M. (2009) An alternative optimal solution technique for a single-vendor single-buyer integrated production inventory model. *International Journal of Production Research*, 47(15), pp. 4063–4076.

Hora, M. and Klassen, R. D. (2013) Learning from others' misfortune: Factors influencing knowledge acquisition to reduce operational risk. *Journal of Operations Management*, 31(1), pp. 52-61.

Horbach, J. (2008) Determinants of environmental innovation – New evidence from German panel data sources. *Research Policy*, 37(1), pp. 163-173.

Horizon2020 (2012) Retrieved October 2013, from Horizon2020 – Research and Innovation: http://ec.europa.eu/research/ horizon2020/index_en.cfm?pg=home&video=none

Horlings, L. G. and Marsden, T. K. (2011) Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could 'feed the world'. *Global environmental change*, 21(2), pp. 441-452.

Horton, P., Koh, L. and Guang, V. S. (2015) An integrated theoretical framework to enhance resource efficiency, sustainability and human health in agri-food systems. *Journal of Cleaner Production*.

Hsu, C. C., Choon Tan, K., Hanim Mohamad Zailani, S. and Jayaraman, V. (2013) Supply chain drivers that foster the development of green initiatives in an emerging economy. *International Journal of Operations & Production Management*, 33(6), pp. 656-688.

Hsu, C. W., Kuo, T. C., Chen, S. H. and Hu, A. H. (2013) Using DEMATEL to develop a carbon management model of supplier selection in green supply chain management. *Journal of Cleaner Production*, 56, pp. 164-172.

Hu, A. H. and Hsu, C. W. (2010) Critical factors for implementing green supply chain management practice: an empirical study of electrical and electronics industries in Taiwan. *Management research review*, 33(6), pp. 586-608.

Hu, A. H., Hsu, C. W., Kuo, T. C. and Wu, W. C. (2008) ''Risk evaluation of green components to hazardous substance using FMEA and FAHP''. *Expert Systems with Applications*.

Huang, C. K., Chenga, T. L., Kao, T. C. and Goyal, S. K. (2011) An integrated inventory model involving manufacturing setup cost reduction in compound Poisson process. *International Journal of Production Research*, 49(4), pp. 1219–1228.

Huang, J. (2005) ''The ministry of economic affairs establishes a RoHS service corps to help the electrical and electronic industries build green supply chains''. *Taiwan Cleaner Production Newsletter*, 1(1), pp. 2-3.

Huerta-Barrientos, A., Elizondo-Cortés, M. and de la Mota, I. F. (2014) Analysis of scientific collaboration patterns in the co-authorship network of Simulation–Optimization of supply chains. *Simulation Modelling Practice and Theory*, 46, pp.135-148.

Hulme, M. (2003) Abrupt climate change: can society cope? *Philosophical Transactions of the Royal Society of London; Series A: Mathematical Physical and Engineering Sciences*, 361(1810), pp. 2001–2019.

Hult, T., Ketchen, D. and Arrfelt, M. (2007) Strategic supply chain management: improving Performance through a culture of competitiveness and knowledge development. *Strategic Management Journal*, 28, pp. 1035–1052.

i-CARGO Project (2013) i-CARGO Project (online) Available from: http://i-cargo.eu/ [Accessed on October 2013]

Ingirige, M. J. B., Joness, K. and Proverbs, D. (2008) Investigating SME resilience and their adaptive capacities to extreme weather events: A literature review and synthesis.

INTERFACE Project. (2013) INTERFACE Project (online) Available from: [Accessed on Nobember 2013]

Iofrida, N., De Luca, A. I., Strano, A., & Gulisano, G. (2014). Social Life Cycle Assessment in a constructivist realism perspective: a methodological proposal. In Proceedings of Pre-Proceeding of the 4th International Seminar in Social LCA, Social LCA in progress (pp. 19-21).

Ivanaj, S., Ivanaj, V., McIntyre, J., Da Costa, N. G. and Lozano, R. (2015) Multinational Enterprises' strategic dynamics and climate change: drivers, barriers and impacts of necessary organisational change. *Journal of Cleaner Production*.

Ivanov, D., Dolgui, A. and Sokolov, B. (2012) "Applicability of optimal control theory to adaptive supply chain planning and scheduling." *Annual Reviews in Control*, 36(1), pp. 73-84.

Jacobsson, S. and Bergek, A. (2011) Innovation system analyses and sustainability transitions: Contributions and suggestions for research. *Environmental Innovation and Societal Transitions*, 1(1), pp. 41-57.

Janssen, M. A., Bodin, Ö., Anderies, J. M., Elmqvist, T., Ernstson, H., McAllister, R. R. J., Olsson, P. and Ryan, P., (2006) Toward a network perspective of the study of resilience in social-ecological systems. *Ecology and Society*, 11, pp. 15.

Jansson, Å. (2013) Reaching for a sustainable, resilient urban future using the lens of ecosystem services. *Ecological Economics*, 86, pp. 285-291.

Janvier-James, A. M. (2012) A New Introduction to Supply Chains and Supply Chain Management: Definitions and Theories Perspective. *International Business Research*, 5(1), pp. 194-207.

Jarvis, A. J., Leedal, D. T. and Hewitt, C. N. (2012) Climate-society feedbacks and the avoidance of dangerous climate change. *Nature Climate Change*, 2(9), pp. 668-671.

Jayarama, J., Tan, K. C. and Nachiappan, S. P. (2010) Examining the interrelationships between supply chain integration scope and supply chain management efforts. *International Journal of Production Research*, 48(22), pp. 6837–6857.

Jayaraman, V., Patterson, R. A. and Rolland, E. (2003) The design of reverse distribution networks: models and solution procedures. *European Journal of Operational Research*, 150, pp. 128–149.

John, S. T. and Sridharan, R. (2015) Modelling and analysis of network design for a reverse supply chain. *Journal of Manufacturing Technology Management*, 26(6), pp. 853-867.

Johnson, M. E. (2006) Supply Chain Management: Technology Globalization, and Policy at a Crossroads. *Interfaces*, 36(3), pp. 191–193.

Johnson, N., Elliott, D. and Drake, P. (2013) Exploring the role of social capital in facilitating supply chain resilience. *Supply Chain Management: An International Journal*, 18(3), pp. 324-336.

Jungbae R. J., Hong, P. and Park, Y. (2008) Organizational culture and supply chain strategy: a framework for effective information flows. *Journal of Enterprise Information Management*, 21(4), pp. 361-376.

Juttner, U. and Maklan, S. (2011) Supply Chain Resilience in the Global Financial Crisis: An Empirical Study. *Supply Chain Management: An International Journal*, 14(4), pp. 246-259.

Kahn, W. A., Barton, M. A. and Fellows, S. (2013) Organizational crises and the disturbance of relational systems. *Academy of Management Review*, 38(3), pp. 377–396.

Kainuma, Y. and Tawara, N. (2006) A multiple attribute utility theory approach to lean and green supply chain management. *International Journal of Production Economics*, 101(1), pp. 99–108

Kalish, S. and Lilien, G. L. (1996) A market entry timing model for new technologies. *Management Science*, 32, pp. 196-205.

Kamalahmadi, M. and Parast, M. M. (2016) A review of the literature on the principles of enterprise and supply chain resilience: Major findings and directions for future research. *International Journal of Production Economics*, 171, pp. 116-133.

Kamberelis, G. and Dimitriadis, G. (2013) *Focus groups: From structured interviews to collective conversations*. Routledge.

Kanda, A. and Deshmukh, S. (2008) Supply chain co-ordination: Perspectives, empirical studies and research directions. *International Journal of Production Economics*, 115 (2), pp. 316–335.

Kaynak, H. and Hartley, J. (2008) A replication and extension of quality management into the supply chain. *Journal of Operations Management*, 26(4), pp. 468–489.

Keating, B., Quazi, A., Kriz, A. et al. (2008) In Pursuit of a Sustainable Supply Chain: Insights from Westpac Banking Corporation. *University of Wollongdong* .

Ken, G., Barbara, M. and Steve, N. (2000) Greening organizations: purchasing, consumption and innovation. *Organization and Environment*, 13(2), pp. 206–225.

Keohane, R. O. and Victor, D. G. (2016) Cooperation and discord in global climate policy. *Nature Climate Change*, 6(6), pp. 570-575.

Ketchen, J. and Hult, G. (2007) Bridging organization theory and supply chain management: The case of best value supply chains. *Journal of Operations Management*, 25(2), pp. 573-580.

Ketikidis, P. H., Hayes, O. P., Lazuras, L. and Gunasekaran, A. (2013) Environmental practices and performance and their relationships among Kosovo construction companies: A framework for analysis in transition economies. *International Journal of Services and Operations Management*, 14(1), pp. 115-130.

Ketikidis, P., Solomon, A. and Hajrizi, B. (2016) Focusing on the Triple Helix: a strategy for ensuring continuity and growth in crisis struck countries. *In University – Industry Interaction Conference*, 1-3rd June, Amsterdam, Netherlands.

Kidd, P. S. and Parshall, M. B. (2000) Getting the focus and the group: enhancing analytical rigor in focus group research. *Qualitative health research*, 10(3), pp. 293-308.

Kilbourne, W. E., Beckmann, S. C. and Thelen, E. (2002) The role of the dominant social paradigm in environmental attitudes: a multinational examination. *Journal of Business Research*, 55(3), pp. 193–204.

Kilubi, I. and Haasis, H. D. (2015) Supply chain risk management enablers-A framework development through systematic review of the literature from 2000 to 2015. *International Journal of Business Science and Applied Management*, 10(1).

Kim, Y., Chen, Y. S. and Linderman, K. (2015) Supply network disruption and resilience: A network structural perspective. *Journal of Operations Management*, 33, pp. 43-59.

Kim, Y., Chen,Y., Linderman,K., (2015). Supply network disruption and resilience: a network structural perspective. J.Oper.Manag. 33–34, 43–59.

King, A., Lenox, M. and Terlaak, A. (2005) The strategic use of decentralized institutions: exploring certification with the ISO 14001 management standard. *Academy of Management Journal*, 48, pp. 1091–1106.
King, D., Shalaby, A. and Eng, P. (2016) Performance Metrics and Analysis of Transit Network Resilience in Toronto. In *Transportation Research Board 95th Annual Meeting* (No. 16-2441).

Kistruck, G. M., Morris, S. S., Webb, J. W. and Stevens, C. E. (2015) The importance of client heterogeneity in predicting make-or-buy decisions. *Journal of Operations Management*, 33, pp. 97-110.

Kitchen, L. and Marsden, T. (2009) Creating sustainable rural development through stimulating the eco-economy: beyond the eco-economic paradox? *Sociologia Ruralis,* 49(3), pp. 273–293.

Kleindorfer, P. R., Singhal, K. and Van Wassenhove, L. N. (2005) Sustainable Operations Management. *Production & Operations Management*, 14(4), pp. 482–492.

Klibi, W., Martel, A. and Guitouni, A. (2010) The design of robust value-creating supply chain networks: a critical review. *European Journal of Operational Research*, 203(2), pp. 283-293.

Koh, S. C. L. (2014) Challenges in Implementing Models for Suppliers Environmental Performance Measurement. *Production Planning and Control*.

Koh, S. C. L., Acquaye, A., Rana, N., Genovese, A., Barrett, P., Gibbs, D. and Kuylenstierna, J. (2011) Supply chain environmental analysis (SCEnAT)-a new system for delivering a low carbon supply chain.

Koh, S. C. L., Demirbag, M., Bayraktar, E., Tatoglu, E. and Zaim, S. (2007) The impact of supply chain management practices on performance of SMEs. *Industrial Management & Data Systems*, 107(1), pp. 103-124.

Koh, S. C. L., Genovese, A., Acquaye, A. A., Barratt, P., Rana, N., Kuylenstierna, J. and Gibbs, D. (2013) Decarbonising product supply chains: design and development of an integrated evidence-based decision support system–the supply chain environmental analysis tool (SCEnAT). *International Journal of Production Research*, 51(7), pp. 2092-2109.

Koh, S. C. L., Genovese, A., Acquaye, A. and Barratt, P. (2013) Decarbonising product supply chains: design and development of an integrated evidence-based decision support system – the supply chain environmental analysis tool (SCEnAT). *International Journal of Production Research*, 51(7), pp. 2092-2109.

Koplin, J., Seuring, S. and M. Mesterharm (2007) Incorporating sustainability into supply management in the automotive industry: The case of the Volkswagen AG. *Journal of Cleaner Production*, 15(11/12), pp. 1053–1062.

Kovács, G. (2004) Framing a demand network for sustainability. *Progress in Industrial Ecology: an International Journal*, 1(4), pp. 397 - 410.

Krause, D., Youngdahl, W. and Ramaswamy, K. (2014) Manufacturing–Still a missing link? *Journal of Operations Management*, 32(7), pp. 399-402.

Kreibich, H., van den Bergh, J. C., Bouwer, L. M., Bubeck, P., Ciavola, P., Green, C., Hallegatte, S., Logar, I., Meyer, V., Schwarze, R. and Thieken, A. H. (2014) Costing natural hazards. *Nature Climate Change*, 4(5), pp. 303-306.

Kristianto, Y., Gunasekaran, A., Helo, P. and Hao, Y. (2014). A model of resilient supply chain network design: A two-stage programming with fuzzy shortest path. *Expert Systems with Applications*, 41(1), pp. 39-49.

Kuei, C., Madua, C. and Lin, C. (2011) Developing global supply chain quality management systems. *International Journal of Production Research*, 49(15), pp. 4457–4481.

Kumar, S., Tiwari, M. K. and Babiceanu, R. F. (2010) Minimisation of supply chain cost with emdebbed risk using computational intelligence approaches. *International Journal of Production Research*, 48, pp. 3717-3739.

L4LIFE Project. (2013) *L4LIFE Website(online)* Available from: [Accessed on November 2013]

Laclau, E. and Bhaskar, R. (2015) Discourse theory vs critical realism. *Alethia*.

Lai, K. H., Wong, C. W. Y. and Cheng, T. C. E. (2006) Institutional isomorphism and the adoption of information technology for supply chain management. *Computers in Industry*, 57(1), pp. 93–98.

Lambert, D. (2004) *Supply chain management – processes, partnerships, performance.* Sarasota, FL: Supply Chain Management Institute.

Lazuras, L., Ketikidis, P. H. and Solomon, A. (2014) Adoption of Smart Logistics: From Testbeds to Successful Implementation. In *18th Panhellenic Logistics Conference*. Thessaloniki, Greece.

Lebel, L., Anderies, J. M., Campbell, B., Folke, C., Hatfield-Dodds, S., Hughes, T. P. and Wilson, J. (2006) Governance and the capacity to manage resilience in regional social-ecological systems.

Lee, K. H. and Kim, J. W. (2011) Integrating Suppliers into Green Product Innovation Development: an Empirical Case Study in the Semiconductor Industry. *Business Strategy and the Environment,* pp. 527–538.

Lee, S-Y. (2008) Drivers for the participation of small and medium-sized suppliers in green supply chain initiatives. *Supply Chain Management: An International Journal*, 13(3), pp. 185–98.

Lee, T. R., Phuong Nha Le, T., Genovese, A. and Koh, L. C. S. (2011) Using FAHP to determine the criteria for partner's selection within a green supply chain: The case of hand tool industry in Taiwan. *Journal of Manufacturing Technology Management*, 23(1), pp. 25-55.

Lee, Y. and Kincade, D. H. (2003) US apparel manufacturers' company characteristic differences based on SCM activities. *Journal of Fashion Marketing and Management*, 7(10), pp. 31–48.

Lengnick-Hall, C.A., Beck, T.E., Lengnick-Hall, M.L., (2011). Developinga capacity for organizational resilience through strategic human resource management. Hum. Resour.Manag.Rev.21(3),243–255.

Leventon, J., Dyer, J. C. and Van Alstine, J. D. (2015) The private sector in climate governance: opportunities for climate compatible development through multilevel industry-government engagement. *Journal of Cleaner Production*, 102, pp. 316-323.

Lewis, M. A. (2000) Lean production and sustainable competitive advantage. *International Journal of Operations & Production Management*, 20(8), pp. 959-978.

LI, C. and COATES, G. (2016) Design And Development Of An Agent-based Model For Business Operations Faced With Flood Disruption. *International Journal of Design & Nature and Ecodynamics*, 11(2), pp. 97-106.

Li, G., Gu, Y.-G. and Song, Z.-H. (2013) Evolution of cooperation on heterogeneous supply networks.

Li, H. and Li, L. (2000) Integrating systems concepts into manufacturing information systems. *Systems Research and Behavioral Sciences*, 17, pp. 135–147.

Li, L. (2007) *Supply chain management: Concepts, techniques, and practices – Enhancing value through collaboration.* Hackensack, New Jersey: World Scientific Publishing.

Li, S., Ragu-Nathan, B. and Ragu-Nathan, T. S. (2006) The Impact of Supply Chain Management Practices on Competitive Advantage and Organizational Performance. *Omega*, 34(2), pp. 107–124.

Liker, J. K. and Choi, T. Y. (2004) Building deep supplier relationships. *Harvard Business Review*, pp. 104–113.

