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# LIST OF ABBREVIATIONS

Absorptive Capacity (ACAP)

Adaptation (ADAPT)

Analysis of Moment Structures (AMOS)

Average Shared Variance (ASV)

Average Variance Extracted (AVE)

Collaborative Networked Organisations (CNOs)

Collaborative Networks (CN)

Combination (COM)

Common Latent Factor (CLF)

Common Method Bias (CMB)

Comparative Fit Index (CFI)

Composite Reliability (CR)

Computerized Self-Administered Questionnaires (CSAQ)

Confirmatory factor analysis (CFA)

Cultural-Historical Activity Theory (CHAT)

Degrees of freedom (DF)

Design Manufacturing Integration (DMI)

Engineering, Procurement Construction (EPC)

Enhanced Ant Colony Optimiser (ACO)

Enterprise Resource Planning (ERP)

Entrepreneurial Orientation (EO)

European Interoperability Framework (EIF)

Exploratory factor Analysis (EFA)

Externalisation (EXT)

General Linear Modeling (GLM)

Goodness of Fit (GFI)

Human Resource (HR)

Information Technology (IT)

Intellectual Property Rights (IPR)

Internalisation (INT)

Kaiser-Mayer-Olkin (KMO)

Knowledge-Based View (KBV)

Manufacturing Sales Integration (MSI)

Multiple Regressions (MR)

New Product Development (NPD)

Northeast of England Process Industry Cluster (NEPIC)

Operationalizing Innovation (INOV)

Operationalizing Replication (REPLIC)

Organisational Interoperability (OINT)

Parsimony Goodness of Fit (PGFI)

Parsimony Normed Fit Index (PNFI)

Professional Virtual Communities (PVC)

Resource Based View (RBV)

Root Mean Squared Error of Approximation (RMSEA)

Small Medium Enterprises (SMEs)

Socialisation (SOC)

Socialisation-Externalisation-Combination-Internalisation (SECI)

Special Purpose Vehicles (SPVs)

Special Weapons and Tactics (SWAT)

Strictly Confirmatory (SC),

Structural Equation Modeling (SEM)

The Normed Fit Index (NFI)

Toyota Production System (TPS)

Transactive Memory System (TMS)

Tucker-Lewis Index (TLI)

Variance Inflation Factor (VIF)

Virtual Enterprises (VEs)

Virtual Organisation Breeding Environments (VBE)

**CHAPTER ONE: INTRODUCTION**

* 1. **Background and Study Rationale**

This study examines the mediating role of firms’ dynamic capabilities on the ability to share tacit and explicit knowledge with critical partners in the pursuit of innovation, adaptation, and replication when engaged in *virtual enterprises* (VE). The study was conceived (in part) from the researcher’s personal insights and experience in the financial sector, where it is common to find banks engaged in financing arrangements with several geographically dispersed, complementary and sometimes, rival firms. Bank margins depend almost entirely on well-structured risk premiums (interests on loans). In many instances, a performing loan could unexpectedly turn bad if there are miscalculations in the split-second *put* or *call* knowledge-based investment decisions made by managers (see Boulding et al. 2016). This chapter provides a prelude to the theoretical rationale for examining the mediating impact of three key organisational dynamic capabilities - Absorptive Capacity (ACAP), Transactive Memory System (TMS), and Organisational Interoperability (OINT) - on the processes for tacit and explicit knowledge sharing in virtual enterprises (VEs). To underpin the study’s concept development, the researcher conducted in-depth reviews of the extant literature and held consultations with the supervisory team, academics in the domains of knowledge sharing and dynamic capabilities as well as practitioners with experience in collaborative networks.

First, a background to the study is provided to highlight the study’s scope and rationale. Next, the study’s objectives are outlined, followed by a concise description of the methodology adopted and the relevance of the study to management research and practice. Finally, a summary of the structure for the rest of this thesis is presented.

* + 1. **Research Context and Scope: The Importance of Collaborative Networks for Inter-Organisational Knowledge Sharing**

Many organisations today have access to more information than was thought possible just a few decades ago, as a result of recent advances in wireless and database technologies. Consequently, organisations that were once autonomous and geographically dispersed are now able to form tenured and technology-aided networks, with common or compatible goals, known in the literature as *collaborative networks* (Esposito and Evangelista, 2014).

Across the globe, there are several industry clusters comprised of autonomous firms engaged in long-term vertical or horizontal collaborative agreements. Such industry clusters, knowledge communities, or breeding environments, foster the development of compatible operating principles and infrastructure, which in turn, improves the preparedness and capabilities of member organisations to form temporary and competitive alliances with minimal penalties in set-up time and costs (Romero et al., 2007). Due to factors like uncertain economic condition, price fluctuations, resource and capability constraints, business risks, advances in technology, and market expansion strategies among others, firms often prefer to pool their capabilities and risks together in episodic collaborative networks, which are business-driven and technology-enabled. This form of collaborative network is refered to in the literature as a *virtual enterprise* (VE) (Camarinha-Matos et al., 2009; Esposito and Evangelista, 2014; Msanjila and Afsarmanesh, 2007).

Some VEs are configured and managed by large multinational acting as owners or leaders and responsible for coordinating all co-production activities throughout the duration or tenure of the collaboration. Such VEs are known as *hierarchical VEs* and are quite common in New Product Development (NPD) teams and modular product manufacturing consortia in hi-tech industries (Esposito and Evangelista, 2014). The second form of VEs are called *holarchical VEs* andare formed by self-organising and relatively similar firms, looking to pool together capacity, expertise, or resources to meet specific market needs, for which none of the parties is capable of conducting in isolation (Esposito and Evangelista, 2014). Big retail chains (including rivals) have been known to pool logistics capabilities together in this manner to aid the distribution of products with very short shelf-lives and order lead-times.

With advances in wireless technology, the synchronisation of tasks and communication across barriers of time, location, industry and organisational structure, has become a lot easier and in many cases, more cost-effective than engaging with partners through traditional means. Thus, for most firms in fast-paced industries, VEs constitute a competitive business configuration because they provide the flexibility to pursue several business ventures simultaneously with highly experienced and specialised partners, in order to maximise the benefits of context- or location-specific capabilities and resources.

### **1.1.2 Organisational Knowledge Management: Conceptualising Tacit and Explicit Knowledge**

In information and knowledge management domains, any object that can be used to warehouse or capture applicable organisational knowledge or a firm’s tacit processing capabilities is called an organisational *knowledge artefact*. The tacit knowledge made explicit in these artefacts can be shared in context and within stipulated boundaries, using annotated reports, analogies for the communication of technical knowledge and real-time alerts (online) to relevant parties regarding ongoing developments and best practices. Today, text database computing has made it possible for autonomous firms to search, code, update, and retrieve knowledge artefacts collaboratively across the virtual dimensions of time, space, and structure. Knowledge artefacts, in a sense, objectify human comprehension and capture it in the form of organized memory for easy sorting and retrieval. In a study on the role of knowledge artefacts in clinical pathways (teams of medical experts in different specialties synchronizing their expertise in operations) Sarini et al. (2008) explained that:

“almost any manual, internal report, bulletin and circular that has been collaboratively edited and that can be re-edited, amended or even only annotated and referred to by their “consumers” can be considered a knowledge artefact, as long as it “incorporates” some core competencies and some “best practice” in which members of a community recognize themselves to solve problems and add value to their activities” (p 2).

For very risky projects in industries with such political, socio-economic, and technical contingencies that could potentially outweigh the benefits of long-term collaborations (e.g. Banking and Oil and Gas industries), VEs enable firms to establish bankruptcy remote entities with distinct objectives, structure, configuration, and participants. Such entities are often completely different from their parent companies in terms of culture, leadership, technical, and relational capabilities for knowledge sharing. Likewise, in such industries, potential knowledge stored in artefacts is also obsoleted quite rapidly.

Knowledge is viewed as having two mutually reinforcing dimensions, namely *explicit* and *tacit* knowledge. Explicit knowledge is the dimension that can be captured, stored, and expressed in words, writings, equations, numbers, and standardised routines (Brown and Duguid, 2001). Tacit knowledge, on the other hand, is personal, difficult to express, context specific and primarily derived from the intuition and insights of the knower (Nonaka, 1994; Oguz and Sengün, 2011; Polanyi, 1966; Sabherwal and Becerra-Fernandez, 2003). It is often linked to an individual’s physical or cognitive sensory perception, movements, fine-motor skills, and experience-based or instinctive rules of thumb (Nonaka et al., 2006; Kogut and Zander, 1992). This means that organisations possess a critical dimension of knowledge that cannot be expressed or codified into knowledge artefacts because it is tacitly embedded in human actors and other intangible knowledge repositories such as *routines* (Dyer and Singh, 1998; Oguz and Sengün, 2011; Shamsie and Mannor, 2012). Routines by definition, are a set of rule-like heuristics used by organisations to standardise the decisions required for day-to-day operations, management, and administrative processes (Miller et al., 2012).

### **The SECI Model of Tacit and Explicit Knowledge Conversion and Sharing**

Several models and frameworks have been developed to explain how organisational knowledge is shared (Argote et al., 2003; Argote and Miron-Spektor, 2011). Of the existing ‘process theories’ of knowledge sharing in the literature, the Socialisation-Externalisation-Combination-Internalisation (SECI) framework by Nonaka and Takeuchi (1996) is a well-researched and logical framework that explains how knowledge sharing occurs in organisations, following a four-step process to overcome the constraints of individual boundaries and information asymmetries. In its conceptualisation, the SECI framework also provides a clear epistemological distinction between tacit and explicit knowledge sharing. Nonaka and Takeuchi (1996) proposed that tacit knowledge can be converted into explicit knowledge and vice-versa, through an intricate knowledge sharing spiral comprising four stages – *socialisation, externalisation, combination, and internalisation*. According to the SECI framework, socialisation processes are used to share experiences and expert knowledge among employees, teams, and organisations. The tacit knowledge acquired through socialisation is then externalised as mental models, mind maps, artefacts, analogies and so on. Over time, different aspects of externalised knowledge are filtered, rationalised, and ‘justified’ through the organisation’s ‘collective mind’ and eventually combined to form new organisational routines and practices. As employees gather more experience, they begin to internalise their newly combined routines and eventually express them as new organisational tacit knowledge.

In a departure from the pervasive view in classical economics that information is synonymous to externalised knowledge (or conceptual artefacts), the SECI model proposes that organisational knowledge transcends such ‘material or physical spaces’ and embeds itself in the corporate vision, culture, mind-set, and actions of firms (see Alavi and Leidner, 2001). Nonaka and Konno (1998) argued that these ‘intangible spaces’ provide firms with the unique social environment for the creation of routines. The authors likened these learning spaces to a metaphysical concept known as *‘ba’*, originally proposed by Japanese philosophers, Kitaro Nishida and Shimizu.

The SECI model proposes that while explicit knowledge is embedded in material spaces like technology-aided repositories, unlike information, it is contextual and must be tacitly understood through *social justification.* Nonaka and Takeuchi (1996) suggested that social justification requires the four human mediated SECI processes to “validate” individual knowledge as acceptable organisational knowledge. The second spiral within the model- called the knowledge conversion spiral – represents tacit to explicit knowledge conversions (through socialisation and externalisation processes only) and explicit to new-tacit knowledge conversions (through combination and internalisation processes only). Nonaka and Takeuchi (1996) proposed that these two phases of knowledge conversion are continuous and overlapping. In the first cycle, individual knowledge is re-contextualized and re-coded to generate collective organisation knowledge, while the second represents the interpretation, combination and externalisation of tacit knowledge to create new conceptual artefacts for firms, which can then be internalised as new tacit knowledge.

While the SECI model has been applied successfully in different studies (mostly individual, team, and organisational studies), some critics claim that the static differentiation between tacit and explicit knowledge is perhaps, an oversimplification of some tacit qualities of ‘knowing’ such as intuition and gut feelings, which are difficult and sometimes, impossible to codify (Gourlay, 2006; McAdam et al., 2007).

Others have questioned the idea of viewing tacit and explicit knowledge as a continuum, as implied by the proposed loops or spirals in Nonaka’s SECI model. There have also been claims that the SECI model does not clearly account for the role of “conceptual artefacts” because it assumes that tacit knowledge is created, stored and externalised in a manner suitable to the parameters (processing speed, capacity, etc.) of human cognition (Bereiter, 2005). The advent of technologies capable of processing data and information at incredible speeds somewhat supports this claim.

Although technology-based artefacts and analogies are useful for storing knowledge and are universally available, the ability to retrieve, process and reabsorb knowledge stored in such external artefacts is a critical distinguishing factor that sets creative firms apart from their contemporaries. Research findings from decades of organisational studies, cognitive management, strategic management and knowledge management are unanimous in the view that firms that possess certain learning *meta-routines* are better able to unlock the tacit knowledge embedded in intangible repositories such as people, processes, and routines.

Studies on sports teams, for instance, have shown that the timely and coordinated decisions made by teams do not depend on the skills or technical artefacts (explicit knowledge) available to each player. For fans and players of ball games, it is common knowledge that the accurate split-second decisions made during play usually takes a panel of expert commentators with technical/cognitive artefacts a long time to analyse and decode. Management studies on such sports teams suggest that it is impossible for team players to think through or plan out the details of a play sequence with their teammates because of the fluid context of each game. Thus, successful teams must be able to recognise, decode, absorb, and transfer in real time, the same “principled patterns” used by analysts several minutes later in their commentary or technical analysis (Bereiter and Scardamalia, 2005). In other words, it is a complex and time consuming task to explain a phenomenon driven by tacit knowledge (which can happen in an instant) in explicit terms.

### **1.1.4 The Antecedent Role of Dynamic Capabilities in Organisational Knowledge Sharing Processes**

There is a rich body of literature on dynamic capabilities, and Eisenhardt and Martin (2000) were among the first to empirically demonstrate that the problem-solving or opportunity-seeking routines developed by management are the microfoundation of organisational knowledge and a source of competitiveness – and not ordinary capabilities in themselves. Zahra et al. (2006 p 3) viewed dynamic capabilities as “the abilities to re-configure a firm’s resources and routines in the manner envisioned and deemed appropriate by its principal decision maker(s).” Dynamic capabilities have also been defined as metaroutines that “govern the rate of change” of ordinary or substantive capabilities (Collis, 1994), and enable firms to excel above “zero profit conditions” where productivity is consistent but outpaced by the rate of innovation in an industry (Teece, 2007).

Dynamic capabilities have been broken down into (1) capabilities that enable firms to sense and shape opportunities and threats, (2) capabilities that enable firms to seize and capitalise on opportunities, and (3) capabilities that enable firms to maintain long-term competitiveness by “enhancing, combining, protecting, and reconfiguring” the intangible (knowledge assets) and tangible asset of firms (Eisenhardt and Martin, 2000; Winter, 2003). Although there are several firm-specific dynamic capabilities, this study focuses on three main dynamic capabilities that have been linked specifically to inter-organisational learning and knowledge sharing in extant studies (Argote, 2015; Argote and Ren, 2012; Innis and Berta, 2016). These capabilities include; Absorptive Capacity (ACAP), Transactive Memory Systems (TMS), and Organisational Interoperability (OINT). Together, these dynamic capabilities play quite a significant role in the success of collaborative ventures and technology aided virtualisation (Badillo Enciso and Moreno Serrano, 2014; Camarinha-Matos et al., 2009).

ACAP is a measure of an organisation’s ability to identify, adapt and apply new information to create value (Cohen and Levinthal, 1990; Zahra and George, 2002). Transactive memory is a measure of an organisation’s ability to encode, store and retrieve knowledge and meta-knowledge about where to find requisite expertise (Wegner, 1987). OINT is a measure of the ability to synchronise the technological, social, and cultural systems of an organisation with those of others (Lei Zeng and Mai Chan, 2004). A review of the qualities attainable by firms with these dynamic capabilities suggests that they are infact, composite measures of the “enabling conditions” underscored by Nonaka and colleagues in their conceptualisation of the SECI model.

While the impacts of each of these capabilities on performance have been sufficiently explored in previous studies, it is important, given the preceding arguments, to understand the manner in which they affect knowledge sharing in VEs, in order to better inform practitioner’s choices of VE partners, and investment in developing learning qualities in organisations. This research draws on existing theoretical arguments and proposes that the SECI model of knowledge sharing requires some reconceptualization to account for the mediating role of dynamic capabilities.

### **1.1.5 The Relevance of Knowledge Outcomes: Is it always Virtuous to be Virtual?**

Innovation is generally considered a vital source of competitiveness and perhaps, the most sought after knowledge outcome by most firms. While there are several definitions, Crossan and Apaydin (2010) defined innovation as:

“the production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome.” (p. 1155)

Unfortunately, innovations are costly and time-barred. According to the Deloitte’s Shift Index, the average life expectancy of a Fortune 500 company has dropped from about 75 years in the 1960’s to below 15 years today, and may continue to decline to under five years at the current pace (Denning, 2011). This assertion was also reflected in a report by the American Enterprise Institute, which noted that about 88% of companies that were once revered as highly innovative just under 60 years ago, have either gone bankrupt, merged with others, or are simply irrelevant today (Perry, 2014). In a grim but astute observation, the executive chairperson of Cisco, John Chambers, predicted that over a third of businesses today could fail in the next ten years, and about 30% would succeed in recreating a poor and possibly, ‘digital’ shadow of their current form (Bort, 2015). For the most part, even with reliable intellectual property rights protection, knowledge leakages still occur, and this has the adverse effect of diluting firms’ unique knowledge offerings or increasing their innovation investment portfolios, with the attendant risk of failed investments. Thus, a pressing question for researchers and indeed, the managers of such highly innovative companies that are now gradually slipping into the ‘mediocre or failing’ category is: *‘what can a firm’s management do to sustain its learning momentum and competitiveness*?

Kolb (1984) observed that in all human endeavours, learning from experience is the "holistic process of adaptation to the world" (p: 31). This assertion is even more so for organisations today, because organisational knowledge, as explained earlier, has tacit and ambiguous dimensions and in many cases, employees and managers alike cannot quite decipher accurately, the source of their firm’s competitiveness. Consequently, two seldom researched knowledge outcomes that are pursued by most firms alongside their innovative efforts are (1) the ability to *adapt* knowledge from others to suit specific contexts and (2) the ability to *replicate* existing knowledge verbatim (Winter et al., 2011). Replication is a knowledge sharing outcome that results from substantially modifying the routines, processes, and in some cases, the identity of a firm so that they resemble those of competitors with more innovative routines and processes. Since the aspects of a competitor’s knowledge template that provide its competitive advantage may be unclear for the reasons mentioned above, there is often “a real challenge involved in discriminating the replicable and desirable features of a firm’s knowledge template from other possible causes of success” (Winter and Szulanski, 2001, p. 735). Thus, replication usually requires trials and errors and complex strategic judgment calls regarding what aspects of a template to replicate and how to blend in replications so as not to appear copied.

One of the main reasons why firms may opt to replicate knowledge is that replication is a concerted effort towards the exact copying of a set of routines, to afford the replicator the added benefits of such routines without having to invest heavily in decoding the underlying causes and interdependencies that support successful routines. Consequently, scholars like Winter and Szulanski, (2002) have suggested that firms usually adopt a replication strategy to deal with the causal ambiguity inherent in transfers of complex but successful routines. However, in many cases, replicator firms are far removed from the innovator’s setting and thus, they either have to create a new and compatible context to accommodate replications, or modify the knowledge offerings of innovative firms to suit their present context. This knowledge outcome is known as *adaptation* (Corredoira & McDermott, 2014)

While innovation has been linked to dynamic capabilities in several studies, adaptation and replication have rarely been examined, which may lead one to question whether VEs are always a good idea. Studies have shown that strategic VEs must be well timed to be effective and innovative firms must be able to synchronise their collaborations with the industry’s pace of development (Corredoira and McDermott, 2014). The odds for knowledge replication are higher in industries with high knowledge appropriability regimes (or ease of transfer) because the barriers to entry and the ease of poaching expertise are marginal compared to industries where knowledge is highly *sticky* (Hess and Rothamel, 2011). Thus, considering the context of VEs, it is important to understand the role of firms’ dynamic capabilities in facilitating innovation, adaptation, and replication strategies respectively.

## **1.2 Theory**

The research propositions and conceptual model developed in this study are underpinned by two extant theories that attempt to explain the boundaries of firms and the sources of competitive advantage. The theories explored are the *Knowledge-Based View* and the *Relational View of Strategic Management*.

The knowledge-based view (KBV) is a useful perspective for examining the dual role of knowledge as a market-based driver of *comparative advantage* as well as a firm-based driver of *competition* (Grant, 1996b; Kogut and Zander, 1992; Pemberton and Stonehouse, 2000). The KBV assumes that knowledge, in both tacit and explicit forms, is an essential organisational resource, which can be shared and modified through strategic partnerships (Grant, 1996b). The view is underpinned by the single factor theory of value in classical economics, which holds that human productivity is organised around critical resources, and the scarcity of such resources is a measure of value. This view is adopted because it makes a case for knowledge as the main strategic resource that drives collaborative relationships.

Studies have shown that the causal ambiguity of innovations, which makes them difficult for rivals to imitate also increases the difficulty in managing innovative knowledge resources in the long run, following protracted isolation. On the other hand, alignment with evolving trends in a given knowledge domain makes a firm's offerings popular and competitive. However, knowledge alignment could also expose the propriety rights of firms to market imitation or erosion. Accordingly, this view is augmented with the Relational View of Strategic Management, which presupposes that if critical resources are located outside a firm’s boundaries, a certain “collaborative advantage” beyond the firm’s immediate capabilities is achieved through collaboration, and this collaborative advantage allows such a firm to make super-normal profits as well as protect the knowledge generated in its alliances with other firms (Matanda et al., 2016).

## **1.3 Study Aim and Objectives**

Based on the preceding arguments, the objectives of this study include:

***RO1*:** To propose and test a series of hypotheses on the mediating role of dynamic capabilities (absorptive capacity, transactive memory systems and organisational interoperability) on the ability to achieve broad knowledge outcomes (innovation, adaptation, and replication) through tacit and explicit knowledge sharing (SECI processes) in VEs.

***RO2****:* To develop and validate a dynamic conceptual framework based on the above hypotheses to enrich the current theoretical and practical understanding of knowledge sharing in collaborative ventures such as VEs.

To meet the first objective, the literature is reviewed and nine hypotheses are proposed to explain the mediation role played by dynamic capabilities in the process of tacit and explicit knowledge sharing in VEs. To validate the integrity of the two distinct spirals of the SECI model described earlier, further hypotheses are proposed to test the theorised interactions among the stages of tacit knowledge sharing (i.e. the product of socialisation and externalisation (SOC)x(EXT)) and explicit knowledge sharing (i.e. the product of combination and internalisation (COM)x(INT)), which are theorised to occur in continuous spirals within the SECI model. These spirals expand from the individual domain, through teams and eventually to organisational and inter-organisational knowledge creation and sharing.