Lim, S. J. and Phillips, L. (2008) Embedding CSR Values:The Global Footwear Industry's Evolving Governance Structure. *Journal of Business Ethics*, 81(1), pp. 143–156.

Lin, C., Choy, K., Ho, G., Chung, S. and Lam, L. (2013) Survey of green vehicle routing problem: Past and future trends. *Forthcoming in Expert Systems with Applications*.

Lin, Y. and Zhou, L. (2011) The impacts of product design changes on supply chain risk: a case study. *International Journal of Physical Distribution & Logistics Management*, 41(2), pp. 162-186.

Linnenluecke, M. K. (2015) Resilience in business and management research: a review of influential publications and a research agenda. *International Journal of Management Reviews*.

Linnenluecke, M. K., Griffiths, A. and Winn, M. (2012) Extreme weather events and the critical importance of anticipatory adaptation and organizational resilience in responding to impacts. *Business Strategy and the Environment*, 21(1), pp. 17-32.

Linton, J. D., Klassen, R. and Jayaraman, V. (2007) Sustainable Supply Chains:An Introduction. *Journal of Operations Management*, 25(6), pp. 1075-1082.

Liu, X. and Buck, T. (2007) Innovation performance and channels for international technology spillovers: evidence from Chinese high-tech industries. *Research Policy*, 36 (3), pp. 355-366.

Liu, X., Yang, J., Qu, S. and Wang, L. (2012) Sustainable Production: Practices and Determinant Factors of Green Supply Chain Management of Chinese Companies. *Business Strategy and the Environment* , 21, pp. 1–16.

Liu, X., Yeung, A. C., Lo, C. K. and Cheng, T. C. E. (2014) The moderating effects of knowledge characteristics of firms on the financial value of innovative technology products. *Journal of Operations Management*, 32(3), pp. 79-87.

Lockamy, A. and McCormack, K. (2004) Linking SCOR planning practices to supply chain performance: an exploratory study. *International Journal of Operations and Production Management*, 24(12), pp. 1192–1218.

Loh, H. S. and Thai, V. V. (2015) Management of disruptions by seaports: preliminary findings. *Asia Pacific Journal of Marketing and Logistics*, 27(1), pp. 146-162.

Loke, S. P., Downe, A., Sambasivan, M. and Khalid, K. (2011) A STRUCTURAL APPROACH TO INTEGRATING TOTAL QUALITY MANAGEMENT AND KNOWLEDGE MANAGEMENT WITH SUPPLY CHAIN LEARNING. *Journal of Business Economics and Management*, 13(4), pp. 776–800.

Low Carbon Supply Chains Project (2012) *Low Carbon Supply Chains Project*. [online]. Available from: http://www.lowcarbonfutures.org/projects /circular-economy/low-carbon-supply-chains [Accessed October 24th 2013].

Lummus, R. R., Vokurka, R. J. and Duklos, L. K. (2005) Delphi study on supply chain flexibility. *International Journal of Production Research*, 43(13), pp. 2687–2708.

Lundqvist, L. J. (2000) Capacity-building or social construction? Explaining Sweden's shift towards ecological modernisation. *Geoforum*, 31(1), pp. 21-32.

Madu, C. and Kuei, C. (2004) *ERP and supply chain management.* Fairfield: Chi Publishers.

Maheshwari, S. and Jain, P. K. (2015) Supply Chain Modelling Under Uncertainty: A Supplier's Perspective. In *Toward Sustainable Operations of Supply Chain and Logistics Systems* (pp. 51-66). Springer International Publishing.

Mamic, I. (2005) Managing Global Supply Chain: The Sports Footwear, Apparel and Retail Sectors. *Journal of Business Ethics*, 52(1–2), pp. 81–100.

Mandal, S. (2012) An Empirical Investigation into Supply Chain Resilience. *IUP Journal of Supply Chain Management* , pp. 46-61.

Mangan, J., Lalwani, C. and Gardner, B. (2004) Combining quantitative and qualitative methodologies in logistics research. *International Journal of Physical Distribution & Logistics Management*, 34(7), pp. 565-578.

Mann, H., Kumar, U., Kumar, V. and Mann, S. (2010) Drivers of Sustainable Supply Chain Management. *IUP*, pp. 52-63.

Manthou, V., Matopoulos, A. and Vlachopoulou, M. (2005) Internet-based applications in the agri-food supply chain: a survey on the Greek canning sector. *Journal of Food Engineering*, 70(3), pp. 447-454.

Manzini, E. Z. I. O. (2013) Resilient systems and sustainable qualities. *Current: Design Research Journal*, 4, pp. 11-14.

Maon, F., Lindgreen, A. and Vanhamme, J. (2009) Developing supply chains in disaster relief operations through cross-sector socially oriented collaborations: a theoretical framework. *Supply chain management: an international journal*, 14(2), pp. 149-164.

Mari, S. I., Lee, Y. H. and Memon, M. S. (2014) Sustainable and resilient supply chain network design under disruption risks. *Sustainability*, 6(10), pp. 6666-6686.

Mari, S. I., Lee, Y. H., Memon, M. S., Park, Y. S. and Kim, M. (2015) Adaptivity of complex network topologies for designing resilient supply chain networks. *International Journal of Industrial Engineering*, 22(1), pp. 102-116.

Markmann, C., Darkow, I. L. and von der Gracht, H. (2013) A Delphi-based risk analysis—Identifying and assessing future challenges for supply chain security in a multi-stakeholder environment. *Technological Forecasting and Social Change*, 80(9), pp. 1815-1833.

Marsden, T. K., et al (2010) *The New Regulation and Governance of Food: Beyond the Food Crisis*? Routledge, London.

Mason-Jones, R., Naylor, B. and Towill, D. (2000) Lean, agile, or leagile? Matching your supply chain to the marketplace. *Int. J. Prod. Res.*, 38, pp. 4061–4070.

Matopoulos, A., Vlachopoulou, M. and Manthou, V. (2009) Understanding the factors affecting e-business adoption and impact on logistics processes. *Journal of Manufacturing Technology Management*, 20(6), pp. 853-865.

Matopoulos, A., Vlachopoulou, M., Manthou, V. and Manos, B. (2007) A conceptual framework for supply chain collaboration: empirical evidence from the agri-food industry. *Supply Chain Management: An International Journal*, 12(3), pp. 177-186.

Matos, S. and Hall, J. (2007) Integrating Sustainable Development in the Supply Chain: The Case of Life Cycle Assessment in Oil and Gas and Agricultural Biotechnology. *Journal of Operations Management*, 25(6), pp. 1083-1102.

Matos, S. and Hall, J. (2007) Integrating sustainable development in the supply chain: the case of life cycle assessment in oil and gas and agricultural biotechnology. *Journal of Operations Management*, 25(6), pp. 1083–1102.

Mattsson, L. G. and Jenelius, E. (2015) Vulnerability and resilience of transport systems–A discussion of recent research. *Transportation Research Part A: Policy and Practice*, 81, pp. 16-34.

Maurer, H., Doll, C., Chhetri, P., Venner, M. and Kiela, J. (2014) Logistics systems, weather extremes and policy response–a comparison between Europe, the US and Australia. In *Transport Research Arena (TRA) 5th Conference: Transport Solutions from Research to Deployment*.

Mauser, W., Klepper, G., Rice, M., Schmalzbauer, B. S., Hackmann, H., Leemans, R. and Moore, H. (2013) Transdisciplinary global change research: the cocreation of knowledge for sustainability. *Current Opinion in Environmental Sustainability*, 5(3-4), pp. 420–431.

McKinnon, A. (2000) Sustainable distribution: opportunities to improve vehicle loading. *UNEP Industry and Environment*, pp. 27–30.

McKinnon, A. C. (2010) Product-Level Carbon Auditing of Supply Chains: Environmental Imperative or Wasteful Distraction. *International Journal of Physical Distribution & Logistics Management*, 40(1/2), pp. 42–60.

McManus, S., Seville, E., Vargo, J. and Brunsdon, D. (2008) Facilitated process for improving organizational resilience. *Natural Hazards Review*, 9, pp. 81-90.

Meade, N. and Islam, T. (2006) Modelling and forecasting the diffusion of innovation–A 25-year review. *International Journal of forecasting*, 22(3), pp. 519-545.

Meixell, M. and Gargeya, V. (2005) Global supply chain design: a literature review and critique. *Transportaion Research*, 41(6), pp. 531–550.

Melford, R. (2011) The Economic Value of a Sustainable Supply Chain. *Business and Society Review*, 116, pp. 109–143.

Melnyk, S.A.,Closs, D.J., Griffis, S.E., Zobel,C.W., Macdonald,J.R., (2014). Understanding supply chain resilience. Supply Chain Manag.Rev.18(1),34–41.

Melville, N. (2010) INFORMATION SYSTEMS INNOVATION FOR ENVIRONMENTAL SUSTAINABILITY. *MIS Quarterly*, 34(1), pp. 1-21.

Mensah, P., Merkuryev, Y. and Longo, F. (2015) Using ICT in developing a resilient supply chain strategy. *Procedia Computer Science*, 43, pp. 101-108.

Mentzer, J., Foggin, J. and Golicic, S. (2000) Collaboration – The enablers, impediments and benefits. *Supply Chain Management Review*, pp. 52–58.

Merriam, S. (2009) *Qualitative Research: A Guide to Design and Implementation.* San Francisco: Jossey-Bass - a Wiley Print.

Mettänen, P. (2005) Design and Implementation of a Performance Measurement System for a Research Organization. *Production Planning & Control*, 16(2), pp. 178–188.

Mills, J., Schmitz, J. and Frizelle, G. (2004) A strategic review of supply networks. *International Journal of Operations and Production Management*, 24(10), pp. 1012–1036.

Min, H. and Zhou, G. (2002) Supply Chain Modelling: Past, Present and Future. *Computers and Industrial Engineering*, 43, pp. 231-249.

Minsker, B., Baldwin, L., Crittenden, J., Kabbes, K., Karamouz, M., Lansey, K., ... & Rivera, S. (2015). Progress and recommendations for advancing performance-based sustainable and resilient infrastructure design. *Journal of Water Resources Planning and Management*, 141(12), A4015006.

Mohdzain, M., White, A. and Ward, J. (2012) Co-evolution of Supply Chain Strategies and Technologies. *Journal of Enterprise Resource Planning Studies*, pp. 1-9.

Mol, A. (1995) The Re®nement of Production: Ecological Modernization Theory and the Chemical Industry, Cip-data koninklijke bibliotheek, Den Haag.

Mol, A. P. J. (2000) The environmental movement in an era of ecological modernization. *GeoForum*, 31, pp. 45–56.

Moland, A. P. J. and Spaargaren, G. (2005) From additions and withdrawals to environmental flows reframing debates in the environmental social sciences. *Organization & Environment*,18(1), pp. 91–107.

Molina‐Azorín, J. F. and López‐Gamero, M. D. (2014) Mixed methods studies in environmental management research: prevalence, purposes and designs. *Business Strategy and the Environment*.

Molina-Azorin, J. F., Claver-Cortes, E., Pereira-Moliner, J. and Tarı, J. J. (2009) Environmental practices and firm performance: an empirical analysis in the Spanish hotel industry. *Journal of Cleaner Production*, 17, pp. 516-524.

Mollenkopf, D. A., Ruso, I. and Frankel, R. (2007) The returns management process in supply chain strategy. *International Journal of Physical Distribution & Logistics Management*, 37(7), pp. 568-92.

Mollenkopf, D., Closs, D., Twede, D., Lee, S. and Burgess, G. (2005) Assessing the viability of reusable packaging: a relative cost approach. *Journal of Business Logistics*, 26(1), pp. 169-97.

Mont, O. and Leire, C. (2009) Socially responsible purchasing in supply chains: drivers and barriers in Sweden. *Social Responsibility Journal*, 5(3), pp. 388-407.

Moore, M. L. and Westley, F. (2011) Surmountable chasms: networks and social innovation for resilient systems. *Ecology and society*, 16(1), pp. 5.

Muijs, D. (2004) *Doing quantitative research in education: with SPSS.* Gateshead: Athenaeum Press.

Nair, P. R. and Balasubramaniam, O. A. (2010) IT-Enabled Supply Chain Management using Decision Support Systems. *CSI Communications*.

Nakano, M. (2009) A conceptual framework for sustainable manufacturing by focusing on risks in supply chains. In *Advances in Production Management Systems. New Challenges, New Approaches* (pp. 160-167). Springer Berlin Heidelberg.

Natarajarathinam, M., Capar, I. and Narayanan, A. (2009) Managing supply chains in times of crisis: a review of literature and insights. *International Journal of Physical Distribution & Logistics Management*, 39(7), pp. 535-573.

Nawrocka, D. (2008) Environmental supply chain management, ISO 14001 and RoHS, how are small companies in the electronics sector managing? *Corporate Social Responsibility and Environmental Management*, 15, pp. 349–360.

Nawrocka, D. (2008) Inter-organizational use of EMSs in supply chain management: some experiences from Poland and Sweden. *Corporate Social Responsibility and Environmental Management*, 15, pp. 260-269.

Neely, A., Adams, C. and Kennerley, M. (2002), The Performance Prism: the Scorecard.

Ninlawan, C., Seksan, P., Tossapol, K. and Pilada, W. (2010) The implementation of green supply chain management practices in electronics industry. In *Proceedings of the international multiconference of engineers and computer scientists* (Vol. 3, pp. 17-19).

Nooraie, S. V. and Parast, M. M. (2016) Mitigating supply chain disruptions through the assessment of trade-offs among risks, costs and investments in capabilities. *International Journal of Production Economics*, 171, pp. 8-21.

NRC (National Research Council) (2011) *Building community disaster resilience through private–public collaboration*. Committee on private-public sector collaboration to enhance community disaster resilience, geographical science committee. National Research Council. Washington, DC: National Academy of Sciences.

O'Rourke, D. (2014) The science of sustainable supply chains. *Science*, 344(6188), pp. 1124-1127.

O'Brien, E. J., Hajializadeh, D. and Power, R. T. (2015) Quantifying the impact of critical infrastructure failure due to extreme weather events. In *12th International Conference on Applications of Statistics and Probability in Civil Engineering (ICASP12), Vancouver, Canada, 12-15 July, 2015*.

O'Connor, A., O'Brien, E. J. and Hajializadeh, D. (2014, August). Probabilistic analysis of potential impact of extreme weather events on infrastructures. In *Civil Engineering Research in Ireland, Belfast, UK, 28-29 August, 2014*.

Olugu, E. U., Wong, K. Y. and Shaharoun, A. M. (2010) Development of Key Performance Measures for the Automobile Green Supply Chain. *Resources Conservation and Recycling*, 65(6), pp. 567–579.

Omar, A., Sramek, B. D., Myers, M. B. and Mentzer, J. T. (2012) A Global Analysis of Orientation, Coordination, and Flexibility in Supply Chains. *Journal of Business Logistics*, 33(2), pp. 128–144.

Ospina S. & Saz-Carranza, A. (2005). ***Paradox and collaboration in coalition work.*** Annual Meeting of the Academy of Management, “A New Vision of Management In The 21st Century”, August 5-10, 2005. Honolulu, Hawaii, USA.

Pagell, M. and Shevchenko, A. (2014) Why research in sustainable supply chainmanagement should have no future. *Journal of Supply Chain Management*, 1, pp. 44–55.

Pagell, M. and Wu, Z. (2009) Building a More Complete Theory of Sustainable Supply Chain Management Using Case Studies of Ten Exemplars. *Journal of Supply Chain Management*, 45(2), pp. 37–56 .

Palumbi, J. M., Pandolfi, B., Rosen, and J. Roughgarden. 2003. Climate change, human impacts, and the resilience of coral reefs. *Science* 301:929-933.

Papadopoulos, A. M. and Giama, E. (2007).Environmental performance evaluation of thermal insulation materials and its impact on the building, Build. *Environ*, 42, pp. 2178-2187.

Pathak, S. D., Day, J. M., Nair, A., Sawaya, W. J. and Kristal, M. M. (2007) Complexity and adaptivity in supply networks: Building supply network theory using a complex adaptive systems perspective. *Decision Sciences*, 38(4), pp. 547-580.

Pathak, S. D., Wu, Z. and Johnston, D. (2014) Toward a structural view of co-opetition in supply networks. *Journal of Operations Management*, 32(5), pp. 254-267.

Pearson, S. and Benameur, A. (2010) *PRIVACY, SECURITY AND TRUST ISSUES ARISING FROM CLOUD COMPUTING*. Bristol: HP Labs.

Peck, H. (2005) Drivers of Supply Chain Vulnerability: An Integrated Framework. *International Journal of Physical Distribution and Logistics Management*, 35(4), pp. 210-232.

Pellow, D. N., Schnaiberg, A. and Weinberg, A. S. (2000) Advanced industrial countries: Putting the ecological modernisation thesis to the test: The promises and performances of urban recycling. *Environmental Politics*, 9(1), pp. 109-137.

Peppard, J. and Rylander, A. (2006) From value chain to value network: Insights for mobile operators. *European Management Journal*, 24(2-3), pp. 128-141.