## **1.4 Research Methodology**

Following reflective analyses of the researcher’s philosophical considerations and drawing on arguments pertaining to the nature of man and the nature of science, a positivist epistemology and critical realist ontology is adopted.

Realism is the ontological position or worldview embraced by positivists, which assumes that social variables are independent of human perception or investigation and can be reduced to measurable empirical quantities (Goles and Hirschheim, 2000). The realist ontology assumes that subjective variables can be quantified through sense observation and statistical analyses and used in the modelling of causal relationships (reductionism) (Godfrey and Hill, 1995). Consequently, positivists rely on mathematical and statistical methodologies from the physical and natural sciences to analyse data. Positivism further assumes that within specified and testable limits (e.g. sampling adequacy and bias tests), data generated from social actors can be generalised (empiricism), and interpreted as value-free or void of biases (Gill and Johnson, 2010). Like the natural scientists, positivists in the social sciences draw on insights from theories to propose causal relationships among social variables in order to understand them and to predict human social behaviour (Easterby-Smith et al., 2012). Large population samples are often required and ‘hypothetico-deductive models' are used to formulate and test proposed relationships for the ‘falsifiability' of theoretical assumptions against observed data (i.e. verification or refutation) (Walsh et al., 2015).

The measures of the SECI processes, dynamic capabilities, and knowledge outcomes used in this study are adapted from previous studies on collaborative ventures and virtual work among teams. A web-based survey is chosen to maximize the potential of sampling a cross-section of industries where VEs are predominant. Structural Equation Modeling (SEM) is used to carry out the statistical tests and analyses of the resulting data. SEM was selected for its robust capacity to model and test 'statistical causality’ among subjective variables. It allows the researcher to build correlation or covariance-based causal models of interactions among variables in line with theory and to check for *model fit* between the correlation matrices generated and the data collected. If a model fits, then it can be used to verify specific hypotheses (Bollen and Pearl, 2013; Eisenhauer et al., 2015; Henseler et al., 2015). The hypothesized dynamic capability-mediated model in this study is statistically estimated using the Analysis of Moment Structures (AMOS) program (Byrne, 2013). AMOS employs several statistical techniques such as path analysis, causal modeling with latent variables, ANOVA, and multiple linear regressions to examine the relationships among construct (Kline, 2015).

## **1.5 Relevance and Potential Contributions**

The study proposes to make some distinct contributions to theory and practice. Regarding theoretical contributions:

1. It provides a clear conceptualization of a dynamic model of knowledge sharing in collaborative ventures, based on validated and well-explored constructs. Such a model is relevant to future studies examining collaborative ventures and is particularly important for understanding collaborations across virtual organisational boundaries.
2. The study provides empirical evidence on the antecedent impact of dynamic capabilities on the processes of tacit and explicit knowledge sharing in VEs for innovation, adaptation, and replication. This provides further validation of the integrity of the social justification processes conceptualized in the SECI model, and includes a gestalt of dynamic capabilities to account for the dynamic nature of knowledge sharing.
3. Since adaptation and replication are critical knowledge outcomes, the study further provides new evidence on how they are affected by firms’ dynamic capabilities.
4. In validating the link between Socialisation and Externalisation (for tacit knowledge sharing) as well as Combination and Internalisation (for explicit knowledge sharing), the study lends further evidence to the mechanism of tacit to explicit knowledge conversions in collaborative ventures.
5. The research on knowledge sharing is currently quite fragmented, with different streams progressing concurrently in the fields of knowledge and information management, strategic management, organisational studies, and operations and supply chain management. Thus, this study contributes to bridging the research on knowledge sharing from the fields of (1) operations and supply chain management (innovation in collaborative networks), (2) strategic management (dynamic capabilities), (3) organisational studies (knowledge sharing in teams and collaborations) and (4) knowledge management (models of knowledge sharing).

By way of practical contributions:

1. Since dynamic capabilities are conceptualized as being path-dependent, by identifying a gestalt of dynamic capabilities (or organisational metaroutines) that are mutually reinforcing and fit together in a dynamic model of knowledge sharing, companies engaged in VEs can make targeted investments towards developing the requisite capabilities to enhance knowledge sharing in different industries in line with desired knowledge outcomes.
2. Likewise, since dynamic capabilities are conceptualized as cumulative and experience based, companies engaging in VEs can draw on the findings of this study in the assessment of potential VE partners in order to select those with highly developed dynamic capabilities to either complement or augment their own.

## **1.6 Structure of Thesis**

The remainder of this thesis is structured in six distinct chapters as follows:

1. **Literature review:** This chapter reviews the extant literature on organisational knowledge sharing, learning, dynamic capabilities and collaborative networks to find research gaps and to arrive at a conceptualisation of the dynamics of knowledge sharing in VEs. The review sets out the research agenda, provides a clear scope of organisational knowledge and further identifies a fitting process-based model, namely, the SECI model developed by Nonaka and Takeuchi. The SECI model operationalises the important social justification processes for knowledge sharing (socialisation🡪externalisation🡪combination🡪internalisation) and provides sequential conversion steps for tacit (socialisation🡪externalisation) and explicit (combination🡪internalisation) knowledge conversions. The three dynamic capabilities; ACAP, TMS and OINT identified as microfoundations of knowledge sharing are reviewed and the three main outcomes of knowledge sharing- innovation, adaptation and replication- are also reviewed.
2. **Conceptual Framework**: Drawing on prior studies and underpinned by the knowledge based view and relational view, this chapter articulates a number of hypotheses to explain the pivotal role of the three dynamic capabilities (or high order meta-routines) in the sharing of substantive organisational routines for innovation, adaptation, and replication. Furthermore, a framework is developed to extend the theory on knowledge sharing based on the SECI model, by incorporating the three dynamic capabilities examined to highlight their impact on knowledge social justification and tacit-explicit knowledge conversions through different scalar levels (individual, teams, firms) in VEs.
3. **Methodology**: In this chapter, the key phases of the research methodology are examined and discussed. A reflective discussion on the researcher’s philosophical considerations (positivist epistemology and critical realist ontology) is provided and this is supported with arguments on the nature of man and science to highlight the combined impact of these qualities on the development of research paradigms in the social sciences. The chapter also covers the rationale, construct development, and execution of the survey research design (web-based questionnaires) used in the study. Detailed discussions and justifications for the statistical tests and procedures used for the data analyses (SEM) are also provided.
4. **Analysis and Findings**: The demographic and statistical findings from the data analysis on the hypothesised dynamic capability mediated model of knowledge sharing for innovation, adaptation, and replication in VEs are reported in this chapter.
5. **Discussion of Findings and limitations:** This chapter discusses the study’s main findings under four broad subheadings. First, the key findings on the social validation cycle of the SECI model (socialisation🡪externalisation🡪 combination🡪internalisation) are discussed to highlight the relevance of dynamic capabilities in the social justification of knowledge in VEs. Next, the findings on the interaction effect between the processes for tacit knowledge sharing (socialisation🡪externalisation) and explicit knowledge sharing (combination🡪internalisation) are discussed, highlighting the practical and research implications
6. **Research Contribution:** This chapter summarises the research contributions using a 2x2 matrix developed by Corley and Gioia, (2011) to categorise the practical and theoretical contributions of this study on the basis of originality and utility. A subsection of this chapter is dedicated to chronicling the study’s limitations as well as areas for possible extension of the study. Finally, the practical impact of the study is demonstrated in a detailed discussion of a potential application of the study’s framework to a real case study involving a modular product manufacturer. The chapter concludes with a reflection on the possible methodological approach (action research) to be adopted in the execution of this future study.

## **1.7 Chapter Summary**

This chapter presented a concise outline of the scope, rationale, theoretical underpinning, methodology, and relevance of this research on the dynamics of knowledge sharing for innovation, adaptation and replication of knowledge in VEs. It also provided an outline of the thesis structure to aid the reader in navigating the content of the remaining chapters. The next chapter as outlined, is a review of the relevant literature to underpin the focus and scope of the study.

**CHAPTER TWO: LITERATURE REVIEW**

**2.1 Background**

The literature review for this research covers the extant studies on individual, team, organisational and inter-organisational knowledge sharing as well as the principles for collaborative learning. The theories and studies reviewed are drawn from three main management sub-disciplines.

Beginning with the field of knowledge management, a critical discussion of extant studies on the link between organisational knowledge and organisational learning is presented. Furthermore, to outline the scope of knowledge explored, the review proceeds to examine the literature on the distinction among knowledge, information and data, to arrive at a working definition for organisational knowledge in the context of this study. Next, five of the main process-based theories of learning and knowledge sharing are reviewed; namely, (1) Rumelhart and Norman's Three-step Model of Accretion, Structuring, and Tuning, (2) Kolb's Cycle of Experiential Learning, (3) Engeström's Theory of Expansive Learning, (4) Bereiter’s Model of Knowledge Building and (5) Nonaka and Takeuchi's Socialisation-Externalisation-Combination-Internalisation (SECI) Model. This section concludes with a rationale for the adoption of the SECI model in this study’s analysis of the impact of the dynamic capabilities explored on the SECI processes of tacit and explicit knowledge sharing in VEs.

Next, strategic management and organisational studies are reviewed to explore the motives and antecedents for knowledge sharing. This part of the review draws on studies from the strategic management sub-discipline in order to critically appraise the role of organisational dynamic capabilities as microfoundations or enabling conditions for inter-organisational knowledge sharing. Three main strategic level dynamic capabilities are identified and reviewed; namely, organisational Absorptive Capacity (ACAP), Transactive Memory Systems (TMS) and Organisational Interoperability (OINT). Based on a review of a range of organisational studies, three main outcomes of collaborative knowledge sharing are identified and reviewed. The knowledge outcomes reviewed include innovation, adaptation, and replication.

From the operations and supply chain management domain, the researcher proceeds to review the studies on collaborative networks and the impact of virtualisation on the nature and structure of inter-organisational networks. Next, the three (3) Cs of networking - coordination, cooperation and collaboration – are examined to explain how and why firms use collaborative networks to pool capacity, risks and rewards. This is followed by a discussion and classification of the prevalent types of collaborative networks. Finally, the nature and scope of VEs is reviewed, to highlight the antecedents, life-cycle, classification and relevance of VEs as an emerging business configuration and to underpin this study’s focus on knowledge sharing in VEs.

**2.2 Organisational Knowledge and Organisational Learning**

Early theories on the nature of ‘knowledge’ and ‘knowing’ take root in *Cartesian dualism*, often credited to the Greek philosopher, Descartes (Easterby-Smith et al., 2000; Easterby‐Smith et al., 2008; March, 2006). According to the Cartesian school, the abstract “mind” and material “body” exist in ontologically distinct spaces, but interact causally to produce different abstractions of reality (Nonaka and Von Krogh, 2009). Cartesian dualism underpinned a number of classical behavioural economics theories, including the *theory of rational choice*, upon which most of the early research on organisational knowledge was premised (Miller and Miller, 2008; Nonaka and Peltokorpi, 2006). The rational choice theory argues that an "economic man," is one who is both "economic" and "rational"(Miller and Miller, 2008). The economy of such an individual was assumed to originate from partial or absolute *information* about the relevant facets of the environment that impact decision making, actions, and preferred outcomes in business endeavours (Davis, 2013). Rationality on the other hand, was theorised to be the product of regimented patterns of preferences and skills used in the selection of best possible paths to achieving a given business objective from a number of alternative courses of action (McMillan, 2016; Simon, 1955, 1979). Consequently, the emphasis of early studies on organisational knowledge was on the outcomes (ends) rather than the processes (means) for creating and sharing knowledge. One of the earliest researchers to revisit the conceptualisation of the economic man was Simon (1955), who argued that:

“Developments in economics, and particularly in the theory of the business firm, have raised great doubts as to whether this schematized model of economic man provides a suitable foundation on which to erect a theory - whether it be a theory of how firms do behave, or of how they "should" rationally behave.” (p.99)

He introduced the idea of “bounded rationality”, arguing that in business decision making, the rationality of actors is bound to the information they have, their cognitive capacity, and the time constraints on business decisions. Due to the seeming empirical parsimony of the rational choice theory and its conceptualisation of the economic man, it quickly became a foundational premise in management, economics, and other business related disciplines (e.g. finance) for conceptualising both knowledge and information (Felin et al., 2014; McMillan, 2016; Oglethorpe and Heron 2013). Consequently, most of the early theorising on organisational knowledge was underpinned by the notion that organisations were ‘information-processing’ and ‘problem solving machines’, established to overcome the inefficiencies of individual bounded rationality (Nonaka and Toyama, 2003). According to Nonaka et al. (2006):

“At that time, much of the mainstream theory for all practical purposes considered ‘knowledge’ to be interchangeable with ‘information’…organization and management theory based its notions of ‘information’ and ‘information processing’ on scientific work in the area of cognitive psychology dating back to the 1950s. Mainstream theory had therefore neglected important advances in this area for some time. Recent research had found that knowledge is embodied in the individual, and is therefore history dependent, context sensitive, specific, and aimed at problem definition rather than problem depiction, and problem solving.” (pp. 1180).

Today, information technology has transformed traditional factors of production like machinery and regular office equipment into viable repositories of what can be considered, for all intents and purposes, potential organisational knowledge (Frese and Keith, 2015). In addition to advancements in computing functionalities, the most influential contribution of information technology (IT) in the last decade, is the role it plays in linking together autonomous processes and systems (Skyrme, 2012). Although technology aided networks are not entirely new (they have been used for decades in power grids, gas and telecommunication networks) (Chung and Jackson, 2013; Skyrme, 2007), they have become increasingly pervasive, and firms are now able to link previously demarcated facets of their businesses together - from finance and purchasing, to manufacturing, service delivery, and customer feedback systems. This has fuelled researchers’ preoccupation with devising models and frameworks to facilitate our understanding of how best organisations can manage knowledge to maximise its contributions to business performance (Aggestam, 2015). In addition to the role of information technology in modern-day businesses, highly volatile global markets, boundary spanning suppliers, and outsourcing are some of the recent trends that have led organisations to place greater emphasis on distinguishing viable organisational knowledge from information, and data (Aggestam, 2015; Alavi and Leidner, 2001; Genovese et al., 2014).

These concepts appear considerably difficult to define, partly because they are intangible and interdependent, but primarily because they are technically indistinguishable in the absence of theoretically imposed boundaries (Matayong and Mahmood, 2013). Some firms have resorted to investing in standard organisational knowledge management infrastructure and artefacts, like information and communication technologies. However, organisational knowledge is considered different from readily accessible information and data to the extent that it provides firms with “actual or realised competitive strengths” (Rosenzweig et al., 2003). Available empirical evidence suggests that investing solely in technological artefacts without due consideration to the underlying organisational processes that facilitate their utilisation could be counterproductive or even detrimental to firms. In this regard, Sveiby (1997) argued that:

“The widespread but largely unconscious assumption that information is equal to knowledge and that the relationship between a computer and information is equivalent to the relationship between a human brain and human knowledge can lead to dangerous and costly mistakes.” (p.24)

### **Distinguishing Knowledge, Information and Data**

For clarity, it is important to establish conceptual differences among data, information, and knowledge. In the literature, there is a *hierarchical process view* of knowledge, which distinguishes knowledge from information and data, using criteria like the degree of utility, structure, context, and interpretability (Boisot and Canals, 2004; Schultze and Leidner, 2002; Zins, 2007). From this viewpoint, data is defined as potentially useful, but unprocessed facts about the external environment or internal business operations of firms. It is further assumed that through the process of sorting, refining, and structuring, potentially useful information can be obtained from data. Knowledge is thus viewed as the final outcome of refining and contextualizing information through human cognition, reasoning, and learning. It is thought to be highly contextual, structured, and directly applicable to problem solving (Alavi and Leidner, 2001; Andreeva and Kianto, 2012; Baskerville and Dulipovici, 2006).

Some have contended that such a hierarchic distinction among these concepts is far too simplistic, and has fuelled the erroneous assumption that information is an end in itself. In other words, the main critique is that the hierarchic process view inherently supposes that available information is automatically transformed to knowledge (see review by Tuomi, 1999). However, in practice, problem-definition requires *a priori* knowledge in order to make any sense out of available data or information (Andreeva and Kianto, 2012; Howard, and Richard, 2002; Liu et al., 2011). It has been suggested that the hierarchical view emerged perhaps, because scholars have attempted to define knowledge either from a knowledge-seeker or knowledge-creator’s perspective, without due consideration to the cyclic interdependencies between knowledge seeking and knowledge creation (Kakabadse et al., 2003; Schultze and Leidner, 2002).

The second common approach to distinguishing these concepts is the *cyclic process view*. Proponents of this view believe that prior organisational knowledge is an obligatory requirement for interpreting stored data and for creating viable information (Tuomi, 1999). The rationale for this perspective is that in practice, ‘raw data’ from any domain (e.g. medicine, engineering) is usually retrieved, manipulated, and utilized by individuals with prior knowledge or expertise in that domain (Nonaka and Toyama, 2005). Building on the cyclic process view, Kakabadse et al. (2003) suggested that knowledge is synthesised in three stages – first, the realisation of the usefulness of information; secondly, the ‘will to act’, and finally, the ‘wisdom’ or the cognitive ability to apply information accurately. Although Kakabadse and colleague’s framework is theoretically instructive, it provides very little detail on the steps in the conversion process from data through information to knowledge. Furthermore, their conceptualisation of organisational wisdom appears overly conceptual at best, and provides very little information on to how it can be operationalised.

## **2.2 Organisational Knowledge**

Organisational knowledge is often discussed in the literature under one of four distinct conceptual dimensions (Campos and Sánchez, 2003):

1. Epistemological dimension: *tacit* or *explicit*
2. Ontological dimension: *individual* or *social*
3. Systemic dimension: *external* (technical information) or *internal*(cognitive)
4. Strategic dimension: *resources*, *capacities* or *visions*

Although the ontological, systemic, and strategic dimensions differ relatively in scope, they all fall under the broad epistemological categorisation of *tacit* and *explicit* knowledge (Campos and Sánchez, 2003). In a publication titled *Science, Faith and Society,* Polanyi (1946), offered one of the foremost opposing arguments to the positivist view in the sciences and economics regarding the nature of “knowledge”. He claimed that all knowledge (including the knowledge applied in standard routines like closing a door or stopping at a traffic light), relies on personal judgement, which is prone to change. Polanyi further proposed that since all knowing is tied to personal judgement, organisational knowledge is best defined from a post-critical perspective, which concedes that organisations comprehend more than they can prove, and know more than they can explain. In a later article captioned “*The Logic of Tacit Inference”*, Polanyi (1966) proposed a theory of organisational knowledge and articulated the following profound distinction between the *tacit* and *explicit* dimensions of knowledge:

“The explicit content of a theory fails to account for the guidance it affords to future discoveries. To hold a natural law to be true, is to believe that its presence may reveal itself in yet unknown and perhaps yet unthinkable consequences; it is to believe that such laws are features of a reality which as such will continue to bear consequences inexhaustibly. It appears then that scientific discovery cannot be achieved by explicit inference, nor can its true claims be explicitly stated. Discovery must be arrived at by the tacit powers of the mind and its content, so far as it is indeterminate, can be only tacitly known” (p.1)

Explicit knowledge is the dimension that can be captured, stored, and expressed in words, writing, equations, numbers, and standardised routines (Brown and Duguid, 2001)*.* Tacit knowledge on the other hand is personal, difficult to express, context specific and primarily derived from the intuition and insights of the knower (Nonaka, 1994; Oguz and Sengün, 2011; Polanyi, 1966; Sabherwal and Becerra-Fernandez, 2003). It is often linked to an individual’s physical or cognitive sensory perception, movements, fine-motor skills, experience-based, and instinctive rules of thumb (Nonaka et al., 2006; Kogut and Zander, 1992). This means that organisations possess a critical dimension of knowledge that cannot be readily expressed or codified into explicit information or data because it is tacitly embedded in human actors and intangible knowledge repositories such as routines (Dyer and Singh, 1998; Oguz and Sengün, 2011; Shamsie and Mannor, 2012). While tacit and explicit knowledge are clearly distinguishable, scholars have maintained that they are not two distinct *types* of knowledge (McAdam et al., 2007). Therefore, the view that knowledge in tacit form can be made explicit is still heavily debated (Cook and Brown, 1999; Oguz and Sengün, 2011). In his conceptualisation, Polanyi (1966) opined that tacit and explicit knowledge are integral parts of “knowing” and should not be seen as dichotomous but “mutually dependent and reinforcing qualities of knowledge”. In describing the mutual dependence of both dimensions, Polanyi explained that:

“While tacit knowledge can be possessed by itself, explicit knowledge must rely on being tacitly understood and applied. Hence all knowledge is either tacit or rooted in tacit knowledge. A wholly explicit knowledge is unthinkable.” (p.7)

Likewise, Grant (1996) observed that:

“in the form of know-how, skills and practical knowledge of organizational members, tacit knowledge is closely associated with production tasks, and raises the more interesting and complex issues regarding its transfer both within and between organizations.” (p.377).

It follows then, that a quality of organisational knowledge that distinguishes it from information and data is that it carries a tacit dimension that cannot readily be codified in the absence of enabling social and relational structures and infrastructures. Uzzi (1997) outlined three fundamental qualities of tacit knowledge that have largely been overlooked in most of the theories on information, such as the rational choice theory that was discussed earlier. According to Uzzi, in addition to being unique, personal, and context specific, tacit knowledge is (1) accumulative, (2) a precondition for understanding explicit knowledge, and (3) requires a high degree of social embeddedness to be decontextualised. In a study examining the impact of relational embeddedness between managers of multinationals and local subsidiaries on tacit and explicit knowledge sharing in international joint ventures, Dhanaraj et al. (2004) found that the strength of personal ties, trust, shared values, and interoperable systems are fundamental prerequisites for tacit knowledge sharing in international joint ventures. Other studies also show similar findings in respect to the sharing and unidirectional transfer of tacit knowledge (Becerra et al., 2008; Eraut, 2000; Hau, 2013; Leonard and Sensiper, 1998).

Alavi and Leidner (2001) categorised the extant definitions of organisational knowledge into five conceptual categories, namely, studies that define knowledge as (a) *a state of mind*, (b) *an object that can be captured, transferred, and stored in different repositories*, (c) *the process of applying expertise*, (d) *a condition required for retrieving and interpreting information stored in repositories*, and (e) *the capability that enables firms to improve their performance using available information.* Apart from the ‘state of mind’ definition, where the central focus is the human cognition, the object, process, condition, and capability definitions all focus on the ‘processes’ through which human cognition is tailored, captured, and expressed. Thus, these views have facilitated empirical investigations on organisational knowledge by equating the state of organisational knowledge to observable changes in processes, knowledge objects, information quality, or performance (Brown and Duguid, 2001; Cook and Brown, 1999).

Consequently, to overcome the conceptual inefficiencies of viewing knowledge and information as synonymous and interchangeable, more and more organisational studies and management researchers began to adopt iterations of the process view of knowledge, drawing on extant theories on *organisational learning* from the fields of cognitive and behavioural psychology (Engestrom, 1999; Engeström and Sannino, 2012). Organisational knowledge sharing and organisational learning have been studied independently for decades, but Argote and Miron-Spektor (2011) noted that both concepts appear closely related and rather inseparable when one considers the processes involved. In addition, modern perspectives on organisational learning emphasize knowledge *sharing processes* as a precondition for learning over the mere *transfer* of knowledge between a holder and recipient (Argote, 2015; Dixon, 2000). Knowledge sharing and knowledge transfer are used interchangeably in some studies, however there are a few noteworthy conceptual differences. Renzl (2008) explained that knowledge transfer represents a generic “source to recipient” flow of knowledge whereas, knowledge sharing connotes a collective or collaborative endeavour, which is implied by the term ‘sharing’. Knowledge transfer is a unidirectional movement of knowledge across individual or organisational boundaries from a knowledge holder to a recipient (Easterby-Smith et al., 2008). Argote and Ingram (2000) succinctly described it as "the process through which one unit (e.g., group, department, or division) is affected by the experience of another." Knowledge sharing in contrast, is a collaborative process involving concurrent and reciprocal giving and receiving of knowledge aimed at improving individual and collective capabilities (Chen, 2008; Chiu et al., 2006; Lin et al., 2009). In other words, knowledge sharing requires reciprocal knowledge transfers and assimilation.

## **2.3 Extant Theories on Organisational Learning**

There are two fundamental views in the literature on how learning occurs. The behaviourist approach assumes that learning occurs in response to changes in the environment such as competition, uncertainty and other socio-economic and political pressures. The cognitive or post-behaviourist approach assumes that learning is a complex social process of reasoning, which is the human way of reconciling experiences and competencies with practical expectations (Easterby-Smith et al., 2000; Pemberton and Stonehouse, 2000; Sims, 1999). Proponents of the post-behaviourists approach have contended that although behaviourist research is purportedly value-neutral, it appears to be somewhat biased towards social preservation but averse to social change (Lave and Wenger, 1991; Sfard, 1998). Irrespective of the learning approach, the outcome of organisational learning is *the creation of new knowledge stocks and the capability to acquire/build competitive knowledge assets over time* (Argote and Miron-Spektor, 2011).

Learning generally occurs in single or double loops – technically referred to as *adaptive* or *generative* learning respectively (Argyris and Schon, 1974; Chiva et al., 2010). Single-loop or adaptive learning entails making incremental changes to organisational knowledge, without significantly changing underlying organizational principles. The result of adaptive learning is the creation of *complex adaptive systems*, which are capable of efficient self-reorganisation and adaptation to overall system demands (e.g. markets and industries) (Chiva and Habib, 2015; Kantamara and Vathanophas, 2014). In contrast, double loop or generative learning entails making radical changes to underlying organisational principles in line with new experiences or new capabilities (Chiva et al., 2010). This form of learning creates c*omplex generative systems,* capable of self-transcendence, in order to produce radically new knowledge assets (Chiva and Habib, 2015). Although these two forms of learning can occur independently, some organizations are able to concurrently and efficiently act as complex generative, and complex adaptive systems (Örtenblad, 2004).

Argote and Miron-Spektor (2011), noted that organisational learning depends on the organisational *context*, as well as the individual or collective *experiences* of employees. Organisational context can be viewed as the structural artefacts, cultural norms, and strategic imperatives that influence the nature of relationships within and among firms. Experience on the other hand, provides employees with the rationale and *transactive memory* to develop learning relationships that facilitate knowledge sharing and spill-overs across individual, functional unit, and organisational boundaries (Argote et al., 2003; Rosenkopf and McGrath, 2011). In this sense, learning is conceived as occurring in selective social alliances, which are built and nurtured through participation and interactions among players randomly drawn from a complex social system. Employees participating in such social learning alliances have to consciously or inadvertently re-evaluate new ideas against the technical and social standards of competence established within the firm (Chiva and Habib, 2015; Lave and Wenger, 2002). Consequently, organisational learning occurs when the internal social alliances of a firm facilitate the sharing of individual or group experiences and competencies in a manner that leads to tangible changes in their collective capabilities (Aggestam, 2015; Frese and Keith, 2015). Accordingly, Wenger (2000) argued that:

“Competence and experience can be in various relation to each other - from very congruent to very divergent……..either can shape the other, although usually the process is not completely one way. But, whenever the two are in close tension and one starts pulling the other, learning takes place.” (p. 227)

Stacey (2003) cautioned that researchers must be careful not to view organisations as learning entities that are entirely separate from the individuals comprising them. Such a “dichotomous” view of individual and organisational learning in his opinion, raises fundamental epistemological questions about where exactly in organisations learning occurs. He further stressed that:

“to claim that it is only individuals who learn is to continue with the major Western preoccupation with the autonomous individual, and to ignore the importance of social processes.” (p. 326)

He proposed a “complex responsive processes theory of organisational learning”, in which the learning processes of groups and individuals are viewed as “dualities” as opposed to “dichotomies”(Stacey, 2003; Stacey, 1995). The two forms or learning are interrelated because the communication, infrastructure, social interactions, and power relations among independent employees creates unique and “iterated patterns and meanings”, which eventually evolves to become the collective identity of the firm (Stacey, 2003; Stacey, 1995). The established group identity further facilitates the development of idiosyncratic capabilities that cannot be attained by employees in isolation; regardless of their individual contributions to collective knowledge repositories of firms. When substantial changes occur in a firm’s established patterns and meanings as a result of knowledge sharing, the new collective knowledge assets developed in the process constitutes organisational learning, and is distinguishable from individual learning in being greater than the sum of individual inputs (Larsen and Bogers, 2014). In essence, organisational learning has an element of complementarity, which means that the experiences gained from socialising and learning within groups or teams, empowers employees to capitalize on their complementary strengths to create value. They also draw on the complementarities of different team experiences to compensate for systemic weaknesses such as economic, social, and environmental uncertainties, and thereby build the required meta-knowledge or transactive memory needed to maximize employees’ individual capabilities ( Baranchenko and Oglethorpe 2012; Argote, 2015; Lewis, 2003; Peltokorpi and Hasu, 2011).

### **2.3.1 Linking Organisational knowledge and Learning Using Process-Theories of Learning and Knowledge Sharing**

Vayda et al. (1991) argued that any robust definition of organisational knowledge must provide clear theoretical steps to depict the ‘processes’ involved in knowledge creation and sharing. They further noted that:

“Many social scientists use the term ’process’ in a loose, unreflective fashion…. as if they existed independent of human agency…. designating processes in terms of some recognizable outcome of events, even if the events themselves and the linkages among them are little known or understood……events and actions, when linked in some intelligible fashion, constitute processes” (p. 318-320).

Several process theories of knowledge sharing and learning have been developed across the different management sub-disciplines. Based on extant reviews of the most influential process theories of knowledge sharing developed within the last century (see Engeström and Sannino, 2010;Paavola et al., 2004*;* Sfard 1998; Vayda et al., 1991), five qualities of a well-developed process theory have been identified. First, it is argued that a good process theory must clearly define “a sequence of actions or events” in the process of knowledge sharing, that is assumed to hold true in a generalizable sense (Engeström and Sannino, 2010). Secondly, an explicit rationale, logic, or principle must be provided to explain the prescribed order of a theorised process sequence. Thirdly, the theory must include logical causal mechanisms to explain the transitions from one step to another in the sequence. Fourth, an instructive process theory must be somewhat prescriptive, in the sense that it stipulates the preconditions for effective knowledge sharing processes (Sfard 1998; Vayda et al., 1991). Engeström and Sannino (2010) noted that a good process theory may also be descriptive, as long as it provides a sound logic that allows for empirical testing and falsifiability. Finally, to avoid becoming a fad or a “universalist orthodoxy”, a good process theory must specify its limitations and should be compared periodically, to other process theories of knowledge sharing and learning (Engeström and Sannino, 2010). In the next subsection, a concise review is provided on the merits, limitations, and similarities among five instructive post-behaviourist and cognitive process theories of learning and knowledge-sharing, namely;

1. Rumelhart and Norman's (1981) three-step model of accretion, structuring, and tuning.
2. Kolb's (1984) cycle of experiential learning.
3. Engeström's (1987) theory of expansive learning
4. Nonaka and Takeuchi's (1995) Socialisation-Externalisation-Combination-Internalisation (SECI) model on the conversion process of tacit and explicit knowledge.
5. Bereiter’s (2002) model of knowledge building.

## **2.4 Review of Process Theories of Learning and Knowledge Sharing**

Sfard (1998) categorised the main process perspectives on knowledge sharing into two broad metaphors -the *acquisition* and *participation metaphors.* The acquisition metaphor is based on the ‘folk theory of the mind’, and is aligned with the commonly held view that human actions are driven by personally held “justified true belief” (Nonaka, 1994; Paavola and Hakkarainen, 2005). Here, the human mind is seen as a knowledge container, and learning is conceived as the process of filling it. In contrast, adherents of the participation metaphor view learning as a social process that is refined through participation in collaborative activities. Thus, the primary focus is on the process of *knowing* rather than the outcomes of *knowledge*, and the core argument is that knowledge does not reside on its own or within individuals; rather, it emerges from the *process* of participation in social knowledge sharing practices (Brown and Duguid, 2001; Lave and Wenger, 1991, 2002). Furthermore, human cognition and *knowing* is assumed to be “situated” in relationships and organisational routines, and is validated through participation and experience (Brown and Dugid, 2001). In other words, unlike the acquisition metaphor, the participation metaphor holds that the process of knowing is tied to specific social and organisational contexts. Brown and Dugid referred to the validation of knowledge through participation as “enculturation”, and Lave and Wenger (1991) used the phrase “legitimate peripheral participation” - a concept that is widely cited in education research on knowledge sharing. Lave and Wenger (1991) explained that *organisational knowledge* is embedded in the everyday practice of “work” and in organisational routines, and not in the individual cognition of employees. In their seminal paper, which had a significant impact on management reasoning regarding organisational knowledge sharing, they proposed that the fundamental unit within which organisational knowledge sharing occurs is the “community of practice”. They explained that these communities are established through organisational acculturation and collective socialisation processes. They further explained that employees are only able to understand their responsibilities by aligning with the expectations of others and management; which implies that organisational knowledge is a socially constructed phenomena (Weick et al., 2005).

Based on the above definitions, the acquisition and participation metaphors differ in their account of tacit knowledge. On one hand, the acquisition metaphor emphasises interactions among individuals as the main driver of knowledge sharing, without accounting for the role of the social environment or knowledge sharing context. The participation metaphor on the other hand, downplays the role of individual tacit knowledge and places greater emphasis on the knowledge sharing context. Sfard (1998) explained that both perspectives should not be viewed as mutually exclusive, and a good process theory of knowledge sharing must account for aspects of tacit knowledge acquisition among experts and the role of participation and social contexts in knowledge sharing. However, Paavola et al. (2004) cautioned that although a “consensus” would avoid the conflicts between both perspectives, researchers may face conceptual challenges in attempting to combine them in a single process theory of organisational knowledge sharing. Reviews of extant process theories of knowledge sharing by Paavola et al. (2004), and Engeström and Sannino (2010) identified five influential post-behaviourist process theories of knowledge-sharing that incorporate aspects of both the acquisition and participation perspectives. Paavola and colleagues proposed a new metaphor for these hybrid theories, referring to them as *knowledge-creation models of learning.* They further explained that:

“The knowledge-creation view represents a ‘‘trialogical’’ approach because the emphasis is not only on individuals or on community, but on the way people collaboratively develop mediating artifacts”

Next, a concise comparative review of the process-based knowledge creation/sharing theories is provided to inform the selection of a suitable *model of knowledge sharing* upon which to build this thesis on the dynamics of knowledge sharing in VEs.

### **2.4.1 Rumelhart and Norman's Three-step Model of Accretion, Structuring, and Tuning**

Rumelhart and Norman's (1981) process theory of knowledge sharing comprises three qualitatively distinct phases, namely; *Accretion;* or the process of *a*dding new knowledge to pre-established memory, schemas or knowledge repositories; *Structuring;* or the process of creating new conceptual structures to accommodate the integration of new knowledge; and *Tuning;* or the continuous and ongoing process of adjusting and aligning new knowledge schemes to suit specific task delivery, product development, or process optimisation (Paavola et al., 2012; Engeström and Sannino 2010). In an earlier paper, Norman (1978) noted that the proposed sequence from accretion through structuring to tuning is hypothetical, arguing that:

“The different modes of learning do not necessarily occur in sequence…. Still, one expects that over the course of learning about a particular topic, there will be phases in which the mode of learning is primarily of one form.…All three modes of learning are probably always present, however, because learning a complex topic has neither a definite starting point nor a definite ending point. The start always builds upon previously acquired material (thereby making unclear where the start really occurs).” (p. 42)

While the theory outlines sequential and seemingly universal stages of the learning process, Paavola et al. (2012) citing Norman (1982) noted that:

“Accretion, structuring, and tuning seem to be three basic modes of progression from being a novice to being a skilled performer. What is it exactly that takes place during these stages of learning? Alas, the answers are not known, but the search has begun. Several promising lines of research are being followed by investigators around the world.” (p. 89)

Paavola et al. (2012) and Engeström and Sannino (2010), both pointed out that the theory has yet to be explicitly tested empirically, and nearly all references to it have been made to support other knowledge sharing and learning theories.

### **2.4.2 Kolb's Cycle of Experiential Learning**

Kolb (1984) theory of experiential learning explains that collective learning occurs in ‘learning spaces’ and is both experience-based and interactional (Baker et al., 2002; Engeström and Sannino, 2012). Four stages of adaptive learning and knowledge sharing were proposed: *concrete experience*, *reflective observation*, *abstract conceptualisation*, and *active experimentation*. According to Kolb, knowledge sharing depends on how well organisations are able to resolve these apparently opposing cognitive dialectics. Abstract conceptualisation and concrete experience were conceptualised as opposing aspects of “*prehension”*, with the former representing “conceptual interpretations and symbolic representations” through the process of *comprehension*, and the latter representing the refining of personal experiences through the process of *apprehension* (Kolb, 2014). Reflective observation and active experimentation on the other hand, were viewed as two opposing ways of transforming experience into knowledge, where reflective observation focuses on generating knowledge through the process of *intentional reflection*, and active experimentation generates knowledge through sense-driven empirical testing(Kolb, 2014).The -*prehension* and *transformation* dimensions conceptualised by Kolb correspond loosely to Polanyi’s tacit and explicit dimensions of knowledge.

Kolbs theory has spawned other popular variants like the recent ‘4I framework’ by Crossan's et al (1999), which conceptualises the process of organisational knowledge sharing into *intuiting, interpreting, integrating and institutionalizing* processes. Despite its theoretical merits, a major shortcoming of Kolb's theory and derivatives is the lack of a sufficient rationale for the purported cyclic sequence of the four stages. Kolb (1984) noted that:

“…the learning process at any given moment in time may be governed by one or all of these processes interacting simultaneously. Over time, control of the learning process may shift from one of these structural bases for learning to another. Thus, the structural model of learning can be likened to a musical instrument and the process of learning to a musical score that depicts a succession and combination of notes played on the instrument over time. The melodies and themes of a single score form distinctive individual patterns that we will call learning styles.” (p. 61-62)

Perhaps the most significant shortcoming of Kolb’s theory as it relates to this study is that the original conceptualisation was intended to provide a categorisation for different learning styles, which the authors clearly acknowledged in an earlier publication (Engeström and Sannino, 2010). According to Engeström and Sannino:

“…authors commonly depict their own, simplified version of Kolb's original diagram……. This curiously frequent simplification may testify to a widespread wish to find genuinely dynamic process models of learning. It certainly does not adequately represent Kolb's theory and its actual uses as primarily, a classifying device” (p. 49)

### **2.4.3 Engeström's Theory of Expansive Learning**

Engeström (1999) developed a model for expansive learning based on the Cultural-Historical Activity Theory (CHAT) developed by psychologists, Vygotsky and Leontiev (Paavola et al., 2004). According to the theory of expansive learning, knowledge sharing begins with individuals questioning their existing practices. Subsequently, they begin to analyse the historical triggers within the system that gave rise to the practices in question. Following detailed historical analyses, they draw inferences and create new models and solutions for improving such practices. Next, they run experiments on the new models to determine the advantages and shortcomings over existing models. The other proposed stages are implementation, reflection, evaluation of the entire process, and consolidation of newly developed practices and processes (Engeström and Sannino, 2010). Through this expansive learning cycle, participants reconceptualise and modify existing practices. The authors however explained that the model of expansive learning was designed to guide context-specific experimentation and the sequence of stages could change depending on the experimental context (Engestrom, 1999; Engeström et al., 1995). They further developed an intervention technique called the “change laboratory” or “boundary-crossing laboratory”, which provides work teams with a series of guidelines to aid in the reflection and reconceptualization of mutual activities under the guidance of trained ethnographic researchers who would observe, record, compare, and analyse the changes in the activities of work teams. While it is quite similar to Nonaka’s SECI model, the theory of expansive learning makes an important advancement by including a methodology to account for the impact of culture (national and organisational) on learning and knowledge sharing in teams. Although the model is quite detailed and illustrative, the main deterrent in relation to this study is the time and resource constraints for conducting experiments and ethnographic research. Furthermore, although the model prescribes a generalizable sequence for the stages, its non-heuristic nature makes it difficult to apply quantitatively to examine knowledge sharing in several industries.

### **2.4.4 Bereiter’s Model of Knowledge Building**

According to Paavola et al. (2004), Bereiter’s model of knowledge building draws its core arguments from the work of Karl Popper (1972) on how individuals collectively build and propagate *conceptual artefacts* such as routines, product plans, business strategies, marketing plans, theories, ideas, and models. Popper explained that beyond the material world, (World 1), two other important aspects of reality are the world of mental states (World 2), and the world of conceptual creations (World 3) (Bereiter, 1994). In other words, Popper proposed that through human interactions in the physical and mental realms, pools of conceptual artefacts are developed and stored in a separate realm. These artefacts or warehouses of knowledge can be retrieved and manipulated to support the day-to-day functions in the physical and mental realms. So while the conceptual world depends on World 2 and World 1, Popper argued that it is nonetheless quite autonomous (Paavola et al., 2012). Bereiter criticized prior theories of knowledge sharing for viewing ‘the mind’ as a knowledge container, arguing that such theories presuppose that information and knowledge are tailored to the human mind but neglect the role played by conceptual artefacts in shaping cognition. Accordingly, Bereiter’s model of knowledge building distinguishes between the learning activities of the human mind that give rise to concepts, and the knowledge building activities occurring in the realm of concepts and theories (Bereiter, 1994). He argued that in firms, knowledge is shared using collectively developed conceptual artefacts, much in the same manner as scientists use theories and models to create new knowledge. Paavola et al. (2012) explained that Bereiter’s model assumes that:

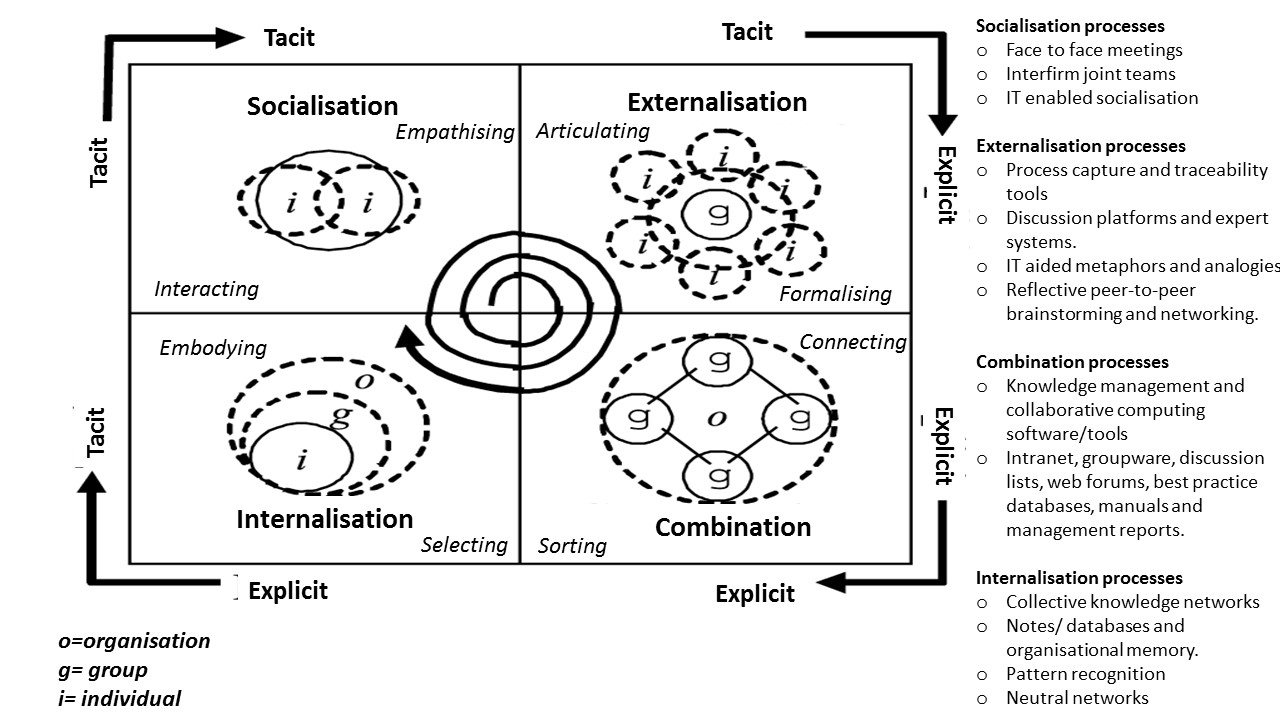
“The primary goal of members of an innovative expert community is not to learn something (i.e., to change, or simply add to, their own mental states) but to solve problems, originate new thoughts, and advance communal knowledge. In other words, their goal is to create new knowledge and add to the value of conceptual artifacts. Bereiter takes a pragmatic and naturalistic stance toward conceptual artifacts. Although they are nonmaterial, we should consider them to be as real as the objects of World 1 (the physical realm).” (p.561-562)

Although the model has been applied extensively in education research, for the purpose of this study, it may be rather daunting (without taking a long-term ethnographic approach) to distinguish the knowledge sharing processes used for improving employees’ capabilities from those used for developing organisational conceptual artefacts.