Perera, S. S., Bell, M. G. and Bliemer, M. C. (2015, September). Modelling Supply Chains as Complex Networks for Investigating Resilience: An Improved Methodological Framework. In *Australasian Transport Research Forum (ATRF), 37th, 2015, Sydney, New South Wales, Australia*.

Perez-Franco, R., Phadnis, S., Caplice, C. and Sheffi, Y. (2016) Rethinking supply chain strategy as a conceptual system.

Pescaroli, G. and Alexander, D. (2016) Critical infrastructure, panarchies and the vulnerability paths of cascading disasters. *Natural Hazards*, pp. 1-18.

Peters, N. J., Hofstetter, J. S. and Hoffmann, V. H. (2011) Institutional entrepreneurship capabilities for interorganizational sustainable supply chain strategies. *The International Journal of Logistics Management*, 22(1), pp. 52-86.

Pettit, T. J., Croxton, K. L. and Fiksel, J. (2013) Ensuring supply chain resilience: development and implementation of an assessment tool. *Journal of Business Logistics*, 34(1), pp. 46-76.

Pettit, T. J., Fiksel, J. and Croxton, K. L. (2010) Ensuring supply chain resilience: development of a conceptual framework. *Journal of Business Logistics*, 31(1), pp. 1-21.

Pham, D. T., Pham, P. T. N. and Thomas, A. J. (2008) Integrated production machines and systems beyond lean manufacturing. *Journal of Manufacturing Technology Management*, 19(6), pp. 695-711.

Pimm, S. (1991) *The balance of nature?* University of Chicago Press, Chicago, Illinois, USA.

Piotrowicz, W. and Cuthbertson, R. (2015) Performance measurement and metrics in supply chains: an exploratory study. *International Journal of Productivity and Performance Management*, 64(8), pp. 1068-1091.

Piramuthu, S. (2005) Knowledge-based framework for automated dynamic supply chain configuration. *European Journal of Operational Research*, 165, pp. 219–230.

Porter, M. and Reinhardt, F. (2007) A strategic approach to climate. *Harvard Business Review*, 85(1), pp. 22–26.

Potoski, M. and Prakash, A. (2005) Covenants with weak swords: ISO 14001 and facilities' environmental performance. *Journal of Policy Analysis and Management*, 24, pp. 745–769.

Power, D. and Gruner, R. L. (2015) Exploring reduced global standards-based inter-organisational information technology adoption. *International Journal of Operations & Production Management*, 35(11), pp. 1488-1511.

Presley, A., Meade, L. and Sarkis, J. (2007) A strategic sustainability justification methodology for organizational decisions: a reverse logistics illustration. *International Journal of Production Research*, 45, pp. 18-19.

Preuss, L. (2005) Rhetoric and reality of corporate greening: a view from the supply chain management function. *Business Strategy and The Environment*, 14, pp. 123–139.

Prigogine, L. (1984) *Order out of Chaos.* New York: Random House.

Psaraftis, H. and Panagakos, G. (2012) Green Corridors in European Surface Freight Logistics and the SuperGreen Project. *Procedia - Social and Behavioral Sciences*, 48, pp. 1723 – 1732.

Puigjaner, L. and Lainez, J. (2008) Capturing dynamics in integrated supply chain management. *Computers and Chemical Engineering* , 32(11), pp. 2582–2605.

Qazi, A., Quigley, J., & Dickson, A. (2015, March). Supply chain risk management: systematic literature review and a conceptual framework for capturing interdependencies between risks. In Industrial Engineering and Operations Management (IEOM), 2015 International Conference on (pp. 1-13). IEEE.

Qazi, A., Quigley, J., Dickson, A., & Gaudenzi, B. (2015). A New Modelling Approach of Evaluating Preventive and Reactive Strategies for Mitigating Supply Chain Risks. In Computational Logistics (pp. 569-585). Springer International Publishing.

Quist, J. (2007) *Backcasting for a sustainable future: the impact after 10 years.* Eburon, Delft, Netherlands.

Radjou, N., Prabhu, J. and Ahuja, S. (2012) Jugaad innovation: think frugal, be flexible, generate breakthrough growth. San Francisco, US: Jossey-Bass–Wiley.

Rail4Chem EU Project (2013) *Rail4Chem EU Project*. [online]. Available from: http://www.captrain.de/r4c.html [Accessed October 5th 2013].

Rajesh, R. and Ravi, V. (2015) Supplier selection in resilient supply chains: a grey relational analysis approach. *Journal of Cleaner Production*, 86, pp. 343-359.

Rao P. (2002) Greening the supply chain: a new initiative in South East Asia. *International Journal of Operations and Production Management*, 22, pp. 632–655.

Rao, P. and Holt, D. (2005) Do green supply chains lead to competitiveness and economic performance? International *Journal of Operations & Production Management*, 25(9), pp. 898–916.

Ravi, V. and Shankar, R. (2005) Analysis of interactions among the barriers of reverse logistics. *International Journal of Technological Forecasting and Social Change*, 72(8), pp. 1011-1029.

Ravi, V., Shankar, R. and Tiwari, M. K. (2005) Analyzing alternatives in reverse logistics for end-of-life computers: ANP and balanced scored approach. *Computers & Industrial Engineering*, 48, pp. 327-56.

References

Rehman, M. A. and Shrivastava, R. (2011) AN INNOVATIVE APPROACH TO EVALUATE GREEN SUPPLY CHAIN MANAGEMENT (GSCM) DRIVERS BY USING INTERPRETIVE STRUCTURAL MODELING (ISM). *International Journal of Innovation and Technology Management*, 8(2), pp. 315–336.

Reinmoeller, P. and VanBaardwijk, N., (2005). The link between diversity and resilience. MIT Sloan Manag.Rev.46(4), 61–65.

Reitan, M. (1998) Ecological modernisation and "Realpolitik": ideas, interests and institutions. *Environmental Politics*, 7(2), pp. 1–16.

Rennings, K. (2000) Redefining innovation—eco-innovation research and the contribution from ecological economics. *Ecological economics*, 32(2), pp. 319-332.

Revell, A. and Rutherfoord, R. (2003) UK environmental policy and the small firm: broadening the focus. *Business Strategy and the Environment*, 12(1), pp. 26.

Rice, J. and Caniato, F. (2003) Building a secure and resilient supply network. *Supply Chain Management Review*, pp. 22–30.

Rivera, J. (2004) Institutional pressures and voluntary environmental behavior in developing countries: evidence from the Costa Rican hotel industry. *Society and Natural Resources*, 17, pp. 779–797.

Roberts, S. (2003) Supply Chain Specific? Understanding the Patchy Success of Ethical Sourcing Initiatives. *Journal of Business Ethics*, 44(2/3), pp. 159–170.

Roe E. (1998) *Taking complexity seriously: policy analysis, triangulation and sustainable development*. Boston (MA): Kluwer Academic Publishers.

Roehrich, J., Lewis, M. and George, G. (2014) Are public-private partnerships a healthy option? A systematic review. *Social Science & Medicine*, 113, pp. 110-119.

Rogers, E. M. (1962) Diffusion of Innovations (first edition). Glencoe: Free Press. ISBN 0-612-62843-4.

Rogers, E. M. (1995) *Diffusion of Innovation*. New York: Free Press.

Roh, J. J., Min, H. and Hong, P. (2011) A co-ordination theory approach to restructuring the supply chain: an empirical study from the focal company perspective. *International Journal of Production Research*, 49(15), pp. 4517–4541.

Romano, P. and Vinelli, A. (2001) Quality management in a supply chain perspective: strategic and operative choices in a textile-apparel network. *International Journal of Operations and Production Management*, 21(4), pp. 446–460.

Rose, A. (2011) Resilience and sustainability in the face of disasters. *Environ. Innov. Soc*, 1, pp. 96–100.

Rosenzweig. P. M. and Singh, J. V. (1991) Organizational environments and the multinational enterprise. *The Acad. Manage. Rev*, 16(2), pp. 340–361.

Rosič, H., Bauer, G. and Jammernegg, W. (2009) A framework for economic and environmental sustainability and resilience of supply chains. In: Rapid modelling for increasing competitiveness, pp 91–104

Ross, T., "Billion Dollar U.S. Weather Disasters 1980-2003," National Climate Data Center, Asheville NC (October 2003).

Rowbottom, U., Bruntock, C. and Hannesson, H. (2011) Three Steps to Achieve Supply Chain Resilience. *Supply Chain Magazine*, pp. 20-24.

Rowley, J. (2002) Using case studies in research. *Manage. Res. News*, 25(1), pp. 16–27, 2002.

Salam, M. A. (2011) Creating Sustainable Supply Chain Through Green Procurement. *IJBIT*, 3(3), pp. 84-89.

Saldanha, J. P., Mello, J. E., Knemeyer, A. M. and Vijayaraghavan, T. A. S. (2015) Implementing supply chain technologies in emerging markets: an institutional theory perspective. *Journal of Supply Chain Management*, 51(1), pp. 5-26.

Sanchez Rodrigues, V., Stantchev, D., Potter, A., Naim, M. and Whiteing, A. (2008) Establishing a transport operation focused uncertainty model for the supply chain. *International Journal of Physical Distribution & Logistics Management*, 38(5), pp. 388-411.

Sanchez, L. G., Wenzel, H. and Jorgensen, M. S. (2004) Models for defining LCM, monitoring LCM practice and assessing its feasibility. *Greener Management International*, 45, pp. 9–20.

Sanders, N. R. (2007) An empirical study of the impact of e-business technologies on organizational collaboration and performance. *Journal of Operations Management*, 25(6), pp. 1332-1347.

Sarkis, J. (2001) Benchmarking for agility. *Benchmarking: An International Journal*, 8(2), pp. 88-108.

Sarkis, J. (2003) A strategic decision framework for green supply chain management. *Journal of cleaner production*, 11(4), pp. 397-409.

Sarkis, J. (2009) A boundaries and flows perspective of green supply chain management. GPMI working Papers. No-7, October. 2009.

Sarkis, J., Gonzalez-Torre, P. and Adenso-Diaz, B. (2010) Stakeholder pressure and the adoption of environmental practices: the mediating effect of training. *Journal of Operations Management*, 28(2), pp. 163–176.

Sarkis, J., Zhu, Q. and Lai, K. H. (2011) An organizational theoretic review of green supply chain management literature. *International Journal of Production Economics*, 130(1), pp. 1-15.

Sarkis, J., Zhu, Q. and Lai, K.-H. (2010) Review of Green Supply Chain Management Literature. *Clark University Article Series*.

Saunders, L. W., Kleiner, B. M., McCoy, A. P., Lingard, H., Mills, T., Blismas, N. and Wakefield, R. (2015) The effect of early supplier engagement on social sustainability outcomes in project-based supply chains. *Journal of Purchasing and Supply Management*, 21(4), pp. 285-295.

Savaskan, R. C., Bhattacharya, S. and Van Wassenhove, L. N. (2004) Closed loop supply chain models with product remanufacturing. *Management Science*, 50, pp. 239–252.

Savo, V., Lepofsky, D., Benner, J. P., Kohfeld, K. E., Bailey, J. and Lertzman, K. (2016) Observations of climate change among subsistence-oriented communities around the world. *Nature Climate Change*, 6(5), pp. 462-473.

SCEnAT 2016. www.scenat.com

SCEnAT LCA Report, 2015 http://www.scenat.com/wp-content/uploads/2012/07/ 2579_Low_Carbon_ Report_Nov2011_1322663482.pdf

SCEnAT LCA Report. (2015). Guidelines. http://www.scenat.com/wp-content/uploads/2012/07/2579 _Low_ Carbon_Report_Nov2011_1322663482.pdf

SCEnAT Tool Report, 2015 http://www.scenat.com/wp-content/uploads/2012/07/ Makingthe Change_ Jan2012_ Final_1328210548.pdf

SCEnAT Tool Report. (2015). Manual. http://www.scenat.com/wp-content/uploads/2012/07/ Makingthe Change_Jan2012_Final_1328210548.pdf

SCENAT. (2013) SCENAT (online) Available from: http://www.sheffield.ac.uk/lscm/scenat [Accessed on October 2013]

Scheffer, M., Carpenter, S., Foley, J.A., Folke, C. and Walker, B. (2001) Catastrophic shifts in ecosystems. *Nature*, 418, pp. 591–596.

Scheffer, M., Westley, F. and Brock, W. (2003) Slow response of societies to new problems: Causes and costs. *Ecosystems*, 6, pp. 493–502.

Schipper, L. and Fulton, L. (2003) Carbon dioxide emissions from transportation: trends, driving forces and forces for change. In D. Hensher, & K. Button, *Handbooks in Transport 4:Handbook of Transport and the Environment* (pp. 203–226). Elsevier.

Scholten, K., Scott, P.S., Fynes,B., (2014). Mitigation processes – antecedents for building supplychain resilience. Supply Chain Manag.:Int.J.19(2),211–228.

Schotter, A. and Goodsite, M. E. (2013) Interdisciplinary perspectives on competitive climate strategy in multinational corporations. *Thunderbird International Business Review*, 55(6), pp. 629-632.

Schumpeter, J.A. (1950) *Capitalism, socialism and democracy*. New York: Harper & Row.

Searcy, D. L. and Mentzer, J. T. (2003) A framework for conducting and evaluating research. *Journal of Accounting Literature*, 22, pp. 130–167.

SEETAC. (2012) *South East European Transport Axis Cooperation*. Trieste, Italy: Central European Initiative - CEI.

Setia, P. and Patel, P. C. (2013) How information systems help create OM capabilities: Consequents and antecedents of operational absorptive capacity. *Journal of Operations Management*, 31(6), pp. 409-431.

Seuring, S. (2004) INDUSTRIAL ECOLOGY, LIFE CYCLES, SUPPLY CHAINS: DIFFERENCES AND INTERRELATIONS. *Business Strategy and the Environment*, 13, pp. 306–319.

Seuring, S. (2005) Case study research in supply chains – An outline and three examples.

Seuring, S. (2011) Supply chain management for sustainable products–insights from research applying mixed methodologies. *Business Strategy and the Environment*, 20(7), pp. 471-484.

Seuring, S. (2013) A review of modeling approaches for sustainable supply chain management. *Decision Support Systems*, 54(4), pp. 1513–1520.

Seuring, S. A. (2008) Assessing the rigor of case study research in supply chain management. *Supply Chain Management: An International Journal*, 13(2), pp. 128-37.

Seuring, S. and Gold, S. (2012) Conducting content-analysis based literature reviews in supply chain management. *Supply Chain Management: An International Journal*, 17(5), pp. 544-555.

Seuring, S. and Müller, M. (2008) Core Issues in Sustainable Supply Chain Management – a Delphi Study. *Business Strategy and the Environment*, 17, pp. 455–466.

Seuring, S., Sarkis, J., Müller, M. and Rao, P. (2008) Sustainability and Supply Chain Management: An Introduction to the Special Issue. *Journal of Cleaner Production*, 16(15), pp. 1545-1551.

Shah, R. (2006) An interview with James P. Womack: Future of process management and implications for management students. *POMS Chronicle*, 13(1), pp. 5–9.

Shang, K. C., Lu, C. S. and Li, S. (2010). A taxonomy of green supply chain management capability among electronics-related manufacturing firms in Taiwan. *Journal of environmental management*, 91(5), pp. 1218-1226.

Shankar, D. (2013) *Sustainable Freight Transportation at XEROX India.* New Delhi: Next Generation Sustainable Freight Transportation Workshop.

Sharma, S. (2000). Managerial interpretations and organizational context.

Shen, L., Olfat, L., Govindan, K., Khodaverdi, R. and Diabat, A. (2013) A fuzzy multi criteria approach for evaluating green supplier's performance in green supply chain with linguistic preferences. *Resources, Conservation and Recycling*, 74, pp. 170-179.

Shepherd, C. and Günter, H. (2010) Measuring supply chain performance: current research and future directions. In *Behavioral Operations in Planning and Scheduling* (pp. 105-121). Springer Berlin Heidelberg.

Sheu, J. B., Chou, Y. H. and Hu, C. C. (2005) An integrated logistics operational model for green-supply chain management. *Transportation Research Part E: Logistics and Transportation Review*, 41(4), pp. 287-313.

Shi, G., Baldwin, J. and Koh, S. C .L. (2012) Conceptualising green supply chain management: A structural model of drivers, practices and performance. *Supply Chain Management: An International Journal*, 17(1) .

Shrivastava, P., Ivanaj, S. and Persson, S. (2013) Transdisciplinary study of sustainable enterprise. Bus. *Strategy Environ*, 22(4), pp. 230-244.

Shukla, A. C., Deshmukh, S. G. and Kanda, A. (2010) Flexibility and Sustainability of Supply Chains: Are They Together? *Global Journal of Flexible Systems Management*, 11(1 /2), pp. 25-38.

Siavalas, F., Bota, E., Solomon, A. and Ketikidis, P. (2016) Quintuple Helix Co-creation as a Pillar for Responsible (Environmentally and Socially) Entrepreneurship. *In 9th International Conference for Entrepreneurship, Innovation and Regional Development*, 23-24 June, Bucharest, Romania.

Siddhartha, & Sachan, A. (2016) Review of agile supply chain implementation frameworks. *International Journal of Business Performance and Supply Chain Modelling*, *8*(1), pp. 27-45.

Simatupang, T. and Sridharan, R. (2002) The collaborative supply chain. *International Journal of Logistics Management*, 13(1), pp. 15–30.

Simon, H. A. (1974) The organization of complex systems. In: HH Pattee, editor. Hierarchy theory: the systems. New York: Braziller. pp. 3-27.

Simpson, C. (2011) Victoria's secret revealed in child picking Burkina Faso Cotton.Bloomberg, http://www.bloomberg.com/news/articles/2011-12-15/victoria-s-secret-revealed-in-child-picking-burkina-faso-cotton

Sivakumar, N., Balasubramanya, A. and Sundaresan, C. N. (2012) Sustainable Supply Chain Excellence:A Biomimetic Perspective. *The IUP Journal of Supply Chain Management*, 9(1), pp. 21-41.

Slack, N., Chambers, S. and Johnston, R. (2004) *Operation Management 4th Edition.* London: Prentice-Hall.

Smart Specialization. (2013) *Smart Specialization*. [online]. Available from: http://ec.europa.eu/research/regions/index_en.cfm?pg=smart_specialisation [Accessed October 16th 2013].

SMART-CM EU Project (2013) *SMART-CM EU Project*. [online]. Available from: http://www.smart-cm.eu/ [Accessed October 6th 2013].

SMARTFREIGHT Project (2013) *SMARTFREIGHT Project*. [online]. Available from: http://www.smartfreight.info/ [Accessed October 17th 2013].

SMARTFUSION EU Project (2013) *SMARTFUSION EU Project*. [online]. Available from: http://www.smartfusion.eu/ [Accessed October 16th 2013].

Smith, A. and Stirling, A. (2010) The politics of social-ecological resilience and sustainable socio-technical transitions. *Ecology and Society*, 15(1), pp. 11.

Smith, A. D. and Rupp, W. T. (2015) Supply chain integration and innovation in a global environment: case studies of best business practices. *International Journal of Logistics Systems and Management*, 22(3), pp. 313-330.

Snyder, L. V., Atan, Z., Peng, P., Rong, Y., Schmitt, A. J. and Sinsoysal, B. (2015) OR/MS models for supply chain disruptions: A review. *IIE Transactions*, pp. 1-21.

Solér, C., Bergström, K. and Shanahan, H. (2010) Green supply chains and the missing link between environmental information and practice. *Business Strategy and the Environment*, 19(1), pp. 14-25.

Solér, C., Bergström, K., & Shanahan, H. (2010) Green Supply Chains and the Missing Link Between Environmental Information and Practice. *Business Strategy and the Environment* , 14–25.

Solomon, A. and Ketikidis, P. (2016) Empirical evidence for Quintuple Helix Co-Creation Towards Solving the Challenge of Low Carbon and Resilient Supply Chains under Innovative Theoretical framework Convergence. In *XIV International Triple Helix Conference 2016*, 25-27 September, Heidelberg, Germany.

Solomon, A. P. Ketikidis and A. Choudhary, 2014, "Leveraging Green Freight Transportation Through an ICT Modelling and Simulation Framework", International Conference on Green Supply Chain (GSC14), 25-27 June, Arras, France

Solomon, A. P. Ketikidis, A. Choudhary, and A. Baresel-Bofinger. 2014, "Drivers and Barriers to Green Freight Transportation: Industry Evidence from UK and India", 18th Panhellenic Logistics Conference, 18-19 November, Thessaloniki, Greece.

Solomon, A., Choudhary, A., & Ketikidis, P. H. 2015. Drivers and Barriers to Green Freight Transportation: Industry Evidence from UK and India. In *20th International Symposium in Logistics*. Bologna, Italy.

Solomon, A., Ketikidis, P. H., & Koh, S. C. L. (2016). Towards a new Theoretical Foundation Convergence as a Key Enabler of a Low Carbon Economy: Practical evidence for Quintuple Helix Co-Creation Towards Solving the Challenge of Low Carbon and Resilient Supply Chains. In *3rd International Conference on Green Supply Chain, 10-13 July*. London, UK.

Solomon, A., Ketikidis, P., & Choudhary, A. (2012) Effective Knowledge Extraction and Utilisation for Efficient Supply Chain Risk Management. *5th Balkan Conference Of Informatics* . Novi Sad: ACM.

Solomon, A., Koh, S. C. L., & Ketikidis, P. H. 2015. Drivers and Barriers to the Implementation of Green and Resilient Freight Transportation in South East Europe. In *10th South East European Doctoral Student Conference*. Thessaloniki, Greece.

Soltani, E., Azadegan, A., Liao, Y. Y. and Phillips, P. (2011) Quality performance in a global supply chain: finding out the weak link. *International Journal of Production Research*, 49(1), pp. 269–293.

Sondeijker, S., Geurts, J., Rotmans, J. and Tukker, A. (2006) Imagining sustainability: the added value of transition scenarios in transition management. *Foresight*, 8(5), pp. 15-30.

Soosay, C. A. and Hyland, P. (2015) A decade of supply chain collaboration and directions for future research. *Supply Chain Management: An International Journal*, 20(6), pp. 613-630.

Soundararajan, V. and Brown, J. A. (2014) Voluntary governance mechanisms in global supply chains: Beyond CSR to a stakeholder utility perspective. *Journal of Business Ethics*, pp. 1-20.

Spaargaren, G. (1996) *The ecological modernization of production and consumption*. Ph.D. Thesis, Wageningen University.

Spence, L. and Bourlakis, M. (2009) The Evolution from Corporate Social Responsibility to Supply Chain Responsibility: The Case of Waitrose. *Supply Chain Management: An International Journal*, 14(4), pp. 291-302.

Spillan, J. E. and Crandall, W. (2002) Crisis planning in the nonprofit sector: should we plan for something bad if it may not occur? *Southern Business Review*, 27(2), pp. 18-29.

Srivastava, S. (2007) Green supply-chain management: a state-of-the-art literature review. *International Journal of Management Reviews*, 9(1), pp. 53-80.

Staley, S. and Warfield, J. (2007) Enterprise integration of product development data: systems science in action . *Enterprise Information Systems*, 1(3), pp. 269–285.

Stapleton, P., Glover, M. and Davis, S. (2001) *Environmental Management Systems: an Implementation Guide for Small and Medium Sized Organizations.* Ann Arbor: NSF International.

Stecke, K. E. and Kumar, S. (2009) Sources of supply chain disruptions, factors that breed vulnerability, and mitigating strategies. *Journal of Marketing Channels*, 16(3), pp. 193-226.

Steensma, H. K. and Corley, K. G. (2000) On the performance of technology-sourcing partnerships: the interaction between partner interdependence and technology attributes. *Academy of Management Journal*, 43(6), pp. 1045-67.

Stern, P. C., Ebi, K. L., Leichenko, R., Olson, R. S., Steinbruner, J. D. and Lempert, R. (2013) Managing risk with climate vulnerability science. *Nature Climate Change*, 3(7), pp. 607-609.

Stevens, P. E. (1996) Focus groups. *Public health nursing*, 13(3), pp. 170-176.

Stevenson, J. R. (2014) *Organisational resilience after the Canterbury eartchquakes: A contextual approach*. PhD Thesis, University of Canterbury.

Stevenson, M. and Busby, J. (2015) An exploratory analysis of counterfeiting strategies: Towards counterfeit-resilient supply chains. *International Journal of Operations & Production Management*, 35(1), pp. 110-144.

Stock, J. R., Boyer, S. L. and Harmon, T. (2010) Research opportunities in supply chains.

Stonebraker, P., Goldhar, J. and Nassos, G. (2009) Weak links in the supply chain: measuring fragility and sustainability. J. Manuf. Technol. Manag. 20(2), pp. 161-177.

StoraEnso Project (2013*) StoraEnso Project*. [online]. Available from: http://www.storaenso.com/ [Accessed October 14th 2013].

Storer, M., Hyland, P., Ferrer, M., Santa, R. and Griffiths, A. (2014) Strategic supply chain management factors influencing agribusiness innovation utilization. *The International Journal of Logistics Management*, 25(3), pp. 487-521.

Strauss, A. and Corbin, J. (1990) *Basics of Qualitative Research: Grounded Theory Procedures and Techniques.* Beverly Hills: Sage Publications.

SUPERGREEN EU Project (2013) *SUPERGREEN EU Project*. [online]. Available from: http://www.supergreenproject.eu/ [Accessed October 17th 2013].

Supply Chain Council (2005) *Supply chain operations reference model: Overview of SCOR version 7.0.* Washington: Supply Chain Council.

Surminski, S. (2013) Private-sector adaptation to climate risk. *Nature Climate Change*, 3(11), pp. 943-945.

Swafford, P., Ghosh, S. and Murthy, N. (2008) Achieving supply chain agility through IT integration and flexibility. *International Journal of Production Economics*, 116(2), pp. 288–297.

Sweeney, E., Grant, D. B. and Mangan, D. J. (2015) The implementation of supply chain management theory in practice: an empirical investigation. *Supply Chain Management: An International Journal*, 20(1), pp. 56-70.

Tabrizi, B. H. and Razmi, J. (2013) Introducing a mixed-integer non-linear fuzzy model for risk management in designing supply chain networks. *Journal of Manufacturing Systems*, 32(2), pp. 295-307.

Tajbakhsh, A. and Hassini, E. (2015) Performance measurement of sustainable supply chains: a review and research questions. *International Journal of Productivity and Performance Management*, 64(6), pp. 744-783.

Taleb, N. N. (2011) Antifragility - or - The property of disorder-loving systems. Available online: http://www.edge.org/q2011/q11_3.html#taleb. Accessed on 31 August 2014.

Talib, F., Rahman, Z. and Qureshi, M. N. (2011) A study of total quality management and supply chain management practices. *International Journal of Productivity and Performance Management*, 60(3), pp. 268–288.

Talley, W. (2003) Environmental impacts of shipping. In D. Hensher, & K. Button, *Handbooks in Transport 4: Handbook of Transport and the Environment* (279–292). Elsevier.

Tan, K. C., Lyman, S. B. and Wisner, J. D. (2002) Supply chain management: a strategic perspective. *International Journal of Operations and Production Management*, 22(6), pp. 614–631.

Tang, C. S. (2006) Robust strategies for mitigating supply chain disruptions. *International Journal of Logistics: Research and Applications,* 9(1), pp. 33-45.

Tang, O., Cao, D. and Schvaneveldt, S. J. (2008) Institutional perspectives on supply chain management. *International Journal of Production Economics*, 115(2), pp. 261.

Tate, W. L., Ellram, L. M. and Kirchoff, J. F. (2010) Corporate Social Responsibility Reports: A Thematic Analysis Related to Supply Chain Management. *Journal of Supply Chain Management: A Global Review of Purchasing & Supply*, 46(1), pp. 19–44.

Taticchi, P., Garengo, P., Nudurupati, S. S., Tonelli, F. and Pasqualino, R. (2015) A review of decision-support tools and performance measurement and sustainable supply chain management. *International Journal of Production Research,* 53(21), pp. 6473-6494.

Taticchi, P., Tonelli, F. and Pasqualino, R. (2013) Performance measurement of sustainable supply chains: a literature review and a research agenda. *International Journal of Productivity and Performance Management*, 62(8), pp. 782-804.

Taylor, G. R. (2005) *Integrating Quantitative and Qualitative Methods in Research.* USA: University Press of America.

Testa, F. and Iraldo, F. (2010) Shadows and lights of GSCM (Green Supply Chain Management): determinants and effects of these practices based on a multi-national study. *Journal of Cleaner Production*, 18(10), pp. 953-962.

Teuscher, P., Grüninger, B. and Ferdinand, N. (2006) Risk management in sustainable supply chain management (SSCM): lessons learnt from the case of GMO-free soybeans. *Corporate Social Responsibility and Environmental Management*, 13(1), pp. 1–10.

Theodorakioglu, Y., Gotzamani, K. and Tsiolvas, G. (2006) Supplier management and its relationship to buyers' quality management. *Supply Chain Management*, 11(2), pp. 148–159.

Thomas, D. R. (2006) A general inductive approach for analyzing qualitative evaluation data. *American journal of evaluation*, 27(2), pp. 237-246.

Thompson, T. M., Rausch, S., Saari, R. K. and Selin, N. E. (2014) A systems approach to evaluating the air quality co-benefits of US carbon policies. *Nature Climate Change*, 4(10), pp. 917-923.

Thorpe, J. and Fennell, S. (2012) Climate Change Risks and Supply Chain Responsibility: How should companies respond when extreme weather affects small-scale producers in their supply chain?. *Oxfam Policy and Practice: Private Sector*, 9(1), pp. 39-62.

Thorpe, R., Holt, R., Macpherson, A. and Pittaway, L. (2005) Using knowledge within small and medium-sized firms: a systematic review of the evidence. International *Journal of Management Reviews*, 7(4), pp. 257-81.

Thun, J. and Muller, A. (2008) An empirical analysis of green supply chain management in the German automotive industry. *Business Strategy and the Environment*, 19(2), pp. 119–132.

Tian, Y., Govindan, K. and Zhu, Q. (2014) A system dynamics model based on evolutionary game theory for green supply chain management diffusion among Chinese manufacturers. *Journal of Cleaner Production*, 80, pp. 96-105.

Tibben-Lembke, R. S. (2002) Life after death: reverse logistics and the product life cycle. *International Journal of Physical Distribution & Logistics Management*, 32, pp. 223–244.

Tihanyi, L., Graffin, S. and George, G. (2014) Rethinking governance in management research. *Academy of Management Journal*, 57(6), pp. 1535-1543.

Torabi, S. A., Namdar, J., Hatefi, S. M. and Jolai, F. (2015) An enhanced possibilistic programming approach for reliable closed-loop supply chain network design. *International Journal of Production Research*, pp. 1-30.

Touati, N. and Jost, V. (2012) *On green routing and scheduling problem.* http://arxiv.org/pdf/1203.1604.pdf: Technical report.

Tranfield, D., Denyer, D. and Smart, P. (2003) Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, 14(3), pp. 207-22.

TransNew (2009) *Support for realising New Member and Associated States' potentials in transport research: Transport research capability in the countries and a regional report South Balkans and Mediterranean.* TransNew.

Transport Research (2009) *Freight Transportation.* Brussels : The EU Commission: Transport Research Knowledge Centre.

Tsoulfas, G. T. and Pappis, C. P. (2006) Environmental principles applicable to supply chains design and operation. *Journal of Cleaner Production*, 14(18), pp. 1593-602.

Tukker, A. and Cohen, M. (2004) Industrial ecology and the automotive transport system: Can Ford shape the future again? *J. Ind. Ecology*, 8(3), pp. 14–17.

Turner, I. (2010) Vulnerability and resilience: Coalescing or paralleling approaches for sustainability science? *Glob. Environ. Chang*, 20, pp. 570–576.

UN (2008) *South Eastern Europe Disaster Risk Mitigation and Adaptation Initiative.* Geneva: United Nations .

Urciuoli, L., Mohanty, S., Hintsa, J. and Gerine Boekesteijn, E. (2014) The resilience of energy supply chains: A multiple case study approach on oil and gas supply chains to Europe. *Supply Chain Management: An International Journal*, 19(1), pp. 46-63.

Vachon S. (2007) Green supply chain practices and the selection of environmental technologies. *International Journal of Production Research*, 45(18/19), pp. 4357–79.

Van den Bergh, J. C., Truffer, B. and Kallis, G. (2011) Environmental innovation and societal transitions: Introduction and overview. *Environmental innovation and societal transitions*, 1(1), pp. 1-23.

Van der Brugge, R. and Van Raak, R. (2007) Facing the adaptive management challenge: insights from transition management. *Ecology and Society*, 12(2), pp. 33.

Van Der Vegt, G., Essens, P., Wahlstrom, M. and George, G. (2015) Managing Risk and Resilience. *Academy of Management Journal*, 58(4) , pp. 971.

Van Hemel, C. and Cramer, J. (2002) Barriers and stimuli for ecodesign in SMEs. *Journal of Cleaner Production*, 10, pp. 439-453.

Varsei, M., Soosay, C., Fahimnia, B. and Sarkis, J. (2014) Framing sustainability performance of supply chains with multidimensional indicators. *Supply Chain Management: An International Journal*, 19(3), pp. 242-257.

Vaughan, G., Methven, J., Anderson, D., Antonescu, B., Baker, L., Baker, T. P., ... & Choularton, T. W. (2015) Cloud banding and winds in intense European cyclones: Results from the DIAMET project. *Bulletin of the American Meteorological Society*, 96(2), pp. 249-265.

Venkatesh, V., Morris, M. G., Davis, G. B. and Davis, F. D. (2003) User acceptance of information technology: Toward a unified view. *MIS quarterly*, pp. 425-478.