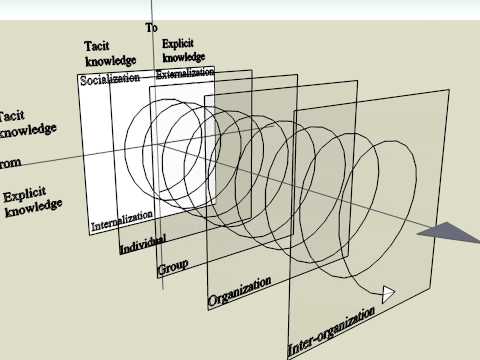
### **2.4.5 Nonaka and Takeuchi's Socialisation-Externalisation-Combination-Internalisation (SECI) Model.**

In their seminal work on knowledge creation titled *The Knowledge-Creating Company,* Nonaka and Takeuchi (1996) proposed a framework for knowledge sharing based on a clearly articulated epistemological distinction between *tacit* and *explicit* knowledge. Theyproposed that tacit knowledge can be converted to explicit knowledge and vice-versa, through an intricate knowledge creation and sharing spiral comprising four stages – *socialisation, externalisation, combination* and *internalisation*. According to the SECI framework, socialisation processes are used to share experiences and expert knowledge among employees, teams, and organisations. The tacit knowledge acquired through socialisation is then externalised as mental models, mind maps, artefacts, analogies and so on. Over time, different aspects of externalised knowledge are filtered, rationalised, and ‘justified’ through the organisation’s ‘collective mind’ and eventually combined to form new organisational routines and practices. As employees gather more experience, they begin to internalise their newly combined routines and eventually express them as new organisational tacit knowledge. Figure 2.1 below shows the SECI conversion spiral with an outline of some of the generic processes that characterise each stage. The SECI theory demonstrates a clear sequential rationale and captures spirals of knowledge conversions from tacit to explicit, and from individual through group, to organisational and inter-organisational knowledge as shown in figure 2.2.

Similar to Kolb’s and Norman’s models, the SECI model draws on Polanyi’s (1966) distinction between tacit and explicit knowledge and Piaget's (1970) figurative and operative aspects of human thought (Nonaka and Takeuchi, 1995). However, unlike other cyclic models, the SECI model clearly delineates the processes required for each stage of knowledge sharing. It includes two categories of processes: (a) processes for creating self-awareness as part of a creative collective and (b) processes for self-transcendence, trust-building, and empathy among parties sharing knowledge.



***Figure 2.1****: The SECI model (Nonaka and Takeuchi, 1995)*



***Figure 2.2:*** *The SECI model showing knowledge spirals across scalar levels*

The SECI further model attempts to explain how the constraints of individual boundaries, information asymmetries, and prior learning are overcome by collectives through situated learning. The model draws on the pioneering work of Nobel Laureate, Ilya Prigogine, famed for his theses on dissipative structures, complex systems, and irreversibility (Nonaka et al., 2006; Von Krogh et al., 2012).  Nonaka and colleagues explained that the metaphysical quality that is often ascribed to knowledge is one of the main reasons why organisational studies have focused extensively on information. The idea that knowledge is ‘abstract’ takes its root in ancient Greek philosophy. Pioneering Greek philosophers like Aristotle assumed that only physical substances were ‘real’ and intangible processes were often denied or viewed as subordinate to physical manifestations. In like manner, the smallest unit of a physical substance (e.g. its atoms) was seen as the simplest form of that substance, and complexity was presumed to increase with quantity. However, in his argument for transcendence in the physical universe, Prigogine (1980) explained that:

“The concept of evolution seems to be central to our understanding of the physical universe. It is remarkable that it appeared almost simultaneously in physics, biology, and sociology, although with quite different specific meanings. In physics it was introduced through the *second law of thermodynamics* …….in biology and sociology, the basic meaning of evolution was just the opposite, describing instead transformations to higher levels of complexity. How can we relate these various meanings of time—time as motion, as in dynamics; time related to irreversibility, as in thermodynamics; time as history, as in biology and sociology?……..We come, then, to the main thesis, which can be formulated as follows:

First, irreversible processes are as *real* as reversible ones; they do not correspond to supplementary approximations that we of necessity superpose upon time-reversible laws. Second, irreversible processes play a fundamental constructive role in the physical world; they are at the bases of important coherent processes that appear with particular clarity on the biological level. Third, irreversibility is deeply rooted in dynamics. One may say that irreversibility starts where the basic concepts of classical or quantum mechanics (such as trajectories or wave functions) cease to be observable. Irreversibility corresponds not to some supplementary approximation introduced into the laws of dynamics, but to an embedding of dynamics within a vaster formalism.” (p.xix)

Building on the above concept of transcendence, Nonaka and colleagues argued that knowledge sharing is better conceptualised as a journey from ‘being to becoming’ (Nonaka et al. 2000). They explained that through social interactions, the individual (likened to a “complex atom”), builds the capability to work collaboratively with others, and the ability to define and simplify problems (Nonaka and Von Krogh, 2009). They further argued that by transcending oneself, the bounded rationality associated with knowledge sharing is diminished and replaced with a collective “justified true belief”, specifically targeted at defining and identifying problems (Nonaka and Konno, 1998; Nonaka and Von Krogh, 2009; Tsai and Li, 2007). As an advancement over preceding models of knowledge sharing, the SECI model accounts for two overlapping sub-spirals in the knowledge sharing process:

1. The *knowledge conversion spiral* of tacit🡪explicit conversions, which captures the re-contextualization and re-coding of individual knowledge into collective and retrievable organisation knowledge.
2. The *social justification spiral which embodies* four distinct and human mediated processes involved in the creation and sharing of organisational knowledge (i.e. socialisation🡪externalisation🡪combination🡪internalisation) (Von Krogh et al., 2012).

Consequently, knowledge; according to the SECI model, transcends ‘material and physical spaces’, and is embedded in intangible “spaces” like the corporate vision, organisational culture, mind-sets, actions, and routines (see Alavi and Leidner, 2001). Explicit knowledge exists in material spaces and is often embedded in technology repositories. However, Nonaka and colleagues argued that while explicit knowledge is accessed and shared readily, unlike information, it is contextual and tacitly understood. Regarding the social justification of knowledge in the SECI model, (Nonaka et al., 2006) noted that:

“Due to ‘embodied necessity’, two individuals will never share exactly the same values, beliefs, observations and viewpoints. Knowledge results from individual investments, and thus reflects personal interests. Therefore, the flip-side of social justification is that knowledge creation is highly fragile and, in effect, individual knowledge often fails to benefit others in the organization and vice versa. On first glance, the fragility inherent in organizational knowledge creation is nothing but a severe obstacle to coherence, creativity, sharing and innovation. However, for reasons of cost and time, not all knowledge created by individuals in the organization can be shared; too much redundancy in knowledge offsets the advantages of specialization and division of labour. Newly created knowledge also needs to be integrated into the organization’s knowledge system. The knowledge system’s maintenance requires an infrastructure (e.g. information system, archive, procedure, routine) that becomes increasingly costly with the system’s growing complexity. Therefore, social justification should be understood as a mechanism by which the organization trades off innovation against cost containment in knowledge creation.” (p.1183)

### **2.4.6 Rationale for Adopting the SECI Process-Model**

The SECI model is instructive for this study because it applies to several levels of analysis (individual, group, organisational, and inter-organisational) in a sequential manner. However, some critics claim that the static differentiation between tacit and explicit knowledge is perhaps, an oversimplification of some tacit qualities of ‘knowing’ such as intuition and gut feelings, which are difficult and sometimes, impossible to codify (Gourlay, 2006; McAdam et al., 2007). Some have also questioned the idea of viewing tacit and explicit knowledge as a continuum, as implied by the proposed loops or spirals in Nonaka’s SECI model. Others claim that the SECI model does not clearly account for the role of “conceptual artifacts” because it assumes that tacit knowledge is created, stored and externalised from the human mind (Bereiter, 2005). There are also concerns that socialisation in the SECI model does not capture the important processes for resolving management controversies and conflicts, which is covered in the ‘questioning’ and ‘analysing’ stages in Engeström model of expansive learning (Engeström, 1999b, p. 380).

Nonaka and Von Krogh (2009) addressed the criticisms raised concerning the SECI model’s proposed tacit🡪 explicit conversion by drawing on the interrelatedness of both forms captured by Polanyi in the original conceptualisation of tacit knowledge cited earlier (see Nonaka and von Krogh, 2009). They explained that knowledge sharing begins with the communication of tacitly held ideas, opinions, and beliefs, which requires some form of socialisation. The communication of tacitly held knowledge like technical skills requires proximity and consistent practice, and its externalisation is evidenced in the transfer of new operational capabilities and routines. Engeström and Sannino (2010) noted that:

“Another weakness shared by the [other] theories is the separation of learning from intentional instruction. Only in the theory by Nonaka and Takeuchi is there an indirect provision for the role of instruction, in the form of general organizational enabling conditions.”

Nonaka and Takeuchi (1995) explained that certain “enabling conditions” created by management must exist for SECI knowledge sharing cycles to be initiated. As shown in figure 2.3, some of the enabling conditions identified include “organizational intention”, “autonomy”, “fluctuation and creative chaos”, “knowledge redundancy”, “requisite variety” and a conducive learning space- which was termed “*Ba*” in a later article (Nonaka and Konno, 1998). Nonaka and Takeuchi (1995) further emphasised that the propensity for knowledge sharing across individual or organisational boundaries is improved in firms with explicit and well-articulated organisational intention for knowledge sharing. Intention here, refers to the knowledge vision of a firm, which dictates the pursuit of external knowledge resources towards achieving a clearly articulated management objective. Another enabling condition for knowledge sharing identified is knowledge redundancy. In management, resources are considered supplementary if they are similar but improve each other’s value additively, and complementary if they are dissimilar but can be combined to produce new knowledge. Consequently, supplementary knowledge resources are those resources for which there is a high degree of redundancy or overlaps among collaborating firms (Rindfleisch and Moorman, 2001: 2) and these overlaps are critical because they enable significantly different firms to find common grounds for collaboration. According to Nonaka and Takeuchi (1995), such knowledge redundancies are essential for initiating the SECI knowledge sharing processes.While redundancy improves the ease of knowledge sharing for problem definition, it somewhat limits the opportunities for new learning because most of the available knowledge at the immediate disposal of collaborating firms is already known. Redundant knowledge however, presents the challenge of double jeopardy where on one hand, similarities in knowledge makes for easy alliances due to knowledge overlaps but on the other, it could turn potential partners into competitors because similar knowledge profiles could mean that either partner can satisfy the same market segment on their own (Sivakumar and Roy 2004).

The third enabling condition outlined is fluctuation and creative chaos, and this refers to the deliberate ‘‘breaking down’’ of existing routines and cognitive frameworks in order to arrive at a temporary chaotic situation which forces employees to unlearn old routines, learn new ones and reconsider strongly held perspectives that may be impeding the flow of new ideas through dialogue. This idea was drawn from the notion of Creative destruction, coined by Schumpeter, (2013) in his book on "Capitalism, Socialism and Democracy" where he defined innovation as:

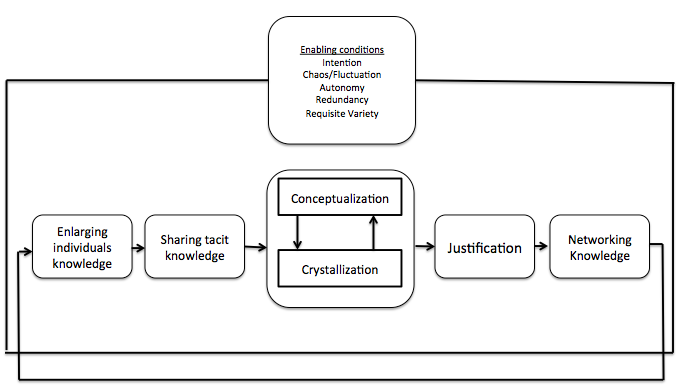
“industrial mutation [which] incessantly revolutionizes the economic structure *from within*, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism. It is what capitalism consists in and what every capitalist concern has got to live in…..Capitalism, not only never is but never can be stationary.” (p. 83)

The next enabling condition described draws on the principle of *requisite variety,* which proposes that an organisation’s internal diversity (e.g. knowledge artefacts, routines and systems) has to be designed to match the fluctuations in the external environment. Control, oversight, or regulation in organisations is often put in place to reduce internal variety and standardise routines across different facets of firms ‘operations (Tee and Lee, 2013; Turner, 2016). The logic behind this reasoning is that routines with high variety (where each employee adopts a different approach) also have a high tendency to alter the entire system's internal state, which should ideally be maintained as close to the system “goal state” (desired task/routine objectives in line with the organisation’s vision) as possible. Thus, in systems that are prone to high process variety, control or oversight serves to prevent the transmission of the effect of variety from the environment to the system (Ashby, 1991; Schilling and Phelps, 2007).

Drawing on the idea of requisite variety Nonaka explained that **for firms to properly manage the diversity of challenges they face in terms of knowledge based routines, rather than pursuing a fully controlled state, they need to build a repertoire of controlled responses, which are just as nuanced as the problems faced**. The concept was borrowed from the pioneering work of British cyberneticist and psychiatrist Ross Ashby, who formulated the law of requisite variety to explain how organisms adapt to their environment and new ways of encoding, interpreting and utilizing information generated from within a system (Ashby, 1991). He argued that of there is a large variety of actions available to a system as control measures, then such a system is able to compensate for a larger variety of perturbations.

While the SECI model does not emphasise disagreements and conflicts, Nonaka and Takeuchi (1995) explained the role of dialogue in socialisation, noting that:

“dialogue can involve considerable conflict and disagreement, but it is precisely such conflict that pushes employees to question existing premises and to make sense of their experience in a new way” (1995, p. 14).



***Figure 2.3:*** *Organizational knowledge creation process*

Paavola et al. (2012) explained that conflict is perceived differently in eastern and western cultures, and thus, the emphasis on conflict in Engeström’s model (based on western firms) compared to Nonaka and Takeuchi’s model (based on Japanese firms) could be cultural.

Likewise, despite Bereiter’s criticism of the SECI model’s poor representation of conceptual artefacts, he conceded that the SECI model goes “pretty far” in explaining important aspects of organisational concept-building through the externalisation and combination processes (Bereiter, 2005, pp. 175–176).

Of the process models of knowledge sharing reviewed, the SECI model has received the widest application in management and other social sciences. Taking together the advantages and short-comings of the models reviewed, the SECI model provides a useful template for capturing the processes of knowledge sharing and is adopted in this study. Details on the application of the model and the operationalisation of the characteristic processes of the stages are presented in the next chapter on the study’s conceptual framework.

Overall, the preceding review of the predominant models and frameworks of organisational knowledge sharing unveils a conceptually significant fact - knowledge sharing is a dynamic process that requires some form of management enablement. Although the enabling conditions for knowledge sharing were clearly explained, the original depiction of the SECI model does not clearly show how and where these conditions fit into the model. Accordingly, we turn to the field of strategic management for a concise review of the extant studies on dynamic capabilities, which are considered in the literature as a management strategy for enabling the development of expertise. The objective is to determine what they are, and to identify the ones that function as enabling conditions for inter-organisational knowledge sharing.

## **2.5 Organisational Dynamic capabilities: The Microfoundations or Enabling Conditions for Inter-Organisational Knowledge Sharing**

Originally, ‘management’ was seen as the science for maintaining the delicate balance between internal organisational order and external equilibria (Nonaka, 1988). However, following the Hawthorne experiments conducted at an Electric Company in Chicago between 1924 to 1932, Mayo and Rothlisberger, argued that management connotes much more than administration, and that organisational productivity appeared more closely associated with management styles and team work than employee benefits (Eisenhardt and Martin, 2000; Peltonen, 2015). This was a ground breaking experiment that heralded a new wave of studies focusing on strategies and frameworks for effectively deploying organisational resources to improve performance and create new value. Shapiro’s (1989) article titled *The Theory of Business Strategy* was pivotal in this regard, as it applied game theory principles to deduce the influence of a firm’s behaviour on the actions of its rivals and the business environment in which it operates (Nonaka, 1988). The studies that followed in this tradition emphasised the role of superior “strategic moves” by management, as a tool for manipulating markets and increasing the shares and profit margins of firms (Eisenhardt and Martin, 2000). The significance of management investments and sunk costs (retrospective costs) soon became the central focus of most studies, since it was realised that such investments, where successful, provided investor firms with a first mover advantage in the market. However, in a well-articulated critique of such game theoretic studies, Eisenhardt and Martin (2000) noted that:

“Rents, from a game theoretic perspective, are ultimately a result of managers' intellectual ability to 'play the game.' The adage of the strategist steeped in this approach is 'do unto others before they do unto you.' ……Since strategic interactions are what receive focal attention, the impression one might receive from this literature is that success in the marketplace is the result of sophisticated plays and counterplays, when this is generally not the case at all…….We worry that fascination with strategic moves and Machiavellian tricks will distract managers from seeking to build more enduring sources of competitive advantage. The approach unfortunately ignores competition as a process involving the development, accumulation, combination, and protection of unique skills and capabilities”. (p.513).

Eisenhardt and Martin’s view was predicated on pioneering arguments by Alchian (1950) and Selznick (1957), who suggested that the problem-solving or opportunity-seeking routines developed by management are in fact, the *microfoundation* of organisational knowledge and the source of competitiveness (Barney and Felin, 2013; Winter, 2003). Since managers’ ability to make rational decisions under uncertain conditions is bound to the information at their disposal as well as other environmental factors, most managers tend to “satisfice” when coping with day-to-day challenges because such operational challenges are often very dynamic and unpredictable (Helfat and Peteraf, 2003; Winter, 2000). As such, the common view held by strategic management researchers was that successful managers do not (and equally, should not) come up with "one-size-fits-all" solutions or operational routines (Teece and Pisano, 1994; Winter, 2003). Instead, they must continually revise their capabilities to keep up with changes in dynamic and unpredictable business environments. The ‘organisational capability’ to change existing routines, create new ones, or integrate changes into existing operations was thus viewed as a necessary requirement for competitiveness (Eisenhardt and Martin, 2000).

According to Winter (2003), an organisational capability is any “high-level routine (or collection of routines) that, together with its implementing input flows, confers upon an organization's management a set of decision options for producing significant outputs of a particular type.” (p.991). Organisational capabilities; as explained by Winter (2003), have had a history of different names, for instance, Selznick (1957) called them "distinctive competencies", Nelson and Winter (1982) referred to them simply as “organisational routines”, and Henderson and Cockburn (1994) called them “architectural competencies” (Eisenhardt and Martin, 2000; Kogut and Zander, 1992; Zahra et al., 2006). Kogut and Zander (1992) explained that these high-level routines are in fact, ‘combinative processes’ that facilitate the synthesis and acquisition of knowledge required for standard organisational processes. Likewise, Teece et al. (1997) noted that high-level organisational routines are idiosyncratic processes, which emerge from “path dependent histories” of firms. They were the first to use the term “dynamic capabilities” which is now widely applied in the strategic management literature. Over the years, dynamic capabilities have been defined variously, and have attracted enormous research attention, particularly in the knowledge management and learning literature. Eisenhardt and Martin (2000) defined dynamic capabilities as:

“antecedent organizational and strategic routines by which managers alter their resource base – acquire and shed resources, integrate them together and recombine them – to generate new value-creating strategies. As such, they are the drivers behind the creation, evolution, and recombination of other resources into new sources of competitive advantage…Dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die.” (p.1107)

Another important definition put forward by Zahra et al. (2006 p.3) viewed dynamic capabilities as “*the abilities to re-configure a firm’s resources and routines in the manner envisioned and deemed appropriate by its principal decision maker(s).”* It is generally agreed that dynamic capabilities are characteristically different from ordinary, substantive, or zero-order capabilities, because in being dynamic, they drive organisational change. According to Collis, (1994) dynamic capabilities “govern the rate of change” of ordinary or substantive capabilities, and Teece, (2007) added that they enable firms to excel above the “zero profit conditions”, which occur when homogeneous firms compete in perfect markets. Zahra et al. (2006) provided the following example to distinguish dynamic from substantive capabilities:

“A new routine for product development is a new substantive capability but the ability to *change* such capabilities is a dynamic capability. Just as a firm has many substantive capabilities of varying strengths, it has many dynamic capabilities of varying strengths. For example, the firm may have a strong dynamic capability to change its product development routine while at the same time have but a weak ability to reconfigure its accounting systems.” (p.5)

Although dynamic capabilities *are* most valuable when businesses operate in rapidly changing and unpredictable environments, Zahra et al. (2006) argued that the emphasis on ‘dynamism’ has more to do with the nature of the capability itself than environmental uncertainty. Furthermore, while dynamic capabilities may directly impact the performance of firms, performance alone is not an indication of the presence or absence of dynamic capabilities (King and Tucci, 2002). In fact, because they are quite expensive to develop, only well-targeted and deployed dynamic capabilities would have an impact on strategic goals and organisational performance. Therefore, the *management and* deployment of dynamic capabilities contributes more to performance-based benefits than the capabilities themselves. In other words, the dynamic capabilities view assigns a significant role to managers (Teece, 2012; Teece, et al., 1997) and places emphasis on their ability to develop routines that facilitate the building and exploiting of prerequisite knowledge resources. Studies have linked dynamic capabilities to NPD (King and Tucci, 2002) venturing into new regional markets (Bingham and Eisenhardt, 2011), creating and improving tangible and intangible resource portfolios (Sirmon, et al., 2007), managing and restructuring collaborative relationships (Dyer and Hatch, 2006), and other knowledge outcomes like replication and adaptation (Rothaermel and Hess, 2007; Winter et al., 2011).

Dynamic capabilities have been broken down into (1) capabilities that enable firms to sense and shape opportunities and threats, (2) capabilities that enable firms to seize and capitalise on opportunities, and (3) capabilities that enable firms to maintain long-term competitiveness by “enhancing, combining, protecting, and reconfiguring” the intangible (knowledge assets) and tangible asset of firms (Eisenhardt and Martin, 2000; Winter, 2003). Although there are several firm-specific dynamic capabilities, this study focuses on three main dynamic capabilities that have been linked specifically to inter-organisational learning and knowledge sharing in the extant literature on knowledge management, and organisational learning (Argote, 2015; Argote and Ren, 2012; Innis and Berta, 2016). These capabilities include; *Absorptive Capacity* (ACAP), *Transactive Memory Systems* (TMS), and *Organisational Interoperability* (OINT). Together, these dynamic capabilities play quite a significant role in the success of collaborative ventures and technology aided virtualisation (Badillo Enciso and Moreno Serrano, 2014; Camarinha-Matos et al., 2009). Next, a concise overview of each of the abovementioned dynamic capabilities is presented to highlight their different roles in inter-organisational knowledge sharing.

### **2.5.1 Organisational Absorptive Capacity**

In a book examining the factors that enable the ‘diffusion’ of technology across firms in the semi-conductor industry, Tilton, (1971) first to observed and documented the assertion that:

"R&D effort provided an in-house technical capability that could keep these firms abreast of the latest developments in semiconductor developments and facilitate the assimilation of new technology developed elsewhere" (p. 71).