Verghese, K. and Lewis, H. (2007) Environmental innovation in industrial packaging: a supply chain approach. International Journal of http://dx.doi.org/10.1080/00207540701450211

Vogelstein, R. (2015) 'Innovation in development', CFR Development Channel, 21 July.

Vonderembrese, M. et al (2006) Designing supply chains: towards theory development. *International Journal of Production Economics*, 100(2), pp. 223–238.

Voss, M. D. and Williams, Z. (2013) Public–private partnerships and supply chain security: C-TPAT as an indicator of relational security. *Journal of Business Logistics*, 34(4), pp. 320-334.

Vurro, C., Russo, A. and Perrini, F. (2009) Shaping Sustainable Value Chains: Network Determinants of Supply Chain Governance Models. *Journal of Business Ethics*, 90, pp. 607–621.

Wadhwa, S. and Rao, K. (2004) A unified framework for manufacturing and supply chain flexibility. *Global J. Flex. Sys. Manag*, 5, pp. 15–22.

Wagner, S. M. and Bode, C. (2006) An empirical investigation into supply chain vulnerability. *Journal of Purchasing and Supply Management*, 12, pp. 301-312.

Walch, C. (2015) Expertise and policy-making in disaster risk reduction. *Nature Climate Change*, 5(8), pp. 706-707.

Walke, R. C., Topkar, V. and Kabiraj, S. (2010) Managing Risk for Green Supply Chain Management: Competitive Strategies for Manufacturing Companies. *Skyline Business Journal*, 6(1), pp. 1-10.

Walker, B. H, Holling, C .S., Carpenter, S. R. and Kinzig, A. (2004) Resilience, adaptability and transformability in social–ecological systems. *Ecology and Society*, 9(2), pp. 5.

Walker, B. H., Anderies, J. M., Kinzig, A. P. and Ryan, P. (2006) Exploring resilience in social-ecological systems through comparative studies and theory development: introduction to the special issue. *Ecology and Society*, 11(1), pp. 12.

Walker, H. and Preuss, L. (2008) Fostering sustainability through sourcing from small businesses: public sector perspectives. *Journal of Cleaner Production*, 16(15), pp. 1600-9.

Walker, H., Di Sisto, L. and McBain, D. (2008) Drivers and barriers to environmental supply chain management practices: lessons from the public and private sectors. *Journal of Purchasing and Supply Management*, 14(1), pp. 69–85.

Walker, W. et al (2003) Defining uncertainty: a conceptual basis for uncertainty management in model based decision support. *Integrated Assessment*, 4(1), pp. 5–17.

Wang, C. and Ahmed, P. (2007) Dynamic capabilities: A review and research agenda. *International Journal of Management Reviews*, 9(1), pp. 31–51.

Wang, E. T., Tai, J. C. and Wei, H. L. (2006) A Virtual Integration Theory of Improved Supply-Chain Performance. *Journal of Management Information Systems*, 23(2), pp. 41–64.

Wang, W. Y., Chan, H. K. and Pauleen, D. (2010) Aligning business process reengineering in implementing global supplychain systems by the SCOR model. *International Journal of Production Research*, 48(19), pp. 5647–5669.

Wedawatta, G., Ingirige, B. and Amaratunga, D. (2010) Building up resilienc e of construction sector SMEs and their supply chains to extreme weather events. *International Journal of Strategic Property Management*, 14(4), pp. 362-375.

WEEE (2003), Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003.
WEF. (2013) *Building Resilience in Supply Chains.* WEF.

Whadhwa, S., Saxena, R. and Chan, F. T. (2008) Framework for flexibility in dynamic supply chain management. *International Journal of Production Research*, 46(6), pp. 1373–1404.

White, A. D. and Mohdzain, M. B. (2009) An Innovative Model of Supply Chain Management: A Single Case Study in the Electronics Sector. *International Journal of Information Technology and Management*, 8(1), pp. 69-84.

Wibeck, V., Dahlgren, M. A. and Öberg, G. (2007) Learning in focus groups an analytical dimension for enhancing focus group research. *Qualitative research*, 7(2), pp. 249-267.

Widmer, R., Oswald-Krap, H., Sinha-Khetriwal, D., Schnellmann, M. and Böni, H. (2005) Global perspectives on e-waste. *Environmental Impact Assessment Review*, Vo25(5), pp. 436-58.

Wieland, A.,Wallenburg, C.M., (2013). The influence of relational competencies on supply chain resilience: a relational view. Int.J.Phys.Distrib.Logist.Manag.43 (4), 300–320.

Wilhelm, M. M., Blome, C., Bhakoo, V. and Paulraj, A. (2016) Sustainability in multi-tier supply chains: Understanding the double agency role of the first-tier supplier. *Journal of Operations Management*, 41, pp. 42-60.

Winebrake, J., Corbett, J., Falzarano, A., Hawker, J., Korfmacher, K., Ketha, S. et al. (2008) Assessing Energy, Environmental, and Economic Tradeoffs in Intermodal Freight Transportation. *Journal of the Air & Waste Management Association*, 58, pp. 1004–1013.

Winn, M. I., Kirchgeorg, M., Griffiths, A., Linnenluecke, M. K. and Günther, E. (2010) Impacts from climate change on organizations: a conceptual foundation. *Business Strategy and the Environment*, 20(3), pp. 157-173.

Winter, M. and Knemeyer, A. M. (2013) Exploring the integration of sustainability and supply chain management: Current state and opportunities for future inquiry. *International Journal of Physical Distribution & Logistics Management*, 43(1), pp. 18-38.

Wolf, J. (2011) Sustainable Supply Chain Management Integration: A Qualitative Analysis of the German Manufacturing Industry. *Journal of Business Ethics* , 102, pp. 221–235.

Wong, C. W., Lai, K. H., Lun, Y. V. and Cheng, T. C. E. (2016) Closed Loop Supply Chain. In *Environmental Management* (pp. 127-140). Springer International Publishing.

Wright, E. O. (2015) Sociological limitations of the climate change encyclical. *Nature Climate Change*, 5(10), pp. 902-903.

Wright, R. and Elcock, K. (2006) The RoHS and WEEE directives: environmental challenges for the electrical and electronic products sector. *Environmental Quality Management*, 15(4), pp. 9-24.

Wu, Z. and Pullman, M. E. (2015) Cultural embeddedness in supply networks. *Journal of Operations Management*, 37, pp. 45-58.

Xavier, W. G., Bandeira-de-Mello, R. and Marcon, R. (2014) Institutional environment and Business Groups' resilience in Brazil. *Journal of Business Research*, 67(5), pp. 900-907.

Xu, L. (2000) The contribution of systems sciences to information systems research. *Systems Research and Behavioral Science*, 17, pp. 105–116.

Yalabik, B., Petruzzi, N. C. and Chhajed, D. (2005) An integrated product returns model with logistics and marketing coordination. *European Journal of Operational Research*, 161, pp. 162–182.

Yang, J. (2012) A Structural Model of Supply Chain Performance in an Emerging Economy. *International Journal of Production Research*, 50 (14), pp. 3895–3903.

Yin, R. K. (2009) Case Study Research: Design and Methods (Applied Social Research Methods), 4th ed., Sage, Newbury Park, CA.

Yin, R.K. *Case Study Research: Design and Methods* (Applied Social Research Methods Series, vol. 5), 3rd ed. Newbury Park, CA: Sage, 2002.

York, R. and Rosa, E. A. (2003) Key challenges to ecological modernization theory institutional efficacy, case study evidence, units of analysis, and the pace of eco-efficiency. *Organization & Environment*, 16(3), pp. 273-288.

Yu L. C. and Hui H. Y. (2008) An empirical study on logistics services provider, intention to adopt green innovations. Journal of Technology. *Management and Innovation*, 3(1), pp. 17-26.

Yu, J., Welford, R. and Hills, P. (2006) Industry responses to EU WEEE and ROHS directives: Perspectives from China. *Corporate Social Responsibility and Environmental Management*, 13(5), pp. 286–299.

Yung, W. K. C., Chan, H. K., Choi, A .C. K., Yue, T. M. and Mazhar, M. I. (2008) An environmental assessment framework with respect to the Requirements of Energy-using Products Directive. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, 222(5), pp. 643-51.

Zhang, L., Wang, S., Li, F., Wang, H., Wange, L. and Tan, W. (2011) A few measures for ensuring supply chain quality. *International Journal of Production Research*, 49(1), pp. 87–97.

Zhao, K., Kumar, A., Harrison, T. P. and Yen, J. (2011) Analyzing the Resilience of Complex Supply Network Topologies against Random and Targeted Disruptions. *IEEE Systems Journal*, 5(1), pp. 28-39.

Zhu, J. and Ruth, M. (2013) Exploring the resilience of industrial ecosystems. *Journal of environmental management*, 122, pp. 65-75.

Zhu, Q. and Geng, Y. (2013) Drivers and barriers of extended supply chain practices for energy saving and emission reduction among Chinese manufacturers. *Journal of Cleaner Production*, 40, pp. 6-12.

Zhu, Q. and Liu, Q. (2010) Eco-design planning in a Chinese telecommunication network company: benchmarking its parent company. *Benchmarking: An International Journal*, 17 (3), pp. 363–377.

Zhu, Q. and Sarkis, J. (2004) Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operations Management*, 22(3), pp. 265–289.

Zhu, Q. and Sarkis, J. (2006) An inter-sectoral comparison of green supply chain management in China: drivers and practices. *Journal of Cleaner Production*, 14(5), pp. 472-86.

Zhu, Q., Geng, Y., Fujita, T. and Hashimoto, S. (2010) Green supply chain management in leading manufacturers: Case studies in Japanese large companies. *Management Research Review*, 33(4), pp. 380-392.

Zhu, Q., Sarkis, J. and Geng, Y. (2005). Green supply chain management in China: pressures, practices and performance. *International Journal of Operations & Production Management*, 25(5), pp. 449-468.

Zhu, Q., Sarkis, J. and Lai, K. H. (2008) Confirmation of a measurement model for green supply chain management practices implementation. *International Journal of Production Economics*, 111(2), pp. 261-273.

Zhu, Q., Sarkis, J. and Lai, K. H. (2012) Green supply chain management innovation diffusion and its relationship to organizational improvement: An ecological modernization perspective. *Journal of Engineering and Technology Management*, 29(1), pp. 168-185.

Zoback, M. L. (2014) “Epicenters” of resilience. *Science*, 346(6207), pp. 283-283.

Appendix A – Research Design: Stage one – Interviews

Dear participant,

This interview is part of my PhD project which aims to propose a quintuple helix implementation framework for resilient and green freight transportation in South East Europe.

With 23% of global carbon-dioxide emissions originating from the transportation industry, it is imperative that significant emphasis and effort be squarely put in controlling its environmental impact. Moving freight creates traffic congestion, air pollution, noise and consumes fuel. Furthermore, risk vulnerabilities and disruptions especially in the road freight are becoming more and more frequent and they negatively impact on the environment.

One of the key disruption sources in the road freight infrastructure consists of severe environmental phenomena (heavy winds, rainfalls, snow, icy roads, floods, fog) which are increasing in frequency and strength in South East Europe. However, overcoming such threats in an uncertain and vulnerable environment is not always possible. To this end, enterprises have recognized the importance of supply chain resilience (the ability of a system to return in the initial state or in a better one after a disruption took place) which has become a central theme in logistics (80% of the companies are interested in resilience). Despite this, companies should take into account the environmental impact of the specific chosen resilience strategy in order to become environmentally friendly.

In this context, this interview will cover the following specific items:

1. Overview on your company.
2. What bad weather conditions did your road freight transportation vehicles have encountered and what problems has your company encountered.
3. What resilience strategies did your company employ and whether there was any consideration about environmental impact during those strategies ?
4. What key performance indicators are being monitored for measuring your business success ?
5. What are the general green practices and technologies that your company employs ?
6. What are your readiness and intentions to be environmentally sustainable and to utilize technology for achieving green and resilient road freight transportation during disruptions.
7. How do you interact with the social stakeholders (i.e, government, society, environmental organizations, innovators)

The interview will be recorded on an audio device as well as written notes will be taken. There are no 'right' or 'wrong' answers, your participation is voluntary and you are free to withdraw from the study without prior notice at any given time. All the responses and the data you provide will be kept confidential and anonymous, and will be analyzed solely for statistical purposes in the context of this project to develop scientific articles and technical reports. The total completion time of this interview will be no longer than 35 minutes.

For any issues or queries related to the project please contact me at asolomon@seerc.org

1. To proceed with the interview please read carefully the following sentences and tick the relevant boxes as appropriate (then sign below, where indicated)

☐ I confirm that I have read and understand the terms and condition for participation in the interview.

☐ I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason and with no foreseeable consequences.

☐ I understand that the interview will be undertaken by the principal investigator (Adrian Solomon)

☐ I agree that the interview will be recorded on an audio device and that notes will be taken during the interview.

☐ I agree that my data gathered in this study may be stored (after it has been anonymised) in a secure storage facility and will be destroyed five years after the study ends.

☐ I acknowledge that this interview has been approved by the appropriate departments.

Name:………………………………………..

Date:…………………………………………

Signature: …………………………………

Questions to be asked

Question 0 – Overall profile of the company

Question 1 - Discussion on the bad weather conditions encountered

Question 2 – What was the resulted problem of that weather condition in terms of time, cost, environmental impact, fuel consumption and other wastes.

Question 3 – What did you do to recover (what strategies)?

Question 4 – When recovering from the disruption, did you consider any environmental issues and how to mitigate them. If yes, what and how ? If not, is it because there is no such policy in your company ? Or because you are unaware of such concerns ?

Question 5 – Did you use any technology to assist you with decision making while devising the recovery strategy ? Who uses this technology and how ?

Question 6 – What KPIs do you use to monitor your business goals ? Which business goals are the most important for your company ? Are there any green business goals ?

Question 7 – What green practices does your company implement ? (a list of practices will be provided). Would you consider implementing green practices when dealing with the resilience process ? What drivers and barriers do you foresee ?

Question 8 – Are you aware of any technological solutions that will assist you in achieving green and resilient freight transportation ? What type of technological solution would you require in this context ?

Question 9 – How do you interact with other industries, government, innovators, society, environmental organizations ?

Appendix B – Research Design: Stage two – Semi-structured survey

Dear participant,

This interview is part of my PhD project which aims to propose a quintuple helix implementation framework for resilient and green freight transportation in South East Europe.

With 23% of global carbon-dioxide emissions originating from the transportation industry, it is imperative that significant emphasis and effort be squarely put in controlling its environmental impact. Moving freight creates traffic congestion, air pollution, noise and consumes fuel. Furthermore, risk vulnerabilities and disruptions especially in the road freight are becoming more and more frequent and they negatively impact on the environment.

One of the key disruption sources in the road freight infrastructure consists of severe environmental phenomena (heavy winds, rainfalls, snow, icy roads, floods, fog) which are increasing in frequency and strength in South East Europe. However, overcoming such threats in an uncertain and vulnerable environment is not always possible. To this end, enterprises have recognized the importance of supply chain resilience (the ability of a system to return in the initial state or in a better one after a disruption took place) which has become a central theme in logistics (80% of the companies are interested in resilience). Despite this, companies should take into account the environmental impact of the specific chosen resilience strategy in order to become environmentally friendly.

In this context, this survey will cover the following specific items:

1. Overview on your company.
2. What bad weather conditions did your road freight transportation vehicles have encountered and what problems has your company encountered.
3. What resilience strategies did your company employ and whether there was any consideration about environmental impact during those strategies ?
4. What key performance indicators are being monitored for measuring your business success ?
5. What are the general green practices and technologies that your company employs ?
6. What are your readiness and intentions to be environmentally sustainable and to utilize technology for achieving green and resilient road freight transportation during disruptions.

Please read each of the following items carefully and mark the answer (by ticking or circling) what best represents your beliefs and experiences. There are no 'right' or 'wrong' answers, you participation is voluntary and you are free to withdraw from the study without prior notice at any given time, all the responses and the data you provide will be kept confidential and anonymous, and will be analyzed solely for statistical purposes in the context of this project to develop scientific articles and technical reports. The total completion time of this survey will be no longer than 25-30 minutes.

Even though some questions seem to be similar, please provide an answer to all of them.

For any issues or queries related to the project please contact us at asolomon@seerc.org

To proceed with survey completion please read carefully the following sentences and tick the relevant boxes as appropriate.

☐ I confirm that I have read and understood the terms and condition for participation in the study.

☐ I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason and with no foreseeable consequences.

☐ I agree to take part in the above study and related training sessions.

☐ I agree that my data gathered in this study may be stored (after it has been anonymised) in a secure storage facility and will be destroyed five years after the study ends.

SECTION A. Background information

1. In which country is your business based?

○ a) Romania

○ b) Serbia

○ c) FYROM

○ d) Bulgaria

○ e) Greece

○ f) Slovenia

○ g) Kosovo

2. Which business sector best describes your company?

○ a) Freight transportation

- b) General logistics
- c) 3PL/4PL
- d) Production/Manufacturing with integrated transportation
- e) Retail/commerce with integrated transportation
- f) Other (please specify)

3. How many employees does your company have?

- a) Under 25
- b) 26 to 50
- c) 51 to 250
- d) More than 251

4. What is your company's annual turnover?

- a) Under £1,000,000
- b) £ 1,000,000 to £ 5,000,000
- c) £ 5,000,001- to £ 10,000,000
- d) £ 10,000,001- to £ 20,000,000
- e) More than £ 20,000,000

5. What is your gender?

- a) Male
- b) Female

6. What is your age group?

- a) 18 to 25 years
- b) 26 to 35 years
- c) 36 to 49 years
- d) 50 to 64 years
- e) 65 years or over

7. What is the highest level of qualification you have gained?

- a) Vocational qualification
- b) Bachelor's degree (e.g., BA/BSc/BEng)
- c) Master's degree
- d) PhD

d) Other (please specify)

____

8. What is your current position in the company?

a) Owner or co-founder/owner

b) Senior manager

c) Middle manager

d) Environmental manager

9. Did your company adopt any type of technology in the last five years ?

a) Yes

b) No

10. Are you the nominated person responsible for environmental issues in your company?

a) Yes

b) No

SECTION B. WEATHER CONDITIONS THAT CAUSE DISRUPTIONS

10. To what extent do the following weather conditions cause disruptions in your transportation system ?

1 = No disruption at all, 2 = Disruptions with limited negative impact, 3 = Neutral, 4 = Disruptions with negative impact, 5 = Disruptions with critical negative impact

	1	2	3	4	5
Heat waves					
Cold waves					
Heavy rains					
Snowfall					
Icy roads					
Strong winds					

Floods					
Thunder storms					
Blizzards					
Fog					
Other natural disasters that cause road blocks and/or road degradations that might impact on your transportation Please mention in the fields below:					

SECTION C. OUTCOMES OF WEATHER DISRUPTIONS

11. What outcomes/losses has your company encountered as an outcome of a weather induced disruption in your transportation system ?

1 = Strongly disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly agree

	1	2	3	4	5	In what weather conditions have you encountered this loss/outcome ? (the weather conditions can be seen in the previous question).
Loss of revenues/profits						
Delays in deliveries						
Missed deliveries						
Inventory inconsistencies						
Overall coordination issues						
Damage of goods						
Longer distances to travel in order to avoid the disruption						
Decrease of vehicle speeds						
Damage to the transportation						

vehicles						
Client complaints						
Staff complaints						
Extra cost that needed to be paid to the drivers						
Increased fuel consumption						
Increased lubricant/oil consumption						
Increased overall truck degradation						
Increased CO_2 emissions						
Congestion						
Safety issues related to the involved staff						
Damage to the transportation infrastructure						

12. If technologies for overcoming and/or mitigating these disasters were available and at low cost, would you use them ?

1 = Definitely not, 2 = Not necessarily, 3 = Neutral, 4 = Maybe, 5 = Definitely yes

1	2	3	4	5

SECTION D. KEY PERFORMANCE INDICATORS

13. What are the most important Economic and Operational key performance indicators in measuring your successes ?

1 = Not at all important, 2 = not important, 3 = not thinking about it, 4 = important, 5 = extremely important

	1	2	3	4	5
Cost per TKM					
Focal firm net profit					

Total transportation time					
On-time deliveries					
Service frequency					
Transportation speed					
Reliability of the transport					
Loading/Unloading time					
Distance to be covered					
Truck loading efficiency/storage					
Access to modal shift					
Efficiency of the resilience mechanism during disruptions					
Efficiency of the resilience mechanism for avoiding disruptions					
Number of trips required to ship a product					
Interaction time with a different truck or additional transportation mean when it comes to freight joining and/or spreading.					
Number of stops required					
Total fuel consumption					
Customer satisfaction					
Safety of the transportation					
Corridor availability and capacity					

14. What are the most important Environmental key performance indicators in measuring your successes?

1 = Not at all important, 2 = not important, 3 = not thinking about it, 4 = important, 5 = extremely important

	1	2	3	4	5
Total energy used					
Total CO_2 emissions per TKM					
Engine standards					

Driver behaviour in terms of driving efficiency					
Overall land waste resulted from transportation					
Mileage in kilometres (or, alternatively, fuel use in litres; or, alternatively, vehicle movements)					
Total amount of environmental penalties and fines					

SECTION E. CURRENT USE OF GREEN PRACTICES

15. To what extent does your company implement (or considers implementing) each of the following initiatives ?

1 = Not considering it, 2 = Planning to consider it, 3 = Considering it currently, 4 = Initiating implementation, 5 = Implementing successfully

	N/A	1	2	3	4	5
Environmental Management System (e.g., ISO14001)						
Total quality environmental management						
Subscription to ISO14001 certification						
Energy/environmental audits						
Designs of products for reduced consumption of material/energy						
Designs of products for reuse, recycle, recovery of material, component parts						
Changes of processes to reduce air and/or odor pollution						
Changes of processes to reduce water and/or solid waste						
Changes of processes to reduce consumption of hazardous/toxic/harmful materials						
Changes of processes to improve energy efficiency						
Redesign supply chain/logistics components for greater environmental efficiency						
Provides environmental training and education for employees						

Senior management commitment to implementing environmental measures						
Mid-level management support for the implementation of environmental measures						
Provides design specifications to suppliers that include environmental requirements						
Cooperates with suppliers to achieve environmental objectives						
Provides suppliers with written environmental requirements						
Asks suppliers to commit to waste and/or energy reduction goals						
Requires that suppliers have implemented an environmental management system						
Conducts environmental evaluation of suppliers						

16. If technologies for overcoming and/or mitigating these disasters were available and at low cost, that would also take into account environmental issues, would you use them ?

1 = Definitely not, 2 = Not necessarily, 3 = Neutral, 4 = Maybe, 5 = Definitely yes

1	2	3	4	5

17. Our major buyers/customers…

1 = Strongly disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly agree

	1	2	3	4	5
Incorporate environmental considerations in selecting their supplies and suppliers					
Request us to have an environmental management system (e.g. ISO 14001)					
Have interest in greening the supply chain					

Provide us with environmental training, education, or technical assistance					
Request information to assure our environmental compliance					
Provide us with detailed, written environmental requirements (e.g., product specification)					

SECTION F. DRIVERS AND BARRIERS TO THE ADOPTION OF GREEN PRACTICES IN TRANSPORTATION

18. How important are the following drivers for the implementation of environmental measures and improvements in your company?

1 = Not at all important, 2 = not important, 3 = not thinking about it, 4 = important, 5 = extremely important

	1	2	3	4	5
a) My company will gain money on the long term					
b) My company will reduce waste, consume less resources and thus become more efficient					
c) My company will have an added value towards my clients as compared to my competitors by having better products and processes					
d) My company care about the environment and society overall and I intend to help reducing the pollution and get public acceptance					
e) My company believes that clients appreciate more our green certifications					
f) My company believes that I will pay lower taxes by complying to the regulations					
g) My company believes this is the next trend in logistics					

h) My company believes that the existing technology and the support for it makes it easy for me to implement GFT					
i) My company believes that the governmental support for green companies is significantly higher.					
j) My company believes that it is a very important need for recovering in a green manner after a disruption takes place.					

19. How important are the following barriers in impeding your company's efforts for environmental improvements?

1 = Not at all important, 2 = not important, 3 = not thinking about it, 4 = important, 5 = extremely important

	1	2	3	4	5
a) My company suffers from lack of commitment					
b) The goals of my company do not include becoming green					
c) The cost of initial investment is too high and the return on investment too lengthy, while governmentally supported access to funds is limited.					
d) The decision making variables in my company will completely over-represent the green decision factor.					
e) It is very hard to control the diversity of external carriers (3PL, 4PL) when devising a general strategy for green transportation.					
f) The technology adoption rate in terms of GFT practices is very limited due to the untrained staff and their acceptance issues.					
g) It will be very hard for my company to devise a proper staff compensation/training scheme or to introduce a new					

job related to green issues.					
h) There is limited access to information related to GFT implementation as well as limited governmental support.					
i) The transportation area is very wide and cross-border, land use and additional tensions in practice adjustment may appear as well as extra costs to mitigate these risks.					
j) There are limited facilities for intermodal transportation, aspect which is critical for implementing proper GFT.					

SECTION G. RESILIENCE MECHANISMS AND STRATEGIES

20. How important are the following resilience mechanisms for your company (consider these strategies in the moment when a disruption takes place in your transportation system as well as after)?

1 = Not at all important, 2 = not important, 3 = not thinking about it, 4 = important, 5 = extremely important

	1	2	3	4	5
Reliance on soft technology such as decision support systems and additional software in order to reach a new supply chain reconfiguration mechanism during disruptions					
Reliance on hard technology such (hardware) in order to reach a better and more efficient new supply chain reconfiguration mechanism					
Interventions at the energy consumption and emission levels in order to mitigate the environmental impact while reconfiguring the system					
Alteration of existing processes in order to achieve improved outcomes					
Improvement of future distribution mechanisms in order to avoid already encountered business inefficiencies					
Improvement of future distribution mechanisms in order to avoid already encountered environmental inefficiencies					
Mechanisms to raise awareness about the importance of environmental sustainability within the company					

Employment of specialized staff for achieving resilience in a green manner					
Relocation of goods					
Better supply chain design and/or partnerships to enable shorter transportation routes					
Better supply chain design and/or partnerships to enable modal shift					
Implementation of risk management strategies					
Implementation of real time weather forecasting solutions to help your company better plan the transportation routs and avoid disruptions					
A knowledge management mechanism that will help my company store and update all the knowledge gained through disruptions and that will automatically consolidate after each new disruption encountered.					

21. How much do you agree or disagree with the following statements related to the mechanisms and technologies mentioned in question No. 20. ?

1 = Strongly disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly agree

	1	2	3	4	5
a) Using those mechanisms and technologies would make my company gain money on the long term					
b) Using those mechanisms and technologies would make my company reduce waste, consume less resources and thus become more efficient					
c) Using those mechanisms and technologies would make my company have an added value towards my clients as compared to my competitors by having better products and processes					
d) Using those mechanisms and technologies would make my company care more about the environment					

SECTION H. PERCEPTIONS

22. How much do you agree or disagree with the following statements?

1 = Strongly disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly agree

	1	2	3	4	5
Implementing green freight transportation initiatives will not be difficult					
Implementing resilience mechanisms for freight transportation will not be difficult					
Implementing resilience mechanisms together with green initiatives for freight transportation will not be difficult					
Resilient and green freight transportation initiatives will be in line with the company's corporate social responsibility goals					
Resilient and green freight transportation initiatives will be in line with the company's values					
It would be easy to implement resilient and green freight transportation initiatives in my company					
Our company is aware of Resilient and green freight transportation initiatives					
Our company is willing to participate in resilient and green freight transportation initiatives					
Our company has managers who have interest in resilient and green freight transportation initiatives					
Our company expects environmental and economic benefits from resilient and green freight transportation initiatives					
Our company would support the implementation and utilizations of resilient and green freight transportation technologies					
Our company would become more competitive in the international market by implementing resilient and green freight transportation initiatives					
Our company would become competitive in the local market by implementing resilient and green freight transportation initiatives					

23. If technologies for overcoming and/or mitigating these disasters were available and at low cost, would you use them ?

1 = Definitely not, 2 = Not necessarily, 3 = Neutral, 4 = Maybe, 5 = Definitely yes

1	2	3	4	5

24. Would you like to stay informed ?

☐ I would like to receive the aggregated results of this survey

☐ I would like to participate in any related future event

Please input your email if you checked one of the above boxes:

THANK YOU VERY MUCH FOR COMPLETING THIS SURVEY !

IN CASE OF FURTHER QUESTIONS PLEASE CONTACT Mr Adrian Solomon – osolomon1@sheffield.ac.uk

Appendix C – Research Design: Stage three – Focus groups

Dear participant,

This focus group is part of my PhD project which aims to propose a quintuple helix implementation framework for resilient and green freight transportation in South East Europe.

With 23% of global carbon-dioxide emissions originating from the transportation industry, it is imperative that significant emphasis and effort be squarely put in controlling its environmental impact. Moving freight creates traffic congestion, air pollution, noise and consumes fuel. Furthermore, risk vulnerabilities and disruptions especially in the road freight are becoming more and more frequent and they negatively impact on the environment.

One of the key disruption sources in the road freight infrastructure consists of severe environmental phenomena (heavy winds, rainfalls, snow, icy roads, floods, fog) which are increasing in frequency and strength in South East Europe. However, overcoming such threats in an uncertain and vulnerable environment is not always possible. To this end, enterprises have recognized the importance of supply chain resilience (the ability of a system to return in the initial state or in a better one after a disruption took place) which has become a central theme in logistics (80% of the companies are interested in resilience). Despite this, companies should take into account the environmental impact of the specific chosen resilience strategy in order to become environmentally friendly.

Even more, research and practice has shown a high demand for quintuple helix co-creation where institutions (government, innovators, industry, society and environmental organizations) should be bridged into a smoothly governed integration & coordination towards becoming the key influencers of eco-innovation adoption across societies. Shortly, it is deemed that a resilient and green freight transportation against weather-induced disruptions can be achieved only through a working quintuple helix mesosystem (social system). However, in the current stage, there is limited evidence of such a concept in Greece.

In this context, this focus group (round-table discussion) will cover the following specific items:

1. Overview on your institution and its roles in regional (sustainable) development.
2. Multilateral confirmation and exploration of the current regional & national findings [attached].
3. How can RGFT/RGSCM be implemented at the quintuple helix mesosystem level ?
4. What are the main drivers and barriers from the point of view of each stakeholder towards the proper implementation of RGFT/RGSCM ?
5. What would drive you towards co-creation with the other quintuple helix stakeholders ?
6. Who do you think should lead the co-creation ?
7. How would you agree with each of the CRQs [attached] ?

For any issues or queries related to the project please contact us at asolomon@seerc.org

To proceed with survey completion please read carefully the following sentences and tick the relevant boxes as appropriate.

☐ I confirm that I have read and understood the terms and condition for participation in the study.

☐ I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason and with no foreseeable consequences.

☐ I agree to take part in the above study and related training sessions.

☐ I agree that my data gathered in this study may be stored (after it has been anonymised) in a secure storage facility and will be destroyed five years after the study ends.

Appendix D – Research Design: Stage three – Modelling

The following diagrams shows the core (high level) aspects that have been used in order to model the supply chain of the companies before, during and after weather-induced disruptions (by applying one of the confirmed strategies). The following examples are related to one of the company that has been modelled:

OPERATION VOLTAGE	220-240V AC/50-60Hz
MAXIMUM POWER CONSUMPTION	2.7W / 3VA
BATTERIES (Ni-Cd)	3.6V/0.6Ah
INDICATIONS- CONTROLS	Battery charge indication LEDs, TEST button
CHARGING TIME	24 h
MINIMUM AUTONOMUS DURATION	1.5 h
ILLUMINATION SOURCE	12 white LED's
ILLUMINATION (230V AC/emergency)	35lm / 85lm
DEGREES OF COVER PROTECTION	IP 20
PRODUCED IN ACCORDANCE WITH	EN 60598-1 EN 60598-2-22 EN 55015 EN 61547 EN 61000-3-2 EN 61000-3
OPERATION TEMPERATURE RANGE	5 to 40 °C
RELATIVE HUMIDITY	Up to 95%
CONSTRUCTION MATERIALS	Bayblend FR3010, transparent polycarbonate
EXTERNAL DIMENSIONS	240 x 90 x 44 mm
TYPICAL WEIGHT	345gr.
GUARANTEE	3 years (1 year for the battery)

Short Description	Full Description	Quantity	Comment
Set of wall plugs and screws	C1022 MOUNTING PLAG AND SCREW 4*40 SET OF 2	1	
Connector	CON.F15112004G1UCBNB00 2,54mm 022547620404 BL21/762/04Z	1	
Jumper	Jumper WEITRONIC 165-201	1	
Battery	A-926 Ni-Cd BATTERY 3,6V600mAh	1	
Cardboard box	CARTON GR-8_LED/220914 PRINTED 1*20	0,05	
Box	Box GR-8LEDS 595-223/041214 (4 colours)	1	
Paper A3	TECHNICAL INSTRUCTIONS	0,25	
Label 1	LABELS 16*8	4	
Label 2	STICKER OF PAPER 90*65	0,1	
PLASTIC PART 534	PLASTIC COVER FOR GR-8/leds	1	
PLASTIC PART 535	REFLECTOR	1	
PLASTIC PART 536	Plastic Case	1	
Sticker	Sticker 174x74mm for GR-8/leds	3	
PCB- LEDs	PCB+SMD GR-8/led _leds / 2501159 X	1	BOM of PCB- LEDs***
PCB- Main	PCB FOR GR-8/led_main / 3107149 X	1	BOM of PCB- Main**