Other pioneering studies like Evenson and Kislev (1975), Mowery (1983), and Allen (1984) made similar observations about this *rare capability* to assimilate external knowledge, which was thought to be conferred on firms by their own R&D efforts (Lane et al., 2006). However, in 1989, Cohen and Levinthal, in their article aptly titled *Innovation and Learning: The two faces of R&D*, extended this emerging body of literature with detailed theoretical explanations drawn from the field of industrial economics, along with supporting empirical evidence on how and why certain R&D efforts of firms played a secondary role in external knowledge assimilation (Cohen and Levinthal, 1989). Cohen and Levinthal gave a fitting name to this role - *Absorptive Capacity (ACAP) -* and in two subsequent articles published in 1990 and 1994, the authors provided a definition of ACAP, a description of its antecedents, and a detailed outline of its outcomes (Cohen and Levinthal, 1990).

Prior to this emergent body of literature, which culminated in the seminal paper by Cohen and Levinthal, technological knowledge was viewed as a “public good” (Lane et al., 2006). The prevailing assumption at the time was that the marginal cost of technological knowledge was very low, and the knowledge behind technology could be likened in many respects to trade winds that drive sail boat on an open sea. Cohen and Levinthal (1989 p. 570) however, explained that the apparent low costs of external technical knowledge acquisition was the result of prior investments in developing the capability to "identify, assimilate, and exploit knowledge from the environment” and this absorptive capacity “represents an important part of a firm's ability to create new knowledge.” Although ACAP was thought to stem from a firms R&D investments, the authors noted that it was a different type of learning from the traditional "learning-by-doing," through which firms improved themselves. ACAP was conceptualised as the unique quality that enabled firms to learn to do things differently (Cohen and Levinthal 1990).

This description of ACAP suggests that it requires long-term preparatory investments to develop, and is a necessary precondition for assimilating external knowledge and for technology diffusion. Such an assertion however, begs the question: if ACAP is a prerequisite for external knowledge assimilation, why do some firms not make the long-term investments required for ACAP building? In addressing this question, Cohen and Levinthal argued that the decision to invest in R&D is driven by managements’ perception of potential incentives and opportunities for learning and acquiring new types of knowledge as a result of making such R&D investments. They further identified other exogenous factors that influenced the decision to invest in R&D. For instance, they noted that the technological opportunities available to firms depends on the value of knowledge present in the firms’ immediate external environment. They stressed that in environments with high *knowledge appropriability* (or ease of knowledge transfer), the propensity to protect intellectual property diminishes, but at the same time, weak intellectual property rights protection increases the incentive to invest in R&D for ACAP building (Cohen and Levinthal, 1990). Similarly, when demand grows and income elasticity is high, they argued that it provides a greater incentive for firms to invest in R&D. While this original conceptualisation was pivotal to the development of the construct, equating ACAP to a firms R&D spending was problematic because it rendered the construct static (Lane et al., 2006).

Cohen and Levinthal (1990) revisited the concept from a socio-cognitive perspective and defined ACAP as a firm-level capability, arguing that it facilitates valuation, assimilation, and commercial utilization of external knowledge in new and innovative ways. They further suggested that firm-level ACAP was a by-product of firms’ innovation and problem-solving experience, and although it is a cumulative capability of the individual ACAP of employees, it also showed a great degree of path-dependence (Lane et al., 2006). Again, in 1994, they published a paper titled *"Fortune Favors the Prepared Firm,* in which they offered yet anothermodification to the definition of ACAP. They noted that in addition to providing the capability to exploit new external knowledge, ACAP facilitates accurate prediction of the nature and direction of technological advances. They suggested that firms that invested in developing ACAP were better positioned to capitalise on emerging trends and modify their product offerings accordingly (Cohen and Levinthal, 1994). Overall, Cohen and Levinthal’s conceptualisation of ACAP was summarised by Lane et al. (2006) as follows:

1. Using certain R&D activities firms are able to develop their knowledge in specific domains of science and technology, and this makes them nimble to detect and apply any related advances to the development of their products (The ability to recognise the value of external knowledge).
2. With experience, firms are able to develop procedures and processes that enable them to incorporate valuable external knowledge (The ability to assimilate external knowledge).
3. With practice, such firms become good at forecasting trends, and tailoring their products to specific markets by using external knowledge and the internal ACAP capability developed from R&D investments (The ability to commercially apply external knowledge).

Given the historical conceptualisation of ACAP, most of the literature that followed viewed ACAP as a product of R&D intensity and the ability to develop patents (Tsai, 2001; Winter, 2003). However, over the years, authors began to operationalize ACAP as a capability in its own right (Lane and Lubatkin, 1998), as a core competency (Szulanski, 2000), and as a set of knowledge sharing routines (Lane et al., 2001). In stark contrast to the original studies linking ACAP to R&D investments, Lane and Lubatkin (1998) argued that although participating in R&D contributed to developing the qualities associated with ACAP, a firms ACAP qualities gave a better indication of its ability to recognise, assimilate, and commercially apply new external knowledge than its R&D portfolio.

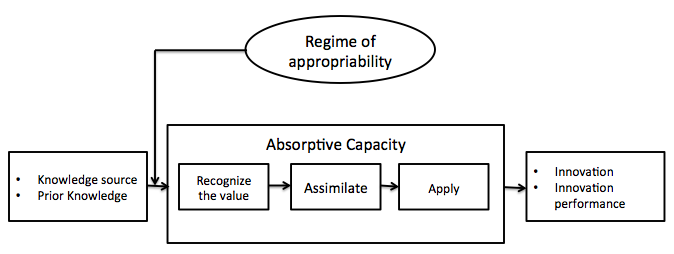
Following the conceptualisation of ACAP, about six prominent studies have attempted to elaborate on the original definition, mostly in an attempt to move the construct from the narrow R&D perspective and locate it in the broader domain of dynamic capabilities (Lane et al., 2006). Szulanski (2000) suggested that ACAP was fundamental for internal and external knowledge transfers because it enables firms to manage both *causal ambiguity* and *stickiness,* which are two predominant factors that affect knowledge transfers. Knowledge management and strategic management researchers observed that if a firms rivals are unable to clearly locate the source of a firm’s competitive performance, then it is usually unlikely that such firms can leverage on such causal links to success to enhance their own success – this is the so-called “causal ambiguity paradox” (Powell et al., 2006; Szulanski et al., 2016). Likewise, following Polanyi (1966) conceptualisation of tacit knowledge, it became apparent that one of the qualities of knowledge that makes its transfer difficult is its rare tendency to ‘stick’ to individuals and contexts- a quality known as stickiness (Szulanski, 2000). Szulanski argued that ACAP is a dynamic capability that managers have to build in order to deal with the challenge of causal ambiguity and stickiness in knowledge transfers. The next significant advancement in the conceptualisation of ACAP was made by Lane and Lubatkin (1998), who argued that ACAP is a dyadic and relational concept and should be studied at the level of dyadic learning since it is relative and may vary across different dyads of learning exchanges. They empirically validated a new form of ACAP, which they called *relative absorptive capacity*.

In a conceptual paper towards the development of a “*relational view”* of strategic management, Dyer and Singh (1998 p. 666) argued that a firm's capacity to identify, assimilate, and utilise external knowledge depends on the “sociological interactions” and collaborative processes developed with relevant partners. Like Lane and Lubatkin, they viewed ACAP as "an iterative process of exchange" but extended the relational view beyond dyads to collaborative relationships. They argued that knowledge exchanges facilitated by ACAP in such collaborations gives rise to "relational rents" or in economics terms, joint supra-normal profits (Dyer and Singh, 1998). This view is revisited and explored further in the development of the theoretical framework for this study in the next chapter.

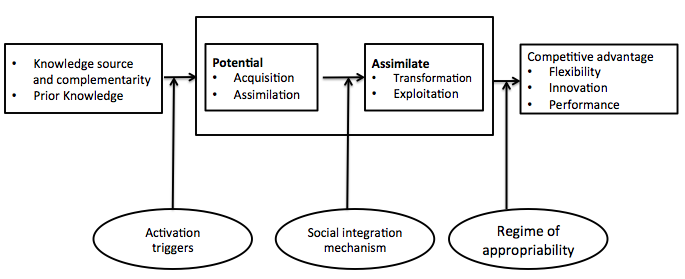
Van Den Bosch et al., (1999) revisited the conceptualisation by Dyer and Singh by delineating a clear role for the learning environment. Based on a number of case studies, they argue that firms’ ACAP is a process based construct, which is not only relational but also dependent on the knowledge environment where firms are based (stable or turbulent). Similar to Dyer and Singh’s view of ACAP, Van den Bosch and colleagues viewed it as an iterative process occurring between firms, their partners, and the external knowledge environment (which could be industry, market, or location driven) (Jansen et al., 2005).

But perhaps, the most notable extension of ACAP was proposed by Zahra and George (2002), who argued that ACAP is a dynamic capability or "a set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge" (2002: 186). They further reconceptualised ACAP into two distinct but overlapping subsets; namely, potential ACAP and realised ACAP. The authors outlined four components of ACAP, with each subset representing a different scope of value creation and knowledge sharing. They explained that:

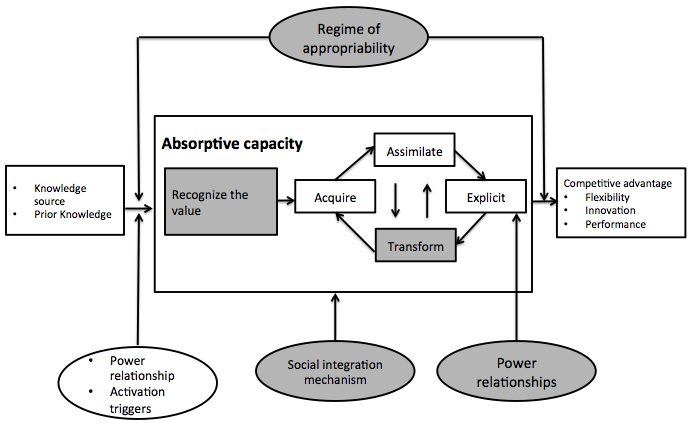
“Potential capacity comprises knowledge acquisition and assimilation capabilities, and realized capacity centers on knowledge transformation and exploitation. Reviewing prior research, we observe that most empirical studies show significant relationships between ACAP and innovative output and other outcomes that pertain to creating a competitive advantage. These outcomes reflect a firm's realized capacity. The potential capacity component, however, has received disproportionately less empirical scrutiny when compared with realized capacity……we posit that potential capacity provides firms with the strategic flexibility and the degrees of freedom to adapt and evolve in high-velocity environments. By doing so, potential capacity allows firms to sustain a competitive advantage even in a dynamic industry context.” (p.185)



*Cohen and Levinthal’s (1990) Absorptive Capacity model*



*Zahra and George’s (2002)* *Absorptive Capacity model*



*Todorova and Durisin’s (2007)* *Absorptive Capacity model*

***Figure 2.4****: Evolution in the conceptualisation of Absorptive Capacity.*

Although this conceptualisation of ACAP has endured empirical and conceptual scrutiny (Camisón and Forés, 2010; Gino et al., 2010; Lane et al., 2006), one important critique of Zahra and George’s reconceptualization by Todorova and Durisin (2007) is noteworthy for the purpose of this study. Todorova and Durisin, like Zahra and George agreed that ACAP as a dynamic capability that helps to sustain a firm's competitiveness. However, they contended that although the reconceptualization into potential and realised lends the concept to proper empirical investigation, the reconceptualised framework had some ambiguities and omissions. First, they noted that the original idea of "recognizing the value," of external knowledge, which is critical for ACAP was omitted from the reconceptualization. Furthermore, they questioned the distinction between potential and realised ACAP, arguing that:

“the new component -namely, knowledge transformation - is not the step after knowledge assimilation, but represents an alternative process linked to assimilation by multiple paths. If we follow this line of reasoning, the neat distinction between the new constructs- namely, potential absorptive capacity and realized absorptive capacity- does not hold any more…… Researchers who use the Zahra and George model and do not reintegrate Cohen and Levinthal's (1989, 1990) conceptualization and related research may miss out on knowledge already existing in the scientific community” (p.775 and 783)

Accordingly, in our examination and operationalisation of this dynamic capability in the next chapter, we recognise Zahra and George’s contributions (see Table 2.1), but take into account the following critique, because the ability to recognise the value of external knowledge as suggested in the original conceptualisation, is viewed as one of the main drivers of VE formation.

***Table 2.1*:** *Dimensions of Absorptive Capacity (Zahra and George 2002)*

|  |  |  |  |
| --- | --- | --- | --- |
| Dimensions of ACAP | Definition | Components | Role |
| Acquisition | “Acquisition refers to the capability to identify and acquire externally generated knowledge that is critical to its operations” | \*Prior investments  \*Prior knowledge  \*Intensity  \*Speed  \*Direction | Scope of search  Perceptual schema  New connections  Quality of learning  Speed of learning |
| Assimilation | “Assimilation refers to the firm's routines and processes that allow it to analyse, process, interpret, and understand the information obtained from external sources” | \*Understanding | Interpretation  Comprehension  Learning |
| Transformation | “Transformation denotes a firm's capability to develop and refine the routines that facilitate combining existing knowledge and the newly acquired and assimilated knowledge” | \*Internalization  \*Conversion | Synergy  Recodification  Bisociation (or the ability of firms to recognize two apparently incongruous sets of information and then combine them to arrive at a new schema) |
| Exploitation | Exploitation is based on the routines that allow firms to refine, extend, and leverage existing competencies or to create new ones by incorporating acquired and transformed knowledge into its operations. | \*Use  \*Implementation | Core competencies  Harvesting resources |

### **2.5.2 Transactive Memory Systems**

TMSs was originally conceptualised by Wegner et al. (1985) as a mechanism by which individuals utilize and combine external knowledge from books, artefacts, and their peers to augment personal memory. Wegner and colleagues identified two distinct components of TMSs; first, the structural component used to link individual memory to *group memory;* and secondly, the transactive processes for encoding, storing, and retrieving knowledge from group memory. It is quite common to find the terms “transactive memory” and “transactive memory systems” used interchangeably in the literature, however Ren and Argote, (2011) noted that while transactive memory refers to the individual memory component, TMS refers to the collective or group memory system.

Transactive memory is the knowledge and experiences held by individuals as well as details about who possesses the type of knowledge that may be required for future purposes (e.g. the random memory system that tells us who to reach out to when in need) and where to find information about what others know (also known as meta-knowledge) (Argote and Ren, 2012). Individual transactive memory or meta-knowledge gives an indication of where to find “who knows what,” but TMS is a compound form of transactive memory involving larger groups like teams, firms, and collaborative ventures engaging in transactive processes and establishing a robust system of transactive memories accessible by all the members of the group (Peltokorpi, 2008). TMS can thus be defined as a shared system used by collectives engaged in some form of relationship, which is developed to enable group members to collectively encode, store, and retrieve requisite information in a timely fashion (Ren et al., 2006). Since these systems are often unique to each group, effective TMS require a systematic approach for updating the memory directory, allocating information to the right repositories, and stipulating the access and retrieval conditions (Argote, 2015).

In their review of three decades of research on TMS, Ren and Argote (2011) identified other similar concepts to TMS, such as He et al. (2007) concept of “shared-task understanding” or shared goals, strategies, and approaches to meeting group tasks, Klimoski and Mohammed (1994) idea of “team mental models” or collective mental representations of a team’s task, and Huber and Lewis (2010) concept of “cross-understanding” of each teammates metal models on a given task. While these concepts share a common theme -the role of collective cognition - TMS is quite distinct because it is more concerned with the timely and effective execution of tasks using a shared team memory. Unlike the other concepts, TMS does not entail shared goals, strategies, beliefs and so on (Choi et al., 2010). Also, TMS emphasises collaborative “division of labour” for group learning, memory retention, and knowledge sharing (Ren and Argote, 2011; Wegner, 1987). This cognitive division of labour is what enables team members to specialize in memorising and sharing different aspects of requisite knowledge. TMS in teams, firms, and inter-organisational collaborations functions like a knowledge repository for storing and retrieving group or organisational memory (Gino et al., 2010). Mathieu et al. (2008) summarised the main antecedents of TMS into (1) member attributes such as demographics, competencies and skills, and personality, the (2) team attributes such as group training, familiarity (shared experiences), communication, interdependencies (extent to which one outcomes depends on others), and existing knowledge structures, and (3) organisational attributes such *as* organisational structure, culture, and location.

A study by Liang et al. (1995) provided remarkable insight into how the concept of TMS operates in groups, and outlined three features that indicate the presence of well-established TMS. These features include the group ability for: (1) memory differentiation (2) task credibility, and (3) task coordination. By observing a group of engineers at an assembly plant for electronics, they found that in teams where the engineers were trained together as a group, each member seemed to specialize in holding memory of specific processes required for the assembly task, and members appeared to trust each other’s memory and expertise, which allowed them to work in a coordinated and effective fashion. On the other hand, in teams where members were trained individually, each member felt obliged to master the whole assembly process and everyone offered their own opinion (sometimes conflicting), which tended to slow down the pace of assembly compared to the teams trained together. Brandon and Hollingshead (2004) argued that cognitive interdependence is a critical prerequisite to the establishment of effective TMS, and is derived from reward/punishment systems and group task structures, which influence how group responsibilities are assigned. Several other studies have since established that groups in which members are trained together are better at developing advanced TMS than groups where members are trained individually because members can observe one another’s performance first hand, and are able to develop and store knowledge about each other’s strengths, weaknesses and expertise (Akgün et al., 2006; Mell et al., 2014; Sue Young et al., 2010). Also, the training atmosphere affords members the opportunity to communicate, ask questions and evaluate one another’s expertise in a relaxed learning environment, which reduces the friction encountered when questioning teammates’ expertise on actual tasks (Lewis and Herndon, 2011).

Another plausible explanation for the role of group training in TMS development was provided by Rulke and Rau (2000). Based on a series of observations, they identified five types of conversations that take place during group tasks. First, some conversations were led by participants claiming to have expertise in a given area. Secondly, other conversations were centred on participants claiming not to have relevant expertise. Thirdly, there were conversations where participants asked questions relating to the requisite area of expertise. Fourth, in other conversations participants were more interested in planning and coordinating group tasks from the onset; and finally, some conversations focused on evaluating the expertise of participants. They noted that in groups that had previously been trained together, most of their conversations were focused on the last three categories.

Team familiarity is another antecedent of TMS. It measures the extent to which team members know about each other based on prior relations or experiences, and it increases the tendency to learn about the expertise and past experiences of teammates (Akgün et al., 2005). For instance, studies by He et al. (2007) showed that familiarity was positively associated with the ease of locating expertise, and members of a team who had previous shared work experience were better able to associate members to specific expertise for enhanced group performance. However, other studies like Jackson and Moreland (2009) have shown contrary relationships between familiarity and the development of effective TMS. Concerning this discrepancy, Ren and Argote (2011) noted that:

“team familiarity affects the dimensions of TMS differently. Knowledge about other members from prior experiences is likely to increase general awareness of expertise distribution among members (the structural or content component of TMS), which may or may not affect TMS processes such as knowledge specialization, task credibility, or coordination”. (p.200)

Communication has been recognised as one of the key antecedents of TMS development, beginning from the seminal paper by Wegner and colleagues, where they likened the communication for TMS development to the sort of communication that occurs between couples in relationships. According to Hollingshead and Brandon (2003), communication enables team members to develop concrete perceptions of expertise, in order to move beyond individual demographics like gender, race, and educational background, which often obscures the ability to accurately decipher relevant expertise in practice. Group discussions have been shown to be an effective means of communication for TMS development. Through group discussions, members showcase their expertise to the group, which facilitates more precise assignment of tasks in the process of cognitive division of labour. This is critical for collaborative success because often times, cognitive division of labour occurs without actual communication, especially in time-constrained or geographically separated facets of a given task (Pearsall et al., 2010). Lewis (2004) noted that the channel and frequency of communication are just as important for the development of effective TMS as the actual interaction among employees and firms. These authors argued that the frequency of face-to-face communication encouraged the development of stronger TMS than other media like emails, text messages and telephone conversations.

However, in contrast to these findings, Kanawattanachai and Yoo (2007) argued that computer-mediated communication is just as important for the development of TMS today. One possible explanation for the discrepancies on the effect of communication modes on TMS development was offered by Ren and Argote (2011). They argued that communication and geography have a close association, and when members cannot engage in face-to-face communication due to distance, computer-mediated communication serves precisely the same purpose. Today, new technologies that enable “telepresence” also facilitate interactions across dispersed locations and could positively influence the ability of collaborating partners to develop shared cognitive division of labour. Geographic distribution has also been shown to affect the development of TMS in virtual teams (O'Leary and Mortensen, 2010). For dispersed teams, TMS can be artificially induced by management functioning as the disseminator of information (providing written feedback) regarding members’ specific knowledge domains (Moreland and Myaskovsky, 2000). Although only a few studies like Kanawattanachai and Yoo (2007), and O’Leary and Mortensen (2010) have empirically examined the role of TMS in virtual teams, the growing spate of virtualisation, geographic dispersion of collaborative networks, and advanced computer-mediated communication makes this a critical dynamic capability to examine in relation to collaborative knowledge sharing. While studies by Griffith et al. (2003) have shown that information technologies diminish the challenges of developing TMS in virtual teams, physical distance is nonetheless, a very significant constraint to TMS development, as Alavi and Tiwana (2002) noted that without a collaborative history, experts from diverse backgrounds and cultures may struggle to develop TMS from scratch. According to Cordery and Soo (2008):

“The boundaries created by virtuality, in the form of geographic, cultural, and temporal–spatial separations; the lack of ‘richness’ in many electronically mediated forms of communication; and the fluctuating membership of virtual team structures pose particular challenges to team knowledge development and information sharing.” (p. 491)

Organisations today rely extensively on their unique knowledge assets to distinguish their offerings from those of their peers. As noted, collaboration is an effective means of leveraging these assets as it enables firms to draw on the knowledge, expertise, and the experience of others in a manner that offers benefits to all parties involved (Akgün et al., 2006). As explained, TMS is a dynamic capability that enables firms to improve their performance and ability to share knowledge effectively in collaborations, as such, it is important to examine the role it plays in supporting knowledge sharing in VEs. Details on studies examining the effect of TMS on knowledge sharing are provided in the next chapter.

### **2.5.3 Organisational Interoperability**

The intensity of collaboration required for successful alliances often varies depending on industry and the collaboration objectives of partnering firms. However, irrespective of degree, collaboration has been shown through several studies to be the single most important factor for inter-organisational knowledge sharing and successful joint-ventures (Cao and Zhang, 2011). However, to be effective, collaborating firms need to conform to standardized interoperability frameworks for seamless knowledge creation, dissemination, and sharing. Although collaboration is often viewed in the research community as a logical approach for joint business ventures involving more than one firm, the sheer complexity of businesses makes effective collaboration with several partners practically difficult to achieve because it requires several levels of interoperability (Gesing et al., 2015). Furthermore, collaboration may exert only marginal and relational impacts on the overall success of alliances or joint ventures if the core aspects of that facilitate the smooth running of enterprise operations are not made interoperable. Sadly, the majority of studies on interoperability have so far, been confined to the realm of IT.

Interoperability is the adaptability of an organisation’s operations, processes, people, culture, and policies to those of other firms, which is needed to take advantage of collaborative opportunities in heterogeneous business environments (Campos et al., 2013). Organisations usually enjoy a great degree of structural autonomy to choose suitable architectures, designs, structures, and systems from a range of options, to provide the right leverage required to transact with other firms without unwarranted leakage of valuable data and information (Hellberg and Grönlund, 2013). Interfirm communication and knowledge sharing is often selective and dependent on firms’ willingness and ability to provide data and information in a format that is compatible to the different architectures, designs, and structures used by critical partners (Klischewski, 2004). Consequently, interoperability requires some degree of ‘associative or collaborative autonomy’ among partners who wish to standardise and control the different levels of information sharing, data sharing, and inter-/intra-firm communication and knowledge sharing required for successful collaborations (Pirnejad et al., 2008). As such, to effectively run collaborative networks involving several partners, interoperability must be viewed in a much broader sense than the traditional focus on systems.

For collaborative ventures, interoperability studies have mostly been conducted concurrently with studies on standardization. Standardization aims at ensuring compatibility among different systems, however, compatibility can be quite expensive to achieve, and often impractical, especially in short-term or one-off collaborations (Kazemzadeh and Sartipi, 2005; Reichert, 2013). Thus, interoperability research focuses on aspects of systems compatibility that are difficult to achieve (lacking or having conflicting standards or uniform implementation). Due to the high adoption costs and slow rate of standardization, interoperability studies focus on strategies for increasing compatibility in IT, systems, culture, and processes to minimize standardization/ synchronization costs (Legner and Wende, 2006). Focusing on interoperability therefore diminishes the bureaucratic red tape of collaboration and standardisation that often remain unspoken of at top strategic levels of management because they mostly occur in day-to-day operations, but are pivotal in determining the success of collaborations (Uusipaavalniemi et al., 2009).

There are currently two broad groups of studies on Interoperability. Exploratory studies are fewer and focus on investigating the interoperability solutions used by businesses and governments to improve knowledge and information flow in collaborative ventures. Majority of the studies on interoperability fall under the second category of constructivist studies, which focus on conceptualising new architectures, models, methodologies and typologies of interoperability (Rezaei et al., 2014). In both exploratory and constructivist studies, different forms of interoperability that impact collaborative success are often examined. While an exhaustive review of these different forms is slightly beyond the scope of this study, brief descriptions are provided in Table 2.2

***Table 2.2****: Types of Interoperability (Fewell et al., 2004)*

|  |  |
| --- | --- |
| Form of Interoperability | Description |
| Systems or Technical Interoperability | Deals with the machine level communication and is usually associated with heterogeneous hardware/software components, systems, and platforms for machine-to-machine communication. It is concerned with the technicalities associated with connecting computers for the purpose of exchanging information; it includes the standards & specifications required for coherent information exchange. It requires communication protocols and infrastructure for exchanging data among systems of collaborating parties. |
| Structural or Conceptual Interoperability | Focuses on developing conceptual models for interoperability to bridge the gap between technical and conceptual designs. It refers to the level of agreement between collaborating parties on the different technical and conceptual formats and schema for interoperability. |
| Syntactic Interoperability | Deals with the representation of data in machine readable formats and the goal is to identify elements and rules for mapping, and bridging between two or more systems to make them capable of communicating and exchanging data. |
| Semantic or Information Interoperability | This refers to the ability to interpret exchanged information meaningfully and accurately to produce compatible results that are interpretable by the end users of collaborating systems. To achieve semantic interoperability, parties must share a common information exchange reference model and the semantic challenge is mostly concerned with enabling different systems to understand and interpret shared information and data in line with the intended meaning. |
| Data Interoperability | This implies establishing a single data definition for all collaborating systems. Data interoperability requires all parties to be involved in the development of standards for data descriptions (catalogues and reference data), data access (database interfaces), and data transport (representation and protocols). Shared data can thus be stored only once, updated, and modified collaboratively to eliminate the tendency for redundant data versions (Approaches for data interoperability include the use of object orientation, extensible data models, extensible mark-up language etc.). |
| Semiotic or Pragmatic Interoperability | This is a higher level of semantic interoperability which deals with unifying all existing conceptual heterogeneity among interoperating systems to make all parties aware of the methods and procedures employed by each system so that the context in which the information is exchanged is unambiguous. |
| Organisational Interoperability | This is a function of technical, syntactical and semantic interoperability, which is concerned with the behaviour or preparedness of organisation to facilitate effective communication and transfer of data, information and knowledge across a variety of systems, infrastructures, geographic regions, and cultures. |

As shown in the description in Table 2.2, most forms of interoperability (save OINT) are concerned with the technicalities of technology-based communication among collaborating firms. However, OINT deals with softer relational factors that affect the other forms of enterprise interoperability required for successful collaborations (Fewell et al., 2004; Kingston et al., 2005).

Interoperable systems must be adaptable to different networks and life-cycle phases of a collaborative network, which may span geographical and legal jurisdictions with different interoperability legislation and requirements. The European Union and the United Nations have developed a number of interoperability frameworks to serve business, governments, and social needs. Notably, the EU has funded a number of interoperability schemes to facilitate collaborations, information, and knowledge sharing among government agencies and business enterprises globally. Examples include the Pan-European standards, created to address interoperability policy issues at country-level and facilitate interoperable delivery of eGovernment services for public administration and business ventures within the jurisdiction and beyond (Kazemzadeh and Sartipi, 2005; Zutshi et al., 2012). Likewise, the European interoperability framework (EIF), and the Interoperability Research Roadmap were designed to identify and mitigate interoperability challenges facing companies and government agencies within the European Union. A number of other useful frameworks and platforms have since been developed, such as ATHENA (launched in 2004 and focused on developing ontologies for IT and business interoperability), ECOLEAD (launched in 2008 to develop support-tools for running effective virtual enterprise breeding environments), and COIN (developed to support utility-like electronic services) (Fewell and Clark, 2003; Zutshi et al., 2012).

OINT is measured either in terms of *interoperability capability levels* or *interoperability maturity levels (*Fewell and Clark, 2003). The capability level refers to the rate of development and deployment of technological means, like the above listed frameworks. OINT maturity levels on the other hand, refers to the degree to which the relational and infrastructural aspects of interoperability are embedded in a firm. According to Clark and Jones (1999)

“Maturity models describe the stages through which systems, processes or organisations progress or evolve as they are defined, implemented and improved. Intrinsic to a maturity model is the concept of levels - with each level used to characterise the state of the system or organisation”

Due to the scope and objectives of this study, it is pertinent to examine the interoperability maturity level, or ability of organisation’s to interoperate with partners in a timely and efficient manner (Fewell et al., 2004). The maturity level of OINT gives an indication of a firm’s capability and available mechanisms in place for changing or adjusting OINT levels in line with the requirements of each VE engagement. The most prominent OINT model developed in the literature was put forward by Clark and Jones (1999) to assess OINT maturity levels among combat and military teams. The model itemises four main attributes of OINT namely:

1. *Preparation*

According to Clark and Jones (1999), preparation is the extent of preparedness of firms to interoperate. The emphasis of this attribute of OINT is the degree to which firms have developed congruent and inclusive infrastructure to position themselves for current and future collaborations. Preparedness encompasses the availability of interoperable doctrines, rules, and practices and the amount of previous relevant training and experience in interoperability that both management and employees have acquired. Organisations venturing into VEs need to be able to adapt their existing doctrines to the requirements of each VE engagement to reduce the impact of uncertainties on joint operations. Preparation also entails that they are capable of making infrastructural adaptations that are aligned to specific VE requirements but also based on some knowledge about emerging requirements in order to position themselves for changes. For successful collaborations, OINT doctrines must be flexible, to give firms the right amount of preparedness for sudden collaborative operations. With reference to OINT for military coalition operations, Hura et al., (2000) noted that some degree of familiarity with alternative interoperability doctrines and processes facilitates smooth interactions with a broad range of potential partners, however, as noted earlier, the right mechanisms must be in place to rapidly evolve, modify, and effect new interoperability doctrines. In this regard, Clark and Jones (1999) pointed out that standardised education, training, and practice are necessary for developing new OINT doctrines and enhancing existing ones.

1. *Understanding*

Understanding is the ability of firms to promptly decode the internal language, doctrine, and communication styles of potential partners from a range of organisational and cultural backgrounds, and is critical for collaborations and successful knowledge sharing. Although it is difficult to decipher the scope of a firm’s understanding, the authors outlined a number of indicative sub-attributes like the presence of shared interpretation of instructions, capabilities, and intent with a wide variety of organisations from diverse cultural, geographical, and industry backgrounds.

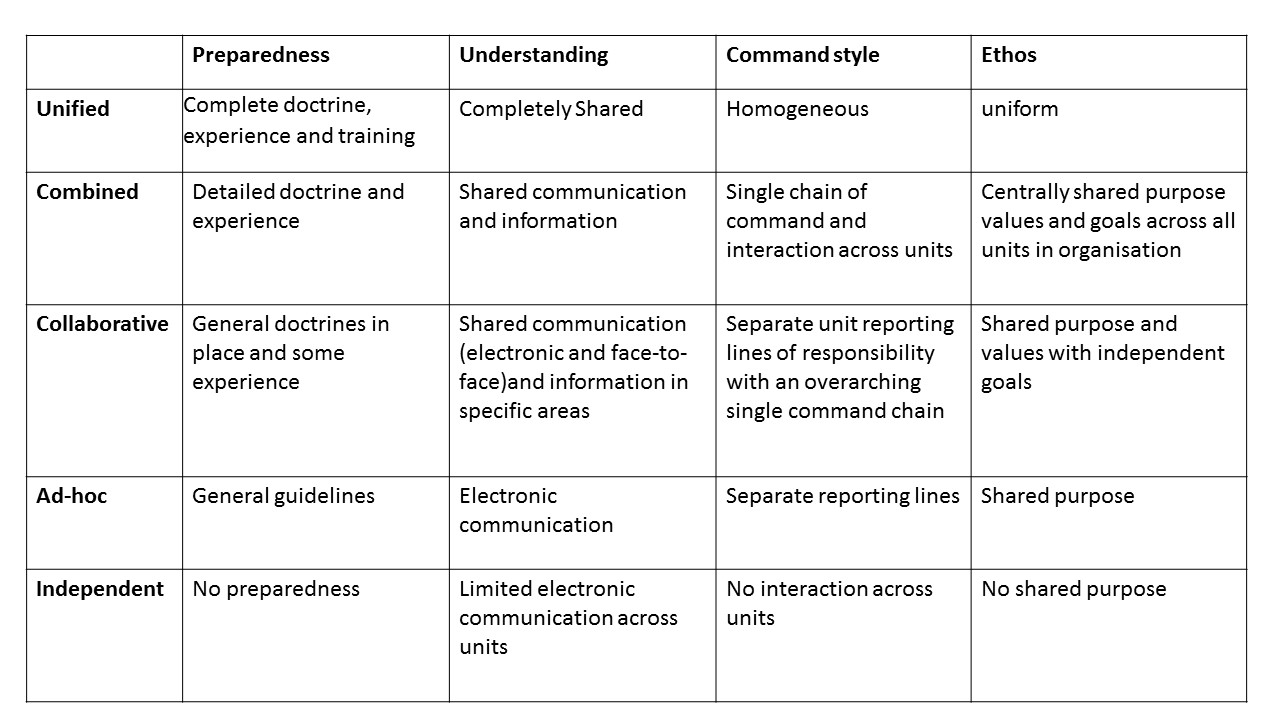
1. *Command Style*

Some practical sub-attributes of interoperable command styles include the ability and willingness to accommodate differences in leadership approaches in collaborations, the ability to self-organise, and the presence of organisational structures that facilitate different levels of autonomy and leadership among functional units and operational teams.

1. *Ethos*

Since OINT requires a delicate balance between performing effectively under adverse conditions and adapting to ongoing changes within a collaborative network, interoperable firms must possess the right organisational attributes for collaborative work such as flexible organisational culture, the propensity to develop evidence-based trust, and organisational goals and aspirations aimed at developing interoperable frameworks. These qualities together make up the Ethos of an organisation towards interoperability.

***Table 2.3:*** *Organisational interoperability reference model (Clark and Jones, 1999)*



As described in Table 2.3, Clark and Jones (1999) further proposed five maturity levels of OINT for the four attributes discussed, namely; unified (highest OINT level), combined, collaborative, ad-hoc, and independent (lowest OINT level). While it is not entirely necessary to achieve the unified level of OINT for all the attributes for successful collaborations, the dynamic capability to interoperate at the combined or collaborative level has been shown to be vital for effective knowledge sharing in collaborative ventures. Surprisingly, there are very few extant studies in management that have explored the impact of OINT on knowledge sharing, however, the evidence from studies on public-private collaborations, military collaborations and cross-government collaborations overwhelmingly supports this notion. Details on the role of OINT from prior studies are presented in the next chapter (theoretical framework).

In the following sub-section, three key meso-level outcomes of knowledge sharing identified from reviewing studies on the role of dynamic capabilities are examined (innovation, adaptation and replication).

## **Outcomes of collaborative Knowledge Sharing**

### **2.6.1 Innovation**

Drucker (1998), opined on the nature and sources of innovation quite succinctly, and his thoughts are re-echoed here to serve as an interesting prelude to the following terse discussions on innovation:

“There are, of course, innovations that spring from a flash of genius. Most innovations, however, especially the successful ones, result from a conscious, purposeful search for innovation opportunities, which are found in only a few situations; unexpected occurrences, incongruities, process needs, industry and market changes, demographic changes, changes in perception, and new knowledge. True, these sources overlap, different as they may be in the nature of their risk, difficulty, and complexity, and the potential for innovation may well lie in more than one area at a time. But together, they account for the great majority of all innovation opportunities.” (p.4)

Innovation is generally considered a vital source of competitiveness and perhaps, the most sought after capability by most firms. However, while there are numerous firm/industry specific measures and indexes of innovation, Crossan and Apaydin (2010) argued that these measures are not always aligned with academic conceptualisations. The term ‘innovation’ first appeared in organisational research in the 1920s, and the key proponent at the time, Joseph Schumpeter, argued that innovation depicted novelty in organisational outputs; such as goods, quality, production processes, markets, supply bases, and organisational structures (Hansen and Wakonen, 1997). However, several researchers have argued that a definition based entirely on novelty may be too broad (Crossan and Apaydin, 2010), and novel processes, products or services would only count as ‘innovative’ if they bring about inventions that are necessary, intentional, beneficial and having economic value (Camisón-Zornoza et al., 2004; Klein and Knight, 2005; Pittaway et al., 2004). Since the field of innovation is very broad, the concise review presented here draws on findings from seven key systematic reviews on innovation from different streams of management by Wolfe (1994), Gopalakrishnan and Damanpour (1997), Garcia and Calantone (2002), Adams et al. (2006), Pittaway et al. (2004), Hauser et al. (2006), and Crossan and Apaydin (2010).

Numerous definitions and a plethora of dimensions of innovation (such as radical, new, incremental, imitative, and discontinuous) have emerged ubiquitously with rather ambiguous operationalisations. Nonetheless, on the face of it, innovation is one of very few constructs in management that immediately invokes a connotation in the mid of a reader/researcher even without a definition. Consequently, in reviewing the literature on innovation as an outcome of knowledge sharing, the main concern was to determine if it mattered how innovations are labelled? A review on technological innovation by Garcia and Calantone (2002) revealed that about 15 construct and nearly 51 distinct scales were used in just 21 empirical studies on NPD reviewed, which perhaps suggests that the problem is less definitional and more to do with the incongruent typologies captured under the big umbrella called innovation. In view of the complexity and context-specific nature of innovation, Wolfe (1994) advised that researchers examining innovation should give consideration to locating the streams of innovation research relevant to a given study, explicating the focal stage(s) of innovation the study seeks to emphasise, and clarifying how innovation as an outcome variable is conceptualised.

Three streams of innovation research have been identified; namely; research focusing on innovation diffusion, organisational innovativeness research, and innovation process research (Wolfe, 1994). Studies on innovation diffusion tend to focus on exploring the mechanisms that affect the diffusion or spread of innovation, and they often focus on the diffusion of patents. The objective of such studies is often to estimate “rates and patterns of innovation adoption over time and/or space” (Adams et al., 2006; Wolfe, 1994). This group of studies often use explanatory survey or questionnaire data expert judgement, or archival data on the rate of innovation diffusion (Attewell, 1992; Garcia and Calantone 2002). The studies on organisational innovativeness on the other hand, focus on the organisational antecedents that affect the rate and propensity to innovate and the unit of analysis is often the organisation. Variance-based empirical models such as a regression models based on survey data are often used to explain the variance in innovation. Studies in this tradition operationalise innovation as a dependent variable, seen as a function of the rate or number of innovations adopted by an organisation. Wolfe (1994) noted that the main criticism is that such studies view innovation as static because of the variance approach adopted, and as such, the rate of change during the innovation process is often overlooked. The author argued that one probable way of managing this challenge is to view innovation as occurring within a given context so as to focus on organisational-specific attributes of innovation as opposed to innovation-specific attributes. The third category are process based studies of organizational innovation, which focus on “how and why innovations emerge, develop, grow, and (perhaps) terminate” (Hauser et al., 2006; Wolfe, 1994). The unit of analysis is often the innovation process and more qualitative approaches are used in its operationalisation. In keeping with the tradition of the prior studies upon which the theorisation in this thesis is based, innovation is viewed as an outcome variable of inter-organisational knowledge sharing; rooted in the organisational innovativeness frame (Greenhalgh et al., 2004; Pittaway et al. 2004). However, to address the challenge of operationalisation alluded to by Wolfe, the other considerations outlined above are further clarified. As noted, there is a general problem of semantics that has confounded innovation research because researchers emphasise different stages of the innovation process without making it clear from the onset. Some studies view organisational innovativeness in terms of the number of innovations *adopted,* while others view it as the *rate* or *extent* of implementation of new knowledge. According to Wolfe (1994):

Studies in which the dependent variable is a composite score of the number of innovations adopted by an organization within a broad class of innovations assume, inappropriately, that different innovations have the same determinants. (p.415)

In consonance with key studies like Nonaka and Takeuchi (1996), whose model of knowledge creation and sharing has been adopted for this research, innovation is conceptualised as the rate or extent of implementation of new knowledge. However, this definition is still quite conflated as there are three main attributes of innovation recognised in the literature, which may affect how “the *rate* or *extent* of implementation of new knowledge is conceptualised” (Crossan and Apaydin 2010; Hauser et al., 2006; Wolfe, 1994). As shown in Table 2.4, researchers are in agreement that innovation in organisations could assume all of following attributes (1) *technological/technical* versus *administrative/organisational* (2) *radical* versus *incremental* (3) *product* versus *process*. Although researchers often study these attributes separately, Damanpour (1991), following a meta-analysis of effects of these attributes (administrative *vs.* technical; radical *vs.* incremental; and product *vs.* process) argued that they were not effective moderators of organisational innovation because they often occur together. Although in a previous study Damanpour (1987) had suggested that these attributes and stages be examined as separate aspects of innovation (see Crossan and Apaydin 2010), he noted in 1991 following a meta-analytic study that:

“Results suggest that the relations between the determinants [attributes] of innovation are stable, casting doubt on previous assertions of their instability. Moderator analysis indicated that the type of organisation adopting innovations and their scope are more effective moderators of the focal relationships than the type of innovation and stage of adoption.” (p.555)

In this study, since the focus is on innovation as an outcome of knowledge sharing in VEs, it is conceived that administrative and technological innovations are both potential outcomes engaging in collaborative ventures (Alvarez and Iske, 2015). In terms of the process/product dichotomy, the process attribute is somewhat related to both administrative and technological innovations, while the product/service attribute is more related to technological innovations (Kim et al., 2012). In a sense, innovation can be viewed as both an outcome and a process of knowledge sharing. Thus, for this purpose, a broad definition of innovation is adopted from the most recent meta-analysis on innovation studies by Crossan and Apaydin (2010) (to the best of the researcher’s knowledge):

“Innovation is the production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome.” (p. 1155)

***Table 2.4****: Attributes/forms of innovation*

|  |  |
| --- | --- |
| Attributes of innovation | Definition |
| Administrative innovation | This is the creation of novel organisational designs that support innovative production and delivery of processes, goods, and services. |
| Technological innovation | Deals with the nature and rate of technological change that supports the design, delivery, and production of novel and economically viable processes, products and services. |
| Radical vs incremental innovation | Radical or disruptive innovations are administrative or technological innovations that significantly alters the industry or market for similar goods, services or processes, or creates an entirely new market niche or segment.  Incremental innovation are administrative or technological innovations affecting existing product, service, and processes with significant enhancements, alterations or upgrades. |

The systematic review of studies on innovation by Pittaway et al. (2004) aptly sums up the rationale for including a broad scope of innovation (administrative and technological) in this study on the impact of dynamic capabilities on knowledge sharing process and outcomes in VE collaborative networks. They noted:

“We find that the principal benefits of networking as identified in the literature include, risk sharing; obtaining access to new markets and technologies; speeding products to market; pooling complementary skills; safeguarding property rights when complete or contingent contracts are not possible; and acting as a key vehicle for obtaining access to external knowledge.…….network relationships with suppliers, customers, and intermediaries such as professional and trade associations are important factors affecting innovation performance and productivity. The review identifies several gaps in the literature that need to be filled. For instance, there is a need for further exploration of the relationship between networking and different forms of innovation, such as, process and organisational innovation” (p.2)

### **2.6.2 Adaptation and Replication**

Unfortunately, innovations and innovative routines are costly and time-barred, and in spite of the best efforts of the most innovative firms, they are not always timely, or at all possible. According to the Deloitte’s Shift Index, the average life expectancy of a Fortune 500 company has dropped from about 75 years in the 1960’s to below 15 years today, and may continue to decline to under 5 years at the current pace (Denning, 2011). This assertion was also reflected in a report by the American Enterprise Institute, which noted that about 88% of companies that were once revered as highly innovative just over 60 years ago, have either gone bankrupt, merged with others, or are simply irrelevant today (Perry, 2014). In a grim but astute observation, the executive chairman of Cisco, John Chambers, predicted that over a third of businesses today could fail in the next 10 years, and about 30% would succeed in recreating a poor and possibly, ‘digital’ shadow of their current form (Bort, 2015). For the most part, even with foolproof intellectual property rights protection, knowledge leakages still occur, and this has the adverse effect of diluting firms’ unique knowledge offerings or increasing their innovation investment portfolios, with the attendant risk of failed investments. Thus, a pressing question for researchers and indeed, the managers such highly innovative companies that are now gradually slipping into the ‘mediocre or failing’ category is; ‘*what can a firm’s management do to sustain its learning momentum and competitiveness?*

Kolb (1984) observed that in all human endeavours, learning from experience is the "holistic process of adaptation to the world" (p: 31). This assertion is even more so for organisations today, because organisational knowledge, as explained earlier, has tacit and ambiguous dimensions and in many cases, employees cannot quite decipher accurately, the source of their own competitiveness. Consequently, two seldom researched knowledge outcomes that are pursued by most firms alongside their innovative efforts are (1) the ability to *adapt* knowledge from others to suit specific contexts and (2) the ability to *replicate* existing knowledge verbatim (Winter et al., 2011). Replication is a knowledge sharing outcome that results from substantially modifying the routines, processes, and in some cases, the identity of a firm, so that they resemble those of competitors with more innovative routines and processes. Since the aspects of a competitor’s knowledge template that provide its competitive advantage may be unclear for the aforementioned reasons, there is often “a real challenge involved in discriminating the replicable and desirable features of the template from other possible causes of success” (Winter and Szulanski, 2001, p. 735). Thus, replication usually requires trials and errors and complex strategic judgment calls regarding what aspect of a template to replicate, the devices with which to achieve such replications, and how to position the replicated template to suits the new context without appearing copied. According to Winter and Szulanski (2001), replication:

“requires the capability to recreate complex, imperfectly understood, and partly tacit productive processes in carefully selected sites, with different human resources every time, facing in many cases resistance from proud, locally autonomous agents” (p. 731)

One of the main reasons why firms may opt to replicate knowledge is that replication is a concerted effort towards the exact copying of a set of routines, to afford the replicator the added benefits of such routines without having to invest heavily in decoding the underlying causes and interdependencies that support successful routines. Consequently, scholars like Winter and Szulanski (2002) have suggested that firms adopt the replication strategy to deal with the causal ambiguity inherent in transfers of complex but successful routines. Firms are sometimes coerced to replicate to keep up with changes in the knowledge profile of an industry or any one of the other drivers noted by Drucker (1998) (cited in the opening argument on innovation). However, they frequently act purposefully to replicate the practices or business models of other successful firm to improve their own competitiveness (Baden-Fuller and Morgan, 2010; Rivkin, 2001). Besides its obvious cost benefits (particularly in industries with high knowledge appropriability regimes), one of the main advantages of replication is that it affords firms the opportunity to outpace competitors in highly volatile industries, without bearing the “first-mover risk” of new innovations, which may fail, or take time to catch on (Ruuska and Brady, 2011; Winter and Szulanski, 2001). Nonetheless, the replicator “must derive from its limited experience with the evolving template an understanding of what is both replicable and worth replicating” (Winter and Szulanski, 2001, p. 731).