BOM of PCB- Main**			
Short Description	**Full Description**	**Quantity**	**Comment**
Capasitor	CAPACITOR 470μF/16V 5x TAPE RoHS	1	
Choc block	Choc block XY300V-A-02P 300-021-1600 MVE152-5-V AK100/2DS-5 MSG02001	1	
Test Button	TEST BUTTON TC-205 (TSAC1)	1	
Male Header	MALE HEADER 2,54mm 1*40 HEIGHT 11,54mm HNS 1*40 02254000761140	3	
Connector 1	Connector PND 2*2 4π 144-16-04-10	1	
Connector 2	Connector LHA-02-TS 022546410-02A NS25-W2P Male 2p Vertical 2204-1021 (A)	1	
PCB Main (PCB+SMD)	PCB+SMD GR-8/led _main / 3007149 X	1	BOM of PCB-Main (PCB+SMD)*
Trasformer 1	TRANSFORMER 9651A027 230V/6V 1,5VA (44085)	1	

Main PCB = production of 8 units				
Phases	Type of machine	Power of machines	Completion time	Energy consumption
1st	FlexLink	500W	1sec	0,139Wh
2nd	SI-P950	2kW	30sec	16,7Wh
3rd	SI-G200 AA	1kW	74sec	20,6Wh
4th	SI-G200 BB	1kW	61sec	16,9Wh
5th	HOTFLOW 2/12	48kW	360sec	4800Wh

		Time(sec)/part	Number of employees
	From the Warehouse (Raw materials and plastic components) to the Production	10	2
Production stages	SMT Machines	35	1
	Injection Machines	40	1
	conventional raw materials	60	2
	Assembly	190	5
	From the Production to the Warehouse (Final products)	10	2

Number of units per batch = 500

Bridge Rectifier SMD 2	S40 0,8A BRIDGE RECTIFIER SMD (TAPE) (551.40S) RoHS	1	
Integrated circuit 1	LM324DR2G OP AMP ONSEMI,,,LM324DT ST REEL RoHS	1	
Integrated circuit 2	LM431ACMX (NSC-TEXAS), TL431ACDT (STM) SO8 RoHS (REEL)	1	
FUSE 1	SMT FUSE 3A SF-1206S300-2 1206 (0468003.NR LITTLEFUSE)	1	
PCB GR-8Leds_MAIN	PCB GR-8Leds_MAIN/3007149 RoHS HAL	1	(raw material)

The **BOM of the LEDs PCB** of GR-8/leds is presented on the following table:

BOM of PCB- LEDs***			
Short Description	**Full Description**	**Quantity**	**Comment**
Resistor SMD 1	RESISTOR SMD 1Ω 1% 1206 (RC1206FR-131RL YAGEO) ±100PPM ROHS	12	
GREEN LEDs	LED SMD WU-2-200SGC-UR GREEN	2	
WHITE LEDs	LED SMD WHITE 67-21S/KK2C-H5757B5L12934Z2/2T/EU(AW) EVERLIGHT min 2400mcd 120° COOL WHITE PLCC2	12	
PCB GR-8_LEDS	PCB GR-8_LEDS/2501159 RoHS HAL	1	(raw material)

Plastic Part 534 = production of 2 units				
Phases	Type of Machine	Power of machine	Completion time	Energy consumption
One phase	HTF200X	30,95kW	36sec	309,5Wh

$$P_{534unit} = \frac{309{,}5Wh}{2} = 154{,}75Wh$$

Plastic Part 535 = production of 2 units				
Phases	Type of Machine	Power of machine	Completion time	Energy consumption
One phase	HTF360X	56,65kW	35sec	550,76Wh

$$P_{535unit} = \frac{550{,}76Wh}{2} = 275{,}38Wh$$

Plastic Part 536 = production of 2 units				
Phases	Type of Machine	Power of machine	Completion time	Energy consumption
One phase	HTF150X	22.35kW	38sec	236Wh

$$P_{536unit} = \frac{236Wh}{2} = 118Wh$$

$$TP_{plastic} = P_{534unit} + P_{535unit} + P_{536unit} = 430{,}13Wh$$

Appendix E – Conference publications & dissemination

2016

- Solomon, A., Ketikidis, P. H., & Koh, S. C. L. (2016). Towards a new Theoretical Foundation Convergence as a Key Enabler of a Low Carbon Economy: Practical evidence for Quintuple Helix Co-Creation Towards Solving the Challenge of Low Carbon and Resilient Supply Chains. In *3rd International Conference on Green Supply Chain, 10-13 July*. London, UK.
- Solomon, A., Koh, S.C.L., Ketikidis, P.H. 2016. Towards a new Theoretical Foundation Convergence as a Key Enabler of a Low Carbon Economy: Practical evidence for Quintuple Helix Co-Creation Towards Solving the Challenge of Low Carbon and Resilient Supply Chains. *Journal of Cleaner Production*.
- Solomon, A, Ketikidis, P. 2016. Empirical evidence for Quintuple Helix Co-Creation Towards Solving the Challenge of Low Carbon and Resilient Supply Chains under Innovative Theoretical framework Convergence. In *XIV International Triple Helix Conference 2016*, 25-27 September, Heidelberg, Germany.
- Siavalas, F., Bota, E., Solomon, A., Ketikidis, P. 2016. Quintuple Helix Co-creation as a Pillar for Responsible (Environmentally and Socially) Entrepreneurship. *In 9th International Conference for Entrepreneurship, Innovation and Regional Development*, 23-24 June, Bucharest, Romania.
- Ketikidis, P., Solomon, A., Hajrizi, B. 2016. Focusing on the Triple Helix: a strategy for ensuring continuity and growth in crisis struck countries. *In University – Industry Interaction Conference*, 1-3rd June, Amsterdam, Netherlands.

2015

- Solomon, A., Choudhary, A., & Ketikidis, P. H. 2015. Drivers and Barriers to Green Freight Transportation: Industry Evidence from UK and India. In *20th International Symposium in Logistics*. Bologna, Italy.
- Solomon, A., Koh, S. C. L., & Ketikidis, P. H. 2015. Drivers and Barriers to the Implementation of Green and Resilient Freight Transportation in South East Europe. In *10th South East European Doctoral Student Conference*. Thessaloniki, Greece.

2014

- A. Solomon, P. Ketikidis, A. Choudhary, and A. Baresel-Bofinger. 2014, “Drivers and Barriers to Green Freight Transportation: Industry Evidence from UK and India”, 18th Panhellenic Logistics Conference, 18-19 November, Thessaloniki, Greece.
- Lazuras, L., Ketikidis, P. H., & Solomon, A. 2014. Adoption of Smart Logistics: From Testbeds to Successful Implementation. In *18th Panhellenic Logistics Conference*. Thessaloniki, Greece.
- A. Solomon, P. Ketikidis and A. Choudhary, 2014, “Leveraging Green Freight Transportation Through an ICT Modelling and Simulation Framework”, International Conference on Green Supply Chain (GSC14), 25-27 June, Arras, France.

- P. Ketikidis, T. Taneva and A. Solomon, 2014, “Boosting the Innovation Potential in the Metropolitan Area of Thessaloniki Through Triple Helix Interactions”, International Conference for Entrepreneurship, Innovation and Regional Development (ICEIRD14), 5-6 June, Nicosia, Cyprus.

2013

- A. Solomon, A. Choudhary. 2013. “Next generation sustainable freight transportation”. NEX-GIFT Project Workshop. New Delhi, India 8th August.

2012

- A. Solomon, P. Ketikidis and A Choudhary, “A Knowledge Based Decision Support System for Supply Chain Risk Management”, 2012, Published in the Proceedings of the 3rd Annual Conference of the European Decision Sciences Institute, Istanbul, Turkey (submitted). (I received bursary for participation to this conference from the Conference Chair)
- A. Solomon, P. Ketikidis and A. Choudhary, “Effective Knowledge Extraction and Utilization for Efficient Supply Chain Risk Management”, 2012, Published in the Proceedings of the 5th Balkan Conference on Informatics, Novi Sad, Serbia.

Appendix F – Data analysis tables

Table 29: Stage two - cross-country weather induced disruptions

		Heat Waves	Cold Waves	Heavy Rains	Snowfall	Icy Roads
Country	BG	1.31	1.37	3.59	4.3	4.38
	FYROM	1.2	1.55	3.4	3.55	3.55
	GR	1.18	1.25	3.16	3.36	3.69
	RO	1.48	1.54	3.37	4.4	4.29
	SLO	1.28	1.18	3.62	3.96	4.21
	SRB	1.21	1.39	3.57	4.36	4.36
		Strong Winds	**Floods**	**Thunder Storms**	**Blizzards**	**Fog**
Country	BG	3	2.12	2.42	4.02	4.02
	FYROM	2.45	2	2.12	3.78	3.78
	GR	2.61	2.1	1.34	2.55	2.55
	RO	3.05	2.1	2.12	4.32	4.32
	SLO	2.59	1.96	2.13	3.02	3.02
	SRB	3.03	2.06	2.34	3.88	3.88

Table 30: Stage two - business outcomes per weather induced disruptions

	Delays in delivery	Overall coordination issues	Client complains	Loss of revenue	Increased fuel consumption	Extra cost	Decrease of speed
Heavy Rains	62%	70%	50%	52%	45%	43%	55%
Snowfall	**87%**	72%	**55%**	**87%**	**76%**	66%	**88%**
Icy Roads	85%	70%	52%	83%	74%	**67%**	85%

Blizzards	65%	72%	50%	59%	42%	40%	55%
Fog	70%	**75%**	52%	58%	67%	49%	79%
	Increased CO2 emission	**Inventory inconsistencies**	**Congestion**	**Longer distance**	**Missed deliveries**	**Staff complains**	
Heavy Rains	55%	68%	82%	45%	58%	35%	
Snowfall	52%	70%	**89%**	**76%**	60%	**45%**	
Icy Roads	50%	**73%**	88%	74%	**75%**	31%	
Blizzards	55%	71%	82%	42%	61%	30%	
Fog	**62%**	72%	88%	67%	62%	32%	

Table 31: Stage two - most problematic disruptions & their outcomes

	Snow fall	**Fog**	**Icy Roads**
Delays in delivery	X (87%)		
Overall coordination issues		X (75%)	
Client complaints	X (55%)		
Loss of revenue	X (87%)		
Increased fuel consumption	X (76%)		
Extra cost	X (67%)		
Increased CO2 emissions		X (62%)	
Inventory inconsistencies			X (73%)
Congestion	X (89%)		
Longer distances	X (76%)		
Missed deliveries			X (75%)
Staff complains	X (45%)		

Table 32: Stage two - cross-country homogeneity of KPIs

Economic and Operational KPIs | Country	BG	FYROM	GR	RO	SLO	SRB
Cost per TKM	3.843373	3.95	3.981818	4.147727	3.78125	3.969697
Focal Firm Profit	3.963855	3.9	4.018182	3.965909	4.0625	4.090909
Total Time	3.987952	3.6	4.109091	4.090909	3.90625	3.939394
On Time Deliveries	3.084337	3.5	2.945455	2.829545	3.28125	3
Service Frequency	3.012048	2.75	3.163636	3.136364	2.71875	3.545455
Transportation Speed	3.168675	2.55	3.072727	2.75	2.625	3.454545
Reliability of Transport	3.048193	3.45	2.890909	2.897727	3.1875	3.272727
Load Unload Time	2.891566	3.1	2.836364	2.704545	2.875	2.969697
Distance to Cover	2.759036	3.4	2.854545	3.238636	2.875	3.606061

Truck Load Efficiency	2.891566	3.4	2.872727	2.852273	3.15625	3.121212
Access to Modal Shift	2.698795	2.8	3.018182	2.920455	3.0625	2.939394
Efficiency During Disruptions	3.012048	2.8	3.145455	3.227273	3.40625	3.242424
Efficiency Before Disruptions	3.180723	3.1	3.072727	2.909091	3.15625	3.242424
Trips Required for Shipment	2.795181	2.65	3.181818	3.068182	3.34375	3.030303
Iteration Time	2.975904	3.2	2.781818	2.806818	2.5	3.030303
Number of Stops Required	3.228916	3.1	3.109091	2.761364	2.5625	3.121212
Total Fuel Consumption	4.072289	3.75	4.090909	3.965909	4.09375	3.818182
Customer Satisfaction	3.975904	4.15	4.272727	4.136364	4.03125	3.939394
Safety of Transportation	2.939759	3.55	2.672727	3.159091	2.78125	3.424242
Corridor Availability and Capacity	3.204819	3.05	3.236364	3.068182	2.84375	3.060606

Table 33: Stage two - KPIs per sector and size

Economic and Operational KPIs	Overall Score	<1M	1M-5M	5M-10M	>10M	Freight	Logistics	3PL/4PL	Manufacturing	Retail
Cost per TKM	3.97	4.17	3.99	3.55	3.96	4.07	3.19	3.50	3.92	3.90
Focal Firm Profit	3.99	3.49	3.19	4.53	3.89	3.19	3.12	4.51	3.89	3.79
Total Time	4.00	4.10	3.89	4.23	4.01	4.12	3.39	4.03	3.78	3.77
On Time Deliveries	3.03	3.13	3.44	2.77	3.55	3.12	3.14	2.11	3.45	3.40
Service Frequency	3.08	2.87	3.78	2.88	3.23	2.81	3.71	2.33	3.22	3.02
Reliability of Transport	3.04	2.98	3.54	2.78	3.14	2.78	3.52	2.99	3.24	3.14
Distance to Cover	3.05	3.06	3.25	2.78	3.05	3.26	3.11	2.76	3.15	3.11
Efficiency During Disruptions	3.15	3.05	3.05	3.78	3.25	3.15	3.22	3.77	3.20	3.12
Efficiency Before Disruptions	3.08	3.10	3.55	2.67	3.18	3.12	3.51	2.57	3.17	3.15
Trips Required for Shipment	3.01	3.21	3.12	2.78	3.45	3.22	3.29	2.28	3.55	3.01
Total Fuel Consumption	4.00	4.10	4.10	3.88	3.89	4.11	4.02	3.68	3.79	3.91

Customer Satisfaction	4.09	4.22	3.99	3.82	4.05	4.21	3.10	3.81	4.15	4.51
Safety of Transportation	3.03	2.83	3.24	3.12	3.01	2.81	3.01	3.11	3.15	2.99
Corridor Availability and Capacity	3.11	3.01	3.78	3.05	3.00	2.98	3.81	3.25	3.02	3.45

Table 34: Stage two - environmental KPIs per country

	Country					
	BG	**FYROM**	**GR**	**RO**	**SLO**	**SRB**
Total Energy Used	3.97	4.05	4.03	4.01	3.84	3.66
Total CO2 Per TKM	2.63	3.05	2.96	3.14	2.87	2.84
Engine Standards	2.92	3.15	2.96	2.92	2.81	2.42
Driver Efficiency	2.81	2.75	3.09	2.97	3.25	2.87
Land Waste	2.10	1.90	2.05	2.10	2.06	1.90
Mileage	3.39	3.55	2.96	3.14	2.62	3.39
Environmental Penalties	4.06	3.90	4.01	4.03	3.87	4.03

Table 35: Stage two - environmental KPIs per sector and size

Environmental KPIs	Overall Score	<1M	1M-5M	5M-10M	>10M	Freight	Logistics	3PL/ 4PL	Manufacturing	Retail
Total Energy Used	3.95	3.90	4.15	3.75	3.70	4.25	4.15	4.05	3.54	3.87
Mileage	3.18	3.05	3.28	3.17	3.45	3.98	3.68	3.67	2.48	2.78
Environmental Penalties	4.01	3.85	4.12	4.02	4.12	3.78	3.92	3.98	4.34	4.39

Table 36: Stage two - relevant KPIs for critical disruptions

WEATHER INDUCED DISRUPTIONS / KEY PERFORMANCE INDICATORS		Delays in delivery	Coordination issues	Client complaints	Loss of revenue	Fuel consumption	Extra cost	CO2 emissions	Inventory issues	Congestion	Longer distances	Missed deliveries	Staff complains
		4.51	**4.19**	**4.06**	**4.05**	**4.03**	**3.98**	**3.60**	**3.53**	**3.46**	**3.38**	**3.21**	**3.02**
Cost per TKM	**3.97**	X			X	X	X				X		
Focal Firm Profit	**3.99**		X		X		X		X	X	X	X	
Total Time	**4.00**	X	X				X		X	X	X	X	X
On Time Deliveries	**3.03**	X	X	X	X		X		X				X
Service Frequency	**3.08**		X	X	X	X	X		X	X	X	X	X
Reliability of Transport	**3.04**	X	X	X	X	X	X	X	X	X	X	X	X
Distance to Cover	**3.05**	X			X	X	X	X	X	X	X	X	
Efficiency During Disruptions	**3.15**	X	X	X	X	X	X	X	X	X	X	X	X
Efficiency Before Disruptions	**3.08**	X	X	X	X	X	X	X	X	X	X	X	X
Trips Required for Shipment	**3.01**	X	X		X	X	X	X	X	X	X		X
Total Fuel Consumption	**4.00**		X		X	X	X	X		X	X		
Customer Satisfaction	**4.09**	X	X	X	X	X	X	X	X	X	X	X	X
Safety of Transportation	**3.03**	X	X	X	X	X	X	X	X	X	X	X	X
Corridor Availability and Capacity	**3.11**	X	X	X	X	X	X	X	X	X	X		X
Total Energy Used	**3.95**	X	X	X	X	X	X	X	X	X	X	X	X
Mileage	**3.18**	X	X	X	X	X	X	X	X	X	X		X
Environmental Penalties	**4.01**	X	X	X	X	X	X	X	X	X	X	X	X
KEY PERFORMANCE INDICATORS / WEATHER CONDITION FOR THE		**Snow fall (87%)**	**Fog (75%)**	**Snow fall (55%)**	**Snow fall (87%)**	**Snow fall (76%)**	**Snow fall (67%)**	**Fog (62%)**	**Icy roads (73%)**	**Snow fall (89%)**	**Snow fall (76%)**	**Icy roads (75%)**	**Snow fall (45%)**