There exists a deep connection between firms and their environment, which in part, provides the context within which organisational knowledge is created and domiciled. Alluding to the Japanese concept of ‘*ba’* or an idealised space for learning by Nonaka and Takeuchi (1996), which was discussed earlier, it is clear that an organisation’s environment entails much more than its geography or industry. It includes important knowledge enabling facets of its history, relationships, experience, and its people (Walker and Wardleworth, 2016; Williams, 2007). Thus, the replication of context-dependent knowledge often goes in tandem with the replication of requisite parts of the knowledge context. However, in many cases, replicator firms are far removed from the innovator’s setting and thus, they have to either create a new and compatible context that allows replication or modify the knowledge offerings from innovative firms to suit their own context. This knowledge outcome is known as adaptation (Corredoira and McDermott, 2014).Consequently, in most cases, replicator firms have to make quick judgement calls to select between the pursuit of precise replications by exploiting external knowledge, or invest in learning to adapt external knowledge to their context through exploration (Ringov et al., 2015). As explained by (Williams, 2007)

“firms are often engaged in both careful copying of practices from a partners, and significant adaptation of practices. In other cases, replication and adaptation are combined within the same set of practices. A set of Latin American telephone companies balance replication and adaptation in their human resource practices. The firms replicate a set of common programs for the rotation, development, and compensation of managers. Each firm, however, adapts the exact positions and levels of the hierarchy to its own institutional environment.” (p.868)

Williams (2007) further argued that certain contingencies support or hinder firms’ decision to replicate or adapt knowledge from external sources, and one of such contingencies is the nature of the knowledge being replicated or adapted. They argued that replication is favoured over adaptation where knowledge is “discrete” or having little or no relevance to other actors outside the firm, such as customers, suppliers, and local institutions. By way of illustration, consider the replication of an internal manufacturing process. A firm may opt to replicate an innovative manufacturing process that is internal and discrete, because it does not have to worry too much about the impact of such replications on its external links. On the other hand, it is harder and comparatively costlier to replicate knowledge that is recognisable by relevant parties outside the firm. A firm attempting to replicate product knowledge for instance, may find such knowledge costly to obtain and difficult to integrate because product knowledge is often “highly interconnected” (Winter, 2007). In other words, the suppliers, customers, and other competitors operating in the same industry are usually aware of unique product attributes, so attempts to replicate such attributes would only amount to copying. In such cases, adaptation is often the preferred strategy.

Adaptation, on the other hand, can be costly for firms that are unable to predict how modifications to their knowledge profile would affect other aspects of their competitiveness. In other words, the less causally ambiguous a firm’s knowledge profile is, the greater the likelihood that knowledge adapted from other firms would succeed (Jensen and Szulanski, 2004; Kaynak and Hartley, 2008; Ruuska and Brady, 2011). By way of illustration, a marginally performing firm that is not fully aware of the critical selling points for its own product or service in a highly competitive industry, may be tempted to adapt successful knowledge offerings from others to grow its market shares. The problem here is that such a firm stands the risk of losing some subtle qualities that appeal to its niche of customers. Consequently, adapting new knowledge may obscure its selling points and result in the loss of market shares. Such firms may have to resort to competing with bigger and more successful players in a more saturated market segment.

Replication has been referred to in the literature as the “McDonald’s approach,” because the company became renowned quite early in the fast food industry, for their unique capability to recreate and operate similar facilities offering products and services at essentially the same standard in different geographical locations (Winter and Szulanski, 2001). For the company, their ability to replicate the knowledge acquired from running a rather successful template of operational routines, provided them with an unrivalled source of competitiveness (Argote and Ingram, 2000; Jensen and Szulanski, 2007; Rivkin, 2001; Teece et al., 1997; Winter, 1995; Winter et al., 2012; Winter and Szulanski, 2001). However, replicating such routines as in the case of McDonald’s, with the right level of precision is not as trivial an endeavour as copying, because it requires the careful creation of abstract patterns and meanings that are recognizable to all parties (customers, suppliers, and regulators) as “the same routine”—although occurring in a completely different organisational location (Szulanski and Jensen, 2004; Winter, 1995). Stressing the importance of maintaining the delicate balance between replication and adaptation, [D’Adderio](http://pubsonline.informs.org/action/doSearch?text1=D%27Adderio%2C+Luciana&field1=Contrib) (2014) noted that:

“Whereas, on one hand, complexity and causal ambiguity demand precise replication of the template for guidance and diagnostic purposes, on the other hand, deferring changes can significantly reduce the effectiveness of the transfer, by preventing the introduction of improvements and innovations and delaying adaptation to the local context.” (p. 1325)

Similarities between the organisational context of knowledge source and recipient is also a decisive factor for assessing the suitability of a planned replication or adaptation effort ([D’Adderio](http://pubsonline.informs.org/action/doSearch?text1=D%27Adderio%2C+Luciana&field1=Contrib), 2014). When contexts differ greatly, recipients stand the risk of missing out or overlooking certain important context-specific factors that influence how successful routines are developed and maintained. Studies have shown that majority of the failures in franchises, joint ventures, and other collaborative alliance are linked to botched knowledge sharing attempts due to differences in organisational contexts (D’Adderio, 2014; Tsang and Kwan, 1999). Conversely, when contexts are similar (e.g. country, culture, governmental regulations, labour requirements, and consumer preferences) replication becomes a safe knowledge outcome to pursue in collaborative ventures. Kogut and Zander (1992) touched on role of dynamic capabilities in dealing with the challenge of decoding knowledge from a specific context in order to render it adaptable or replicable. Explaining what he termed the “replication paradox” he noted that:

“In the efforts to speed the replication of current and new knowledge, there arises a fundamental paradox that the codification and simplification of knowledge also induces the likelihood of imitation. Technology transfer is a desired strategy in the replication and growth of the firm (whether in size or profits); imitation is a principal constraint. An individual is a resource severely restrained by physical and mental limitations. Unless able to train large numbers of individuals or to transform skills into organizing principles, the craft shop is forever simply a shop.” (p. 390)

Context and the ability to create the right *ba* or learning space for knowledge sharing exerts a powerful influence on firms’ ability to replicate or adapt knowledge. Firms like McDonald’s have managed to adjust their product offerings in certain locations to suit the local context through adaptation, but of course, the knowledge of how and what aspects to adapt came from studying, franchising, and allying with local firms operating within such contexts (Rivkin, 2001). In this study, it is argued that such an endeavour cannot be undertaken arbitrarily or based solely on expertise or experience in VEs because of the causal ambiguity associated to tacit knowledge sharing, particularly in different geographical operating environments. Thus, it is proposed that the processes of knowledge sharing required for successful adaptations and replication, and for deciding when to adopt each approach is mediated by the firm’s internal dynamic capabilities – specifically; its ACAP, TMS and its readiness to interoperate. The next subsection reviews the concept of inter-organisational collaborations, with emphasis on the emerging trend of virtualisation, which has created the new and pervasive organisational form for collaborations called *VEs*.

## **2.7 Inter-organisational Networks: The Emerging Role of Virtualisation**

A network is any web of connected nodes and links, where each node represents individuals, teams, or firms and the links connote different connecting and coordinating mechanisms, such as routines, processes, workflow procedures, meetings, and other forms of communication (Ebrahim, 2015). The links within a network function as conduits for resources, data, and information flows for the purpose of creating new knowledge at each node (Skyrme, 2012). By definition, a network is a relational structure “where independent people and groups act as independent nodes, link across boundaries, to work together for a common purpose; it has multiple leaders, lots of voluntary links and interacting levels” (Skyrme, 2007). Today, global networks are used to improve the economies of scale and margins of firms because they provide access to cheaper factors of production through global sourcing from different geographies, and enable firms to reduce logistics costs by moving intensive production phases closer to primary resources or consumer markets (Wagner et al., 2015). Through global networks, firms can gain access to an assortment of potential partners in real-time and cost effectively, with the aid of the internet and other computer-aided networking technologies. While time and proximity are pivotal criteria for effective networking, it seems paradoxical that modern advances in technology (particularly the internet) have enabled the creation of more dispersed networks through the process of *virtualization* (Skyrme, 2007).

As an emerging organisational design, virtualization results in flatter organisational structures, and wider spans of control to facilitate smooth coordination of geographically detached but mutually dependent functions. It is the process of using IT to respond in real time to changing demands while managing long-distance relationships with diverse partners (Liu et al., 2008). Most importantly, virtualisation enables firms to consolidate dispersed resources, and improve the deployment, utilization and replenishment of pooled resources. Virtualization often gives rise to computer aided virtual teams, virtual organisations, or VEs, where participants collaborate temporarily to meet specific market needs (Camarinha-Matos et al., 2009). In relation to the time dimension, virtualisation connotes a network of independent companies connected via integrated IT, and engaged in co-ordinated activities geared towards a common objective, like NPD or other time constrained market objectives like sudden changes in customer demands (Ebrahim, 2015).

Traditionally, NPD was sequential and involved four logical steps. First, acceptable and feasible product concepts were developed through iterated and controlled steps of feedback and feedforward between the R&D department, marketing, and the engineering teams (Schuh et al., 2015). After the development and formal description of feasible product concepts, the design team would then produce a prototype for manufacturing. At the manufacturing phase, critical make or buy decisions involving expertise from various departments such as purchasing, finance, and production planning are made (Wagner et al., 2015). The final stage usually involved staff training, factory/plant configuration, production/assembly scheduling and the actual manufacturing process. Today, with the evolution of information technology, big data resources, and modern manufacturing techniques such as 3-D printing for digital design (Marion et al., 2015), NPD is carried out through a process of ‘concurrent engineering’, which enables the research and development, design, and prototyping phases to run synchronously (Sobek et al., 1999; Terwiesch et al., 2002). This requires more dynamic make or buy decision making than the case of sequential product development.

Another view of virtualisation relates to a firms ‘virtual’ physical locus, and is defined as the geographical dispersion of an organisation’s relationships and operational processes, co-ordinated with the aid of electronic communications. The third view on virtualisation connotes virtualised processes. Table 2.5 below outlines some characteristic features of the three dimensions of virtualisations. From the description of the dimensions of virtualisation, it is clear that virtual networking or virtualisation is less about organisational structures than it is about formal and informal *human cooperation, coordination, and collaboration, and integration* processes, underpinned by information and communication technologies.

Next, the literature on collaborative networks is reviewed to examine the different types. Specific emphasis is placed on the nature, forms, and qualities of a special case of collaborative inter-organisational alliance known as *VEs* – a recent structural advancement in organisational form, which is underpinned by virtualisation*.*

|  |  |  |
| --- | --- | --- |
| Dimension of Virtualisation | Forms | Description |
| Location (space and distance) | Local → Global  Distributed → Centralized  Concentrated→ Dispersed  Physical → Virtual  Fixed → Flexible | In today’s networked economy, as technology and the internet open up global opportunities, suppliers can now compete in almost any market  Location virtualisation could also imply dispersing previously centralised tasks to different locations to take advantage of factors of production  Likewise, previously distributed activities can now be centralised (e.g. inventory management, depots and customer centres, logistics etc.)  For many processes, virtualisation enables the substitution of the physical presence with ‘telepresence’ (carrying out tasks over a computer network)  While tacit knowledge sharing requires personal contact as argued in prior subsections, telepresence through advancements in social media can now offer significant advantages over physical socialisation.  Examples include reduced travel, meetings fixed at participants’ convenience, the space to multi-task while overcoming meeting scheduling problems across distances through virtual meetings, possibility for smooth multi-lingual communication and real-time translations, and the time and space to make considered as opposed to off-the-cuff responses etc. |
| Time | Synchronous→ Asynchronous  Specified→ Flexible  Limited hours→ All hours | Information-based processes can be carried out in real time through virtualisation.  Knowledge-based processes that once required two or more participants to act simultaneously have now been replaced by asynchronous processes (sometimes automated) using virtual networks.  Individuals have the option to interact at their convenience in order to use time flexibly.  Virtual communication can be made available 24/7 without needing to be staffed continuously (online shopping). Time critical responses can be managed virtually by service representatives.  Virtual communication enables businesses to create non-stop cannels of knowledge and information flow that connects people to databases.  Different time zones can be exploited (e.g. ‘sunshine operations’ or moving tasks to different time zone |
| Structure and processes | Sequential →Parallel  Procedural →Object oriented  Aggregated →Dispersed  Stable →Dynamic  Hierarchical →Networked | Physical limitations have created serial work processes (passed from one person to another in sequence). Through virtualisation, shared knowledge repositories now enable firms to run such serial processes in parallel.  In concurrent engineering, Computer-Assisted-Design is used to make marketing, engineering and commercial processes run simultaneously using the same e-proposal that are updated collaboratively as different parts of the manufacturing process are completed.  Rapid supply chain reconfiguration is more feasible through automated and faster supplier sourcing, vetting, and selection processes. |

***Table 2.5:*** *Dimensions of Virtualisation (Skyrme, 2007)*

### **2.7.1 The 3 Cs of Networking: Coordination, Cooperation and Collaboration**

There are several definitions of ‘networks’ in management literature, but they all emphasise some degree of inter-organisational synergy (Camarinha-Matos et al., 2009). Essentially, networks are inter-organisational relationships formed by entities with substantial “operating autonomy” based on trust and contractual ties for the purpose of improving the pooled resource efficiencies of partners, appropriating opportunities that require diverse capabilities and overall performance improvement in collaborative tasks (Provan et al., 2007). As noted, collaboration, coordination, cooperation and integration are the driving concepts behind virtual networks, and these terms have been used in the literature interchangeably to describe different forms of networks (Fabbe-Costes and Jahre, 2008; Flynn et al., 2010). While they each refer to some degree of coupling and sharing among organisations, they are conceptually different in terms of the degree of resource sharing, ownership, and network governance they each connote ( Camarinha-Matos et al., 2009; Cao et al., 2008).

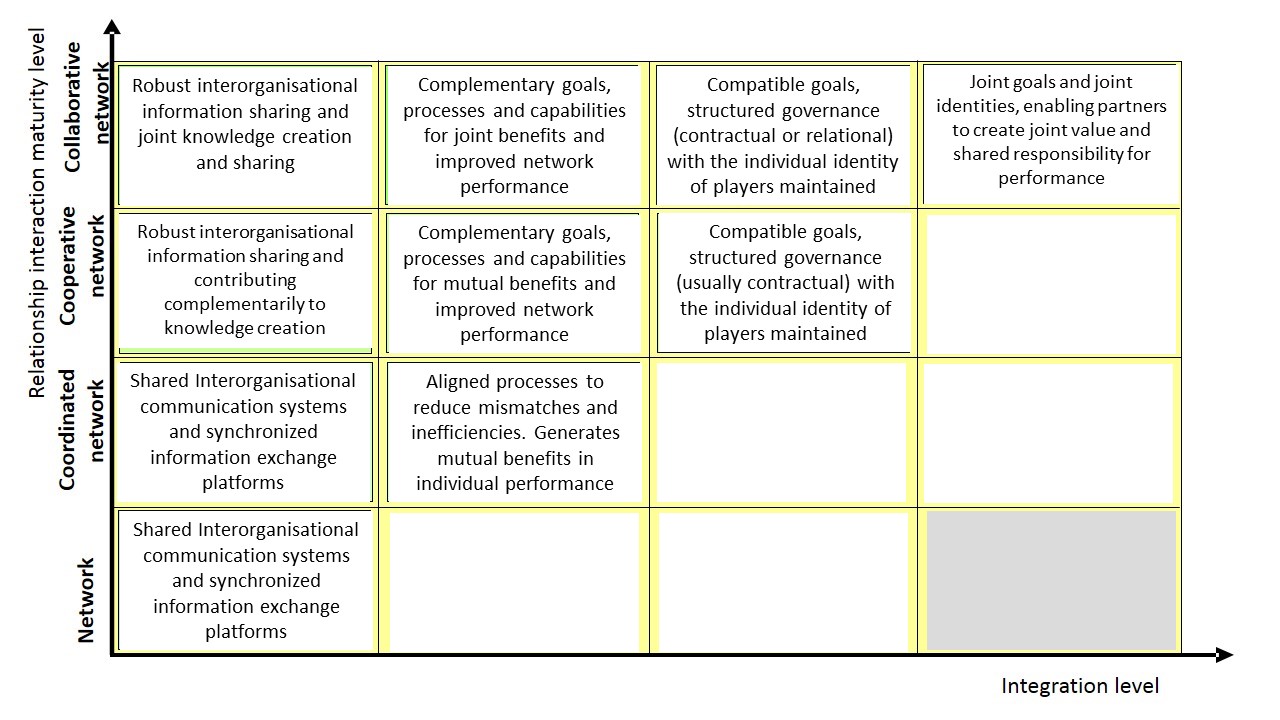
Coordination is concerned with managing dependencies and aligning resources among partners in a network to improve efficiency and overall performance. Players with different goals and ownership, can coordinate their activities to achieve the best possible value on joint projects (Palsule-Desai, 2013; Shukla and Jharkharia, 2013). Coordination is often characterised by informal relationships where information is shared only as needed, and authority/autonomy is retained by participating firms to maintain separate and independent portfolios for resources, risks and rewards. Coordination is often required for routine organisational tasks and promotes division of labour and task interdependence among partners.

Hence, nearly every inter-organisational relationship requires some degree of coordination for routine tactical and operational processes like exchanging information and joint planning, and other administrative processes such as the sequencing, and timing of inter-organisational operations (Das and Teng, 2000; Puranam et al., 2012; Uzzi, 1997). However, the extent of the coordination in inter-organisational alliances may vary depending on (a) the range of activities coordinated (e.g. processes, roles, infrastructure, resource management) and, (b) the nature of inter-organisational tasks (highly interdependent tasks require higher levels of task coordination). Coordination may also refer to partnership arrangements where tasks or projects are executed on a contract basis. Here, one firm acts as the leader, taking on all the decision making, accountability and leadership responsibilities and partners are paid on a fee-for-service basis to cover their contribution(s) to a project (Puranam et al., 2012). There are two fundamental concerns that coordinating partners must address when faced with high task interdependencies and environmental uncertainties. First, they need to assess and appraise the ability of partners to jointly manage tasks, and secondly, they need to assess partners’ capabilities and resources to coordinate interdependent tasks efficiently and in a timely fashion. Failure to address these concerns may lead to coordination failures from inadequate organisational design, structure, or implementation of coordination mechanisms (e.g. “omissions of crucial activities, spatial or temporal misallocation of resources, and incompatibility of activities intended to be complementary”) (Varshney and Oppenheim, 2011). Where they are significant, coordination failures could lead partners to abandon joint enterprises prematurely on account of poor feasibility.

Cooperation goes a step further to include the development of compatible goals or unified operations among players. Here, each player contributes in a specific capacity towards a collective goal under the governance and supervision of a key player (Camarinha-Matos et al., 2009). By definition, inter-organisational cooperation is the joint pursuit of agreed-upon goals and a shared understanding regarding the contributions and payoffs of cooperating parties. It is a behavioural quality of parties and ranges from cooperative behaviour on one hand, to highly uncooperative behaviour on the other (Varshney and Oppenheim, 2011). From the outset of network formation, even before investments are made, the potential contributions (inputs) of partners in terms of time, tangible and intangible resources, and market access, as well as their expectations (output) in terms of improved processes, services or products, new intellectual property rights, greater efficiency, and industry or regional legitimacy must be clearly negotiated. According to Gulati et al. (2012), the agreements reached regarding each party’s inputs and outputs is called “the intended extent of cooperation”, or “the intended scope of the relationship”, which may present in the form of short-term initiatives or long-term engagements. Where firms deviate from agreed terms, cooperation failure usually take the form of decreasing contributions in comparison to agreements, opportunism or attempting to claim more than agreed through resource misappropriation or the exploitation of higher bargaining powers by stronger alliance partners. Such unanticipated changes in partners’ contributions and claims could pose serious relational risks with far reaching consequences that could affect future cooperation (Smets et al., 2016). Consequently, cooperation can be viewed as a strategy that facilitates the sharing of investment risks and benefits that are difficult to appropriate on a transactional basis, such as tactical, operational, commercial, technological, or reputational risks and benefits (Gulati and Sytch, 2007).