DISRUPTION												

Table 37: Stage two - cross-country implementation of green practices

	BG	FYROM	GR	RO	SLO	SRB	Freight	Logistics	3PL-4PL	Manufacturing	Retail
EMS	2.01	1.70	1.92	1.97	1.96	2.09	1.97	2.00	2.08	1.83	1.96
TQEM	2.00	1.85	2.03	2.11	2.00	2.03	2.01	1.88	2.14	1.91	2.19
ISO14001	1.95	2.35	2.01	1.98	1.87	2.09	1.97	2.26	2.08	1.91	1.87
Energy Audits	1.98	2.10	1.96	1.87	1.87	2.06	2.03	1.95	1.94	1.97	1.75
Products Reduced Consumption	3.07	3.05	3.03	3.02	3.06	3.00	3.04	3.04	2.97	3.10	3.03
Products Reduced Waste	2.06	1.90	2.14	2.02	1.96	1.81	2.05	2.15	2.00	1.97	1.85
Process Reduced Odor	1.97	1.85	1.80	1.87	2.00	1.93	1.92	2.00	1.79	1.86	1.87
Process Reduced Waste	1.93	1.70	1.96	1.96	1.78	2.12	1.92	2.11	2.00	1.78	1.89
Process Reduced Hazards	3.09	2.90	2.89	3.09	3.03	2.84	3.10	3.04	2.88	2.86	2.92
Process Improved Efficiency	3.01	3.10	3.05	2.87	3.00	2.84	3.00	2.93	2.94	2.78	3.05
Redesign Supply Chain	3.18	3.10	3.05	2.82	3.40	3.06	3.03	3.13	3.14	2.94	3.10
Environmental Training	2.04	2.10	2.12	2.05	2.00	2.03	2.00	2.08	2.17	2.08	2.10
Senior Management Commitment	1.95	1.90	2.14	2.01	2.09	1.93	2.03	1.97	2.20	1.75	2.03
Middle Management Commitment	1.97	1.85	2.12	1.94	1.81	1.93	1.92	1.88	2.20	1.86	2.05
Environmental Request Suppliers	1.97	2.35	1.98	1.96	1.93	2.12	1.98	1.91	1.94	2.18	2.07
Environmental Collaboration Suppliers	1.92	2.05	2.05	1.97	1.96	2.06	2.01	1.93	1.79	2.07	2.07
Written Requirements Suppliers	2.02	1.90	1.92	1.94	1.87	1.93	1.94	2.02	1.97	1.97	1.89
Supplier Commitment Waste Reduction	2.00	2.10	1.78	1.98	2.34	1.72	1.94	1.93	2.08	1.97	1.98
Suppliers Must Implement EMS	2.16	1.90	2.01	2.02	1.84	2.15	2.11	2.00	2.02	2.00	1.96
Environmental Evaluations Suppliers	2.12	1.95	2.03	2.06	2.15	1.87	2.07	2.24	1.97	1.91	2.01

Table 38: Stage two - cross-country drivers

DRIVERS	Country					
	BG	FYROM	GR	RO	SLO	SRB
	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.
Clients Appreciate Green Certifications	4.13	4.20	3.96	4.18	4.06	4.00
Lower Taxes	4.05	3.90	3.98	4.13	4.00	3.85
Next Trend Logistics	3.96	4.40	4.11	4.05	4.06	4.15
Technology Enables GFT	3.98	4.05	4.20	4.01	4.03	4.09
Governmental Support Is Higher	3.87	3.65	3.95	3.99	3.97	3.91
Believe Important Green Resilience	3.96	3.80	3.96	3.94	3.97	3.88

Table 39: Stage two - cross-sector drivers

DRIVERS	Sector				
	Freight	Logistics	3PL/4PL	Manufacturing	Retail
	Avg.	Avg.	Avg.	Avg.	Avg.
Clients Appreciate Green Certifications	4.20	4.16	4.03	4.11	3.86
Lower Taxes	4.01	4.11	3.94	4.08	4.00
Next Trend Logistics	4.05	4.27	3.88	4.03	4.11
Technology Enables GFT	4.01	3.84	4.26	4.19	4.07
Governmental Support Is Higher	3.93	3.93	3.74	3.92	3.98
Believe Important Green Resilience	3.94	3.98	3.76	3.95	4.00

Table 40: Stage two - cross-country barriers

BARRIERS	Country					
	BG	FYROM	GR	RO	SLO	SRB
	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.
Lack of Commitment	4.06	4.25	3.98	3.90	3.91	4.00
No Green Goals	3.88	3.85	3.93	4.07	3.97	4.06
Too Big Investment	4.02	3.75	3.89	4.00	4.03	4.21
Green KPI Insignificant	4.01	4.20	3.89	4.01	3.91	4.03
Hard to Control 3PL 4PL	4.11	4.20	4.22	3.84	4.00	4.00
Untrained Staff Low Technology Adoption	4.05	3.70	4.11	3.92	4.13	4.15
Hard to Devise Green Job	4.04	4.00	4.22	4.16	3.88	3.94

Limited Information	4.05	3.95	4.07	3.99	3.97	4.15
Bureaucratic to Control Land Use	3.99	4.20	4.07	4.15	3.84	4.15
Limited Intermodal	3.96	3.85	4.13	4.00	4.00	3.88

Table 41: Stage two - cross-sector barriers

BARRIERS	Sector				
	Freight	Logistics	3PL/4PL	Manufacturing	Retail
	Avg.	Avg.	Avg.	Avg.	Avg.
Lack of Commitment	4.03	3.78	4.09	3.89	4.07
No Green Goals	3.96	3.80	4.12	4.08	3.95
Too Big Investment	3.99	4.24	3.82	3.84	4.02
Green KPI Insignificant	4.01	3.87	4.06	4.00	4.02
Hard to Control 3PL 4PL	3.98	4.09	3.94	4.05	4.18
Untrained Staff Low Technology Adoption	4.07	3.89	3.94	3.97	4.09
Hard to Devise Green Job	4.19	3.96	4.12	3.97	3.93
Limited Information	4.05	4.13	3.74	4.16	4.00
Bureaucratic to Control Land Use	4.04	4.13	4.00	4.00	4.16
Limited Intermodal	3.96	3.96	4.21	3.92	4.02

Table 42: Stage two - cross-country resilience strategies

RESILIENCE MECHANISM / STRATEGY	Country					
	BG	FYROM	GR	RO	SLO	SRB
	Count	Count	Count	Count	Count	Count
Reliance Soft Technology	4.08	3.65	3.96	4.08	4.03	3.91
Reliance Hard Technology	2.47	2.55	2.58	2.22	2.19	2.64
Interventions Energy Consumption	2.46	2.20	2.60	2.41	2.50	2.21
Alteration Process	2.53	2.50	2.60	2.24	2.56	2.55
Improvements Business Inefficiencies	4.06	4.25	4.24	4.19	4.19	4.18
Improvements Environmental Inefficiencies	4.19	3.90	3.91	3.80	3.97	3.88
Mechanisms To Raise Awareness	4.10	4.00	3.82	3.89	3.91	3.79
Employment Specialized Staff	4.08	3.90	3.96	4.03	4.28	4.09
Relocation Goods	3.95	4.00	3.93	4.03	3.84	4.12

Shorter Routes	**4.17**	**4.05**	**4.15**	**3.97**	**4.22**	**3.97**
Modal Shift	**1.99**	**1.90**	**2.07**	**1.86**	**1.97**	**1.94**
Risk Management	**4.10**	**4.00**	**3.98**	**3.93**	**4.06**	**4.18**
Real Time Weather	**2.08**	**2.00**	**1.93**	**1.92**	**2.09**	**1.94**
KM Mechanism	**2.01**	**2.00**	**1.85**	**1.86**	**1.53**	**2.03**

Table 43: Stage two - cross-sector resilience strategies

RESILIENCE MECHANISM / STRATEGY	SECTOR				
	Freight	**Logistics**	**3PL/4PL**	**Manufacturing**	**Retail**
	Count	**Count**	**Count**	**Count**	**Count**
Reliance Soft Technology	**3.93**	**4.13**	**4.00**	**4.03**	**4.09**
Reliance Hard Technology	**2.36**	**2.56**	**2.44**	**2.38**	**2.44**
Interventions Energy Consumption	**2.46**	**2.04**	**2.29**	**2.54**	**2.67**
Alteration Process	**2.46**	**2.31**	**2.50**	**2.00**	**2.86**
Improvements Business Inefficiencies	**4.24**	**4.13**	**4.00**	**3.95**	**4.26**
Improvements Environmental Inefficiencies	**3.98**	**4.11**	**3.79**	**3.92**	**3.89**
Mechanisms To Raise Awareness	**3.99**	**3.98**	**3.94**	**3.70**	**3.89**
Employment Specialized Staff	**4.01**	**4.18**	**4.03**	**4.27**	**3.95**
Relocation Goods	**3.99**	**3.96**	**4.06**	**3.95**	**3.95**
Shorter Routes	**4.17**	**4.13**	**3.94**	**3.95**	**4.02**
Modal Shift	**1.99**	**2.02**	**1.97**	**1.84**	**1.88**
Risk Management	**4.04**	**4.02**	**3.88**	**3.95**	**4.14**
Real Time Weather	**2.02**	**1.98**	**2.06**	**1.92**	**1.93**
KM Mechanism	**1.88**	**1.78**	**1.85**	**1.84**	**2.09**

Table 44: Stage two - resilience strategies against drivers & barriers

	DRIVERS	BARRIERS

DRIVERS and BARRIERS to RESILIENT AND GREEN FREIGHT TRANSPORTATION		Client appreciation	Next trend in logistics	Technology enables RGFT	Competitive advantages	Lower taxes	Public acceptance	Green resilience is important	Governmental support is higher	Lack of Commitment	No Green Goals	Too Big Investment	Green KPI Insignificant	Hard to Control 3PL 4PL	Untrained Staff Low Tech	Hard to Devise Green Job	Limited Information	Bureaucratic to Control Land Use	Limited Intermodal
RESILIENCE STRATEGIES AND MECHANISMS		4.10	4.07	4.05	4.03	4.02	3.96	3.94	3.92	3.99	3.97	4.00	3.99	4.04	4.02	4.07	4.03	4.06	3.99
Reliance Soft Technology	4.01		X	X	X							X			X		X		
Reliance Hard Technology	2.41			X	X							X			X		X		
Interventions Energy Consumption	2.43	X	X		X			X	X	X	X		X	X		X	X	X	
Alteration Process	2.46		X		X					X	X				X	X	X		
Improvements Business Inefficiencies	4.17		X	X	X	X			X	X	X				X		X		
Improvements Environmental Inefficienc	3.05	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	

ies																			
Mechanisms To Raise Awareness	3.93							X	X						X	X			
Employment Specialized Staff	4.06							X	X	X	X	X	X			X	X		
Relocation Goods	3.98	X			X							X							
Shorter Routes	4.08	X			X							X		X					
Modal Shift	1.95																		X
Risk Management	4.03		X	X	X			X						X			X		
Real Time Weather	1.99		X	X	X	X		X		X	X	X	X		X		X		
KM Mechanism	1.89		X	X	X	X		X		X	X	X	X		X		X		

Table 45: Stage two - resilience strategies against KPIs

RESILIENCE STRATEGIES AND MECHANISMS	Reliance Soft Technology	Reliance Hard Technology	Interventions Energy Consumption	Alteration Process	Improvements Business Inefficiencies	Improvements Environmental Inefficiencies	Mechanisms To Raise Awareness	Employment Specialized Staff	Relocation Goods	Shorter Routes	Modal Shift	Risk Management	Real Time Weather	KM Mechanism

KEY PERFORMANCE INDICATORS		4.01	2.41	2.43	2.46	4.17	3.05	3.93	4.06	3.98	4.08	1.95	4.03	1.99	1.89
Cost per TKM	**3.97**					X					X				
Focal Firm Profit	**3.99**	X			X	X	X	X	X	X	X	X	X	X	X
Total Time	**4.00**	X	X			X					X	X	X		X
On Time Deliveries	**3.03**	X	X			X					X	X	X		X
Service Frequency	**3.08**	X		X	X	X	X	X	X	X	X	X	X	X	X
Reliability of Transport	**3.04**	X			X	X						X	X		X
Distance to Cover	**3.05**	X		X	X	X	X	X	X	X	X	X	X	X	X
Efficiency During Disruptions	**3.15**	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Efficiency Before Disruptions	**3.08**	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Trips Required for Shipment	**3.01**	X		X	X	X	X	X	X	X	X	X	X	X	X
Total Fuel Consumption	**4.00**	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Customer Satisfaction	**4.09**	X				X				X	X		X		
Safety of Transportation	**3.03**	X			X	X						X	X		X
Corridor Availability and Capacity	**3.11**	X			X	X				X	X	X	X		X
Total Energy Used	**3.95**	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mileage	**3.18**	X		X	X	X	X	X	X	X	X	X	X	X	X
Environment	**4.01**	X	X	X	X	X	X	X	X	X	X	X	X	X	X

al Penalties															

Table 46: Stage two - cross-country behavioural elements

BEHAVIOURAL ELEMENT	Country					
	BG	**FYROM**	**GR**	**RO**	**SLO**	**SRB**
	Avg.	**Avg.**	**Avg.**	**Avg.**	**Avg.**	**Avg.**
PU **Return on Investment**	**4.08**	**3.65**	**3.96**	**4.18**	**4.03**	**3.91**
PU **Competitive Advantage**	**4.06**	**3.25**	**4.12**	**4.02**	**4.22**	**4.08**
PU **Reduced Waste**	**3.96**	**4.02**	**3.98**	**3.99**	**3.84**	**4.12**
PU **Environmental Care**	**3.92**	**4.03**	**3.96**	**3.90**	**4.04**	**4.10**
PEU **Implementation of green freight transportation practices**	**2.58**	**2.00**	**2.23**	**2.40**	**2.46**	**2.40**
PEU **Implementation of resilient freight transportation practices**	**2.50**	**2.20**	**2.43**	**2.70**	**2.16**	**2.20**
PEU **Implementation of green and resilient freight transportation practices**	**2.62**	**2.10**	**2.33**	**2.78**	**2.32**	**2.29**
PI **If practices/technologies for overcoming and/or mitigating these disasters were available and at low cost, would you use them ?**	**3.50**	**3.90**	**3.96**	**3.58**	**3.48**	**3.42**
PI **If practices/technologies for overcoming and/or mitigating these disasters were available and at low cost, that would also take into account environmental issues, would you use them ?**	**3.05**	**2.88**	**3.10**	**2.90**	**2.98**	**3.12**
PI **If practices/technologies for overcoming and/or mitigating these disasters, while improving business efficiency, were available and at low cost, would you use them ?**	**4.06**	**4.05**	**4.02**	**3.85**	**4.02**	**3.97**

Table 47: Stage two - cross-sector behavioural elements

BEHAVIOURAL ELEMENT	SECTOR				
	Freight	**Logistics**	**3PL/4PL**	**Manufacturing**	**Retail**
	Avg.	**Avg.**	**Avg.**	**Avg.**	**Avg.**
PU **Return on Investment**	**4.02**	**3.72**	**3.90**	**4.10**	**4.33**
PU **Competitive Advantage**	**3.98**	**3.44**	**4.15**	**4.25**	**4.23**
PU **Reduced Waste**	**3.95**	**4.07**	**3.90**	**3.92**	**4.20**
PU **Environmental Care**	**3.90**	**4.01**	**3.99**	**4.02**	**4.01**

PEU **Implementation of green freight transportation practices**	**2.55**	**2.10**	**2.33**	**2.31**	**2.42**
PEU **Implementation of resilient freight transportation practices**	**2.41**	**2.25**	**2.49**	**2.55**	**2.21**
PEU **Implementation of green and resilient freight transportation practices**	**2.11**	**2.30**	**2.52**	**2.79**	**2.40**
PI **If practices/technologies for overcoming and/or mitigating these disasters were available and at low cost, would you use them ?**	**3.51**	**3.77**	**4.02**	**3.61**	**3.55**
PI **If practices/technologies for overcoming and/or mitigating these disasters were available and at low cost, that would also take into account environmental issues, would you use them ?**	**3.02**	**2.78**	**3.22**	**2.97**	**3.01**
PI **If practices/technologies for overcoming and/or mitigating these disasters, while improving business efficiency, were available and at low cost, would you use them ?**	**4.05**	**4.02**	**4.08**	**3.90**	**4.02**