Collaboration is an advanced level of cooperation, in which players contribute to decision making and planning towards common goals, shared risks and rewards (Cao and Zhang, 2011; Msanjila and Afsarmanesh, 2007; Ramanathan and Gunasekaran, 2014). Unlike cooperation, contributions, risks, and rewards are shared because the collaborative process requires high level of spontaneity in terms of the nature and timing of contributions made by partners and the collaborative governance mechanism in place (Camarinha-Matos and Afsarmanesh, 2005). Although contractual agreements are used, trust and compatibility among partners are very important factors for successful collaborations. Camarinha-Matos et al. (2009) argued that collaboration requires a balance between internal competition, coordination and cooperation to achieve efficiency in governance, task allocation and resource sharing. Since the resources, risks, and rewards of collaborating partners are pooled, the aggregate competitive advantages of partners known as ‘collaborative advantage’ are often greater than the sum of individual contributions (Malhotra et al., 2005; Vangen and Huxham, 2003). Figure 2.5 outlines the key differences among the types of networks.

While there is no unified definition of integration, most researchers agree that integration represents a ‘high degree’ of collaboration and shared governance in a network (Frohlich and Westbrook, 2001; Van der Vaart and Van Donk, 2008). Bagchi and Skjoett-Larsen (2005) defined it as “the comprehensive collaboration among supply chain network members in strategic, tactical and operational decision-making.”(p. 278) There are debates about the long-term value of integration because it often leads to expensive inter-organisational structural and infrastructural reconfigurations (Das et al., 2006). A systematic review of the antecedents of integration by Obayi et al. (2014) identified organisational culture, network governance, and knowledge sharing as important success factors. Although several studies have explored aspects of governance and culture that impact the performance of networked firms (Cai et al., 2009; Lockström et al., 2010; McCarthy-Byrne and Mentzer, 2011; Van der Vaart and Van Donk, 2008), empirical studies on the dynamics of tacit and explicit knowledge sharing among firms in such networks are surprisingly sparing. This study focuses on the emerging trend of virtualisation to explore knowledge sharing in VEs. VEs are a form of collaborative networks, thus the following subsection presents a concise review of the literature on collaborative networks.



***Figure 2.5:*** *Distinguishing the types of networks (Camarinha-Matos et al., 2009)*

### **2.7.2 Collaborative networks: Harnessing the Strength in Numbers**

*“In the long history of humankind (and animal kind, too) those who learned to collaborate and improvise most effectively have prevailed.” Charles Darwin.*

To effectively deal with rapid and erratic economic, political, and socio-cultural uncertainties in the global business environment, firms usually pool their capabilities and resources together in collaborative networks (CN) with strategic partners (Bititci et al., 2004; Cao and Zhang, 2011; Zacharia et al., 2011). In this study, the following definition of collaborative networks by Camarinha-Matos and Afsarmanesh (2005) is adopted:

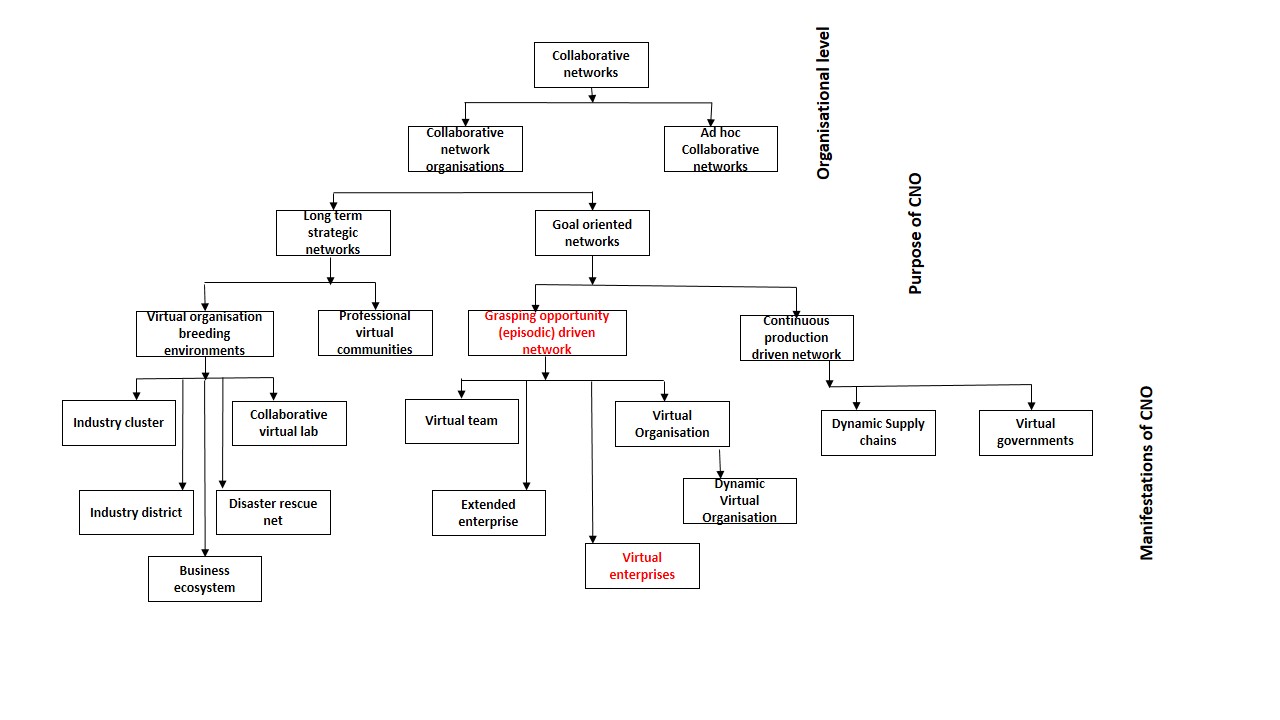
“A collaborative network is constituted by a variety of entities (e.g. organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in terms of their: operating environment, culture, social capital, and goals….supported by computer networks. Unlike other networks, in collaborative networks, collaboration is an intentional property that derives from the shared belief that together, network members can achieve goals that would not be possible or would have a higher cost if attempted by them individually.” (p. 139)

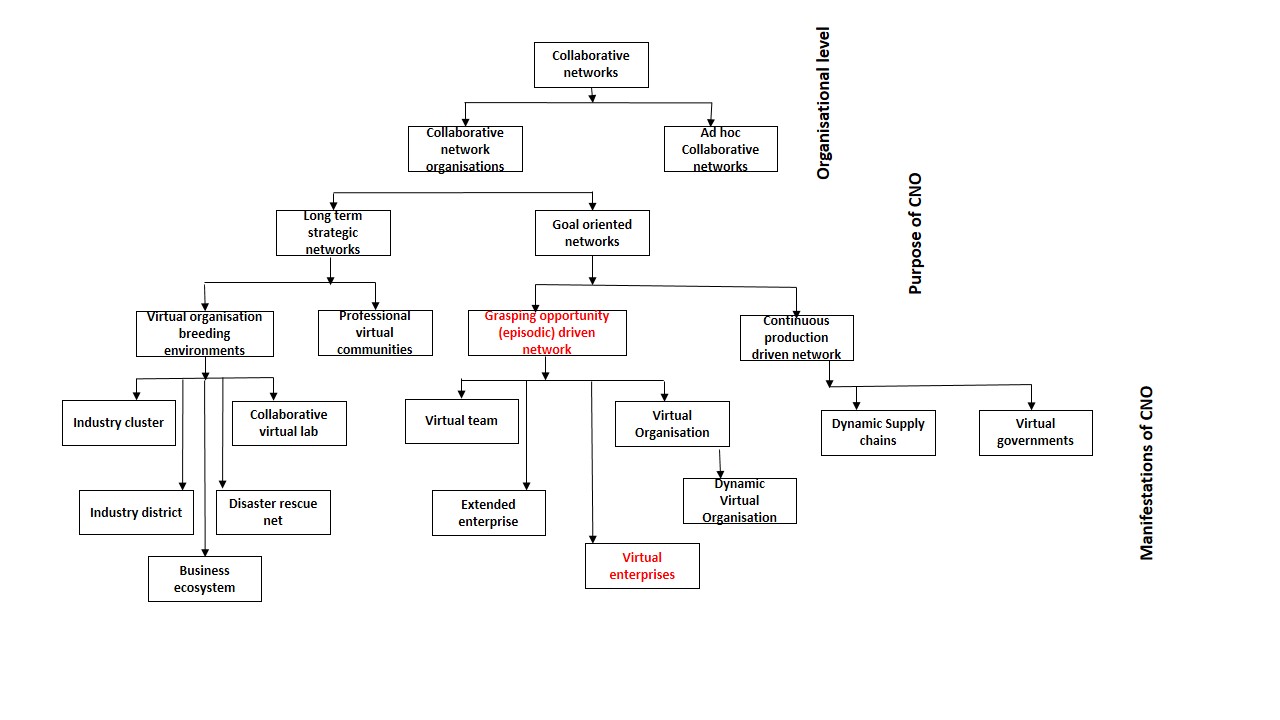
### **2.7.3 Types of Collaborative Networks**

Collaborative networks are generally categorised in the literature as *collaborative networked organisations (CNOs*) or a*d-hoc decentralised networks* as shown in figure 2.4 below( Camarinha-Matos et al., 2009; Esposito and Evangelista, 2014; Levén et al., 2014; Romero et al., 2007; Zaheer and Bell, 2005). CNOs are networks that are characterised by clear objectives and leadership structures, where specific tasks, functions, or processes are designated to specific nodes (firms or departments) within the network. In contrast, ad-hoc networks - such as improvised relief efforts in natural disasters - do not have predetermined objectives, and usually adopt make-shift governance for resource and function allocation as the need arises (Durugbo and Riedel, 2012). Researchers have further classified collaborative network organisations (CNOs) into *long-term* and *short-term (episodic) CNOs* (see figure 2.4)(Camarinha-Matos et al., 2009). Long-term CNOs such as virtual organisation breeding environments (VBE) and professional virtual communities (PVC) are designed to provide the infrastructural and relational support to enable members to form short-term collaborations quickly and effortlessly when opportunities arise. In long-term CNO’s as with most collaborative networks, communication and information dissemination is technology driven, and virtualisation could be spatial; where members are geographically dispersed, structural; where partners are assigned (Gunasekaran and Ngai, 2004). It is claimed that VBEs are able to form short-term networks spontaneously because members already share operating rules, interoperable infrastructure and cooperation agreements (Camarinha-Matos and Afsarmanesh, 2007; Camarinha-Matos et al., 2009; Romero et al., 2007). Some manifestations of VBEs as shown in figure 2.6 include - industry clusters, industry districts, business ecosystems, disaster rescue nets and collaborative virtual labs (Camarinha-Matos et al., 2009; Connell et al., 2014).

Notable examples of long-term VBEs include the Northeast of England Process Industry Cluster (NEPIC), Yorkshire Chemical Focus and Humber Chemical Focus for chemicals manufacturing in the UK, Virtuelle-Fabrik for the metal-mechanics sector in Switzerland and Germany, Swiss-Microtech for the watch industry in Switzerland and China, IECOS, an engineering and manufacturing cluster in Mexico, Orona-eic for the metal-mechanic sector in Spain, Supply Networks Shannon for Electronics in Ireland, CONSEN Euro-Group, a European small and medium scale enterprise cluster, TorinoWireless, for telecommunications in Italy, CebeNetworks and ISOIN for the aeronautics and aerospace sector in Germany and Spain respectively (Afsarmanesh, 2012).

These long-term networks facilitate rapid transition into goal-oriented, short-term networks called virtual organisations (Camarinha-Matos et al., 2009; Romero and Molina, 2011). Whereas operations research deals mainly with continuous collaborations like supply chains (Dyer and Hatch, 2006; Paulraj et al., 2008), market pressures, limited opportunities and business uncertainties have increased the occurrence of episodic, goal-driven virtual organisations in practice (Bititci et al., 2004; Cao and Zhang, 2011; Connell et al., 2014). The focus of this research is a special case of virtual organisation involving several firms collaborating virtually to meet episodic, profit driven and sometimes one-off business opportunities - referred to as *Virtual Enterprises* (VEs).

***Figure2.6****:Classification of collaborative networks (Camarinha-Matos et al., 2009)*

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## **2.8 The Nature and Scope of Virtual Enterprise Collaborations**

This research focuses on *virtual enterprises (VE)* – a special case of episodic virtual organisations that is *dynamic, profit-driven and* designed to respond to episodic and often one-off competitive market opportunities (Hung and Cheng, 2013; Msanjila and Afsarmanesh, 2007). Unlike other virtual organisations, new business opportunities serve as the trigger and prerequisite for forming VEs. They are essentially different from traditional collaborations because they are virtual, rapidly formed and by the same token, rapidly reconfigured (Huang et al., 2002). Byrne et al. (1993) in Bloomberg Businessweek published in 1993 provided one of the earliest definitions of VEs; which he called *virtual cooperation*. He defined virtual cooperation as:

"a temporary network of independent companies - suppliers, customers, even rivals - linked by information technology (IT) to share skills, costs and access to one another's markets. It will have neither central office nor organization chart. It will have no hierarchy, no vertical integration.” (p. 1)

A primary distinguishing feature of VEs compared to other collaborative networks is the temporary design for sharing competencies and the strict market focus (Presley et al., 2001). Tølle et al., (2002) defined VEs as technology aided, transitory and re-configurable business driven cooperation among firms. However, the selection partners and assigning of tasks often presents structural challenges in VE formation. On the other hand, defining sub-tasks, process harmonisation, project control/governance, and redistribution of earnings at termination, are some of the process-oriented challenges encountered in VEs. The following definition of VEs provided by Esposito and Evangelista (2014) based in a systematic review is adopted for this study.

“Virtual enterprises are temporary goal oriented collaborative alliances formed from an aggregation of autonomous organisations into a dynamic network. They are able to rapidly create common working environments and pools of capabilities using IT driven meta-management” (p. 147)

### **2.8.1 Life-cycle of Virtual Enterprises**

Although there is no fixed time-scale for VEs as they typically last for the duration of specific collaborations (Esposito and Evangelista, 2014), the characteristic life-cycle of VEs proceeds through five distinct stages (Camarinha-Matos and Afsarmanesh, 2007):

1. **Initiation and recruiting**: At this stage, members are incorporated into the VE from an open pool of prospective partners or from VBEs at the onset of new business opportunities. This phase represents the planning and incubation stages in the evolution of VEs and in many cases, it occurs before contract bids are made.
2. **Constitution and start-up:** This represents the initial operational phase of the VE, which entails role allocation, project definition, and contracting. The constitution and start-up phase is quite similar to the start-up of a new business, progressing from formation through validation to growth.
3. **Evolution:** VEs usually undergo changes as projects mature. These changes may involve membership, governance, operating principles or business focus/ strategy for the course of a project and for prospective extension of the VE.
4. **Metamorphosis:** Evolution may lead to radical changes in the objectives and membership structure of initial VE constitution. At this stage, VEs may evolve to become longer term virtual organisations.
5. **Dissolution:** This marks the end of the VE lifecycle, signalled by project termination. However, where VEs have evolved into long-term virtual organisations, dissolution is typically substituted by series of metamorphosis to preserve the working knowledge and relational capital acquired in the project execution and evolution stages.

### **2.8.2 Classification of Virtual Enterprises**

Based on an extensive review of scholarly articles, two predominant forms or VE configurations were identiﬁed, namely: *the hierarchical or centralised VE and the holarchical VE* or decentralised VE (Bititci et al., 2004; Camarinha-Matos et al., 2009; Cao and Dowlatshahi, 2005; Esposito and Evangelista, 2014; Yoo and Kim, 2002). Hierarchical or centralised VEs are convened by a leader or “broker firm”, responsible for apportioning tasks, risks, costs and rewards to participant firms. In manufacturing, the broker is often the end product integrator responsible for consolidating the various outputs of the entire enterprise. Holarchical or decentralised VEs in contrast – a term derived from the word ‘*holon’* from swarm-robotics and manufacturing systems optimisation research – are formed by autonomous and similar firms collaborating to accomplish a set goal without needing a centralised supervisory entity (Esposito and Evangelista, 2014).

Both hierarchical and holarchical VEs require computer-aided systems for coordination and standardisation of processes, inputs, outputs, and uniform performance measurements for all participants in the network (Backhouse and Burns, 1999). Although hierarchical and holarchical VEs may be vertical collaborations (i.e. collaboration among firms from complementary industries working towards a goal) or horizontal collaborations (i.e. collaboration among competitors in the same industry at the same stage of production), Camarinha-Matos and Afsarmanesh (2007) noted that holarchical VEs are more often horizontal collaborations. The general consensus however, is that VE configurations quite frequently predict the enterprise life cycle and fate of collaborations after project tenures elapse. This implies that VE configurations might also in some measure, affect the processes of tacit and explicit knowledge sharing (Esposito and Evangelista, 2014).

While robust capabilities and flexibility are obvious paybacks of VEs, the configuration of VEs presents certain real risks, such as the potential loss of proprietary rights, uneven allocation of tasks and rewards and challenges with trust building (Byrne et al., 1993). From the preceding discussions on VE, it appears that they are as intermediate form between market and hierarchical structured enterprises, distinguished from other intermediate organisational forms such as long-term cooperation in being episodic and virtual. Thus, the peculiar nature of VEs, and their recent emergence as a formidable business structure owing to our technology driven economy, makes VEs an important organisational context to explore, particularly in relation to collaborative knowledge sharing.

Majority of the studies on VEs focus on the role of information technology as an enabler of collaborative decision making and information sharing (Bititci et al., 2004; Candai et al., 2010; Camarinha-Matos & Afsarmanesh, 2005; Camarinha-Matos et al., 2009; Cao and Zhang, 2011; Durugbo and Riedel, 2012; Nyaga et al., 2010). However, as previously demonstrated, knowledge sharing – which is critical for the success of any collaborative relationship – is mainly influenced by the cognitive aspects of organisational learning (Lyons et al., 2012; Paulraj et al., 2008; Vangen and Huxham, 2003; Zacharia et al., 2011). While the relationship between the learning abilities of organisations and knowledge sharing is conceptually indicative, it remains underexplored. Thus the uniqueness of VEs provides a theoretically and practically compelling case to explore how the dynamic capabilities affect both tacit and explicit knowledge sharing.

## **2.9 Chapter Summary**

This chapter reviewed the extant literature on organisational knowledge sharing, learning, dynamic capabilities and collaborative networks to find research gaps and arrive at a conceptualisation of the dynamics of knowledge sharing in VEs. The review sets out the research agenda by providing a clear scope of organisational knowledge and by further identifing a fitting process-based model of knowledge sharing by Nonaka and Takeuchi called the SECI model. The SECI model operationalises the processes required for social justification in inter-organisational knowledge sharing and provides a sequence of steps for the continuous spiral of transformation from tacit (socialisation🡪externalisation) to explicit (combination🡪internalisation) knowledge. While the model is indicative, critics have pointed out that the main shortcoming is the lack of a conceptual representation of the model’s dynamic nature as it affects the spiralling processes of knowledge sharing from individuals through teams to entire organisations and collaborations. Based on the review, three dynamic capabilities; ACAP, TMS and OINT were identified as microfoundations or antecedent meta routines required for knowledge sharing as well as improving firms’ ordinary or substantive capabilities and competitiveness by facilitating innovation, adaptation and replication. In the next chapter, a conceptual framework linking these dynamic capabilities as mediators in the SECI model is developed and underpinned by relevant management theories.

# 3.0 THEORY

## **3.1 Background**

In the previous chapter, a review of the literature revealed the interesting potential to examine a dynamic capability mediated process-based model of knowledge sharing for innovation, adaptation and replication of knowledge in VEs. The review identified the SECI process-based model for social justification and tacit-explicit knowledge conversion in VEs, but argued that the model needs to be optimised by including three dynamic capabilities; ACAP, TMS and OINT as mediators of the outlined processes for tacit and explicit knowledge sharing. This chapter examines the literature for a theoretical rationale to underpin the proposed relationships among the processes for tacit knowledge sharing, the dynamic capabilities, and knowledge sharing in VEs.

Theory could be defined as “an ordered set of assertions about a generic behaviour or structure, assumed to hold throughout a significantly broad range of specific instances.” (Wacker, 1998 p.264). Although some researchers support the notion of research for research’s sake, a fundamental reason for social science research is to identify valid and applicable social principles that govern the actions and interactions of social collectives such as societies, organisations, and networks. Studies are categorised as ‘theory building’ if they advance the current knowledge of relationships among poorly understood social variables, or ‘theory testing’ when previously validated social principles are re-examined in different contexts (Corley and Gioia, 2011; Gioia and Pitre, 1990).

The current study explores relationships among prior established constructs in a theory building fashion, and this chapter presents the theoretical groundwork for the hypothesised relationships on knowledge sharing in VEs. The chapter begins with an examination of the role of knowledge as a source of competitive advantage for firms, drawing on the knowledge-based theory by Grant (1996). Next, the relational view of strategic management by Dyer and Singh (1998) is examined to explain the antecedents and business incentives for knowledge sharing in inter-firm collaborations. The relational view challenges and builds upon two predominant strategic management perspectives on value creation in firms; namely; the resource based view of firm-level ‘competitive advantage’ by Wernerfelt (1984) and the idea of industry led comparative advantage proposed by Porter (1989). The relational view theorises about how firms generate super-normal profits from the ‘relational rents’ of inter-firm collaborations. Following the discussions on these theories, a concise review of extant studies on knowledge sharing in collaborative ventures that have applied both perspectives is presented to rationalise the present study’s conceptualisation of knowledge sharing in VEs from these theoretical perspectives. The shortcomings of both perspectives are also highlighted. Based on these theories, a conceptual framework supported by relevant research evidence is developed, and research hypotheses on the mediating role of the dynamic capabilities explored on knowledge sharing for innovation, adaptation, and replication in VEs are advanced.

## **3.2 The Knowledge-Based View**

A recurring discourse in economics and strategic management concerns the trade-offs that firms’ must make in deciding whether to invest in self-organisation or to rely on the intervention of markets in pursuit of value creation. The core premise of the resource based view is that rare, valuable, and unique strategic resources are the main source of competitive advantage to organisations (Barney, 1991; Barney, 2001; Wernerfelt, 1995). However, as noted by Priem and Butler (2001a), ‘strategic resources’ and ‘competitive advantage’ are evaluated on the same basis of efficiency and effectiveness, thus, it may be misleading to extend the premises of the RBV to inter-organisational resources because collaborating organisations sometimes hold different views on what constitutes a ‘valuable resource’ (Priem and Butler, 2001b).

The knowledge-based view (KBV) is a useful perspective for examining the dual role of knowledge as a market-based driver of comparative advantage (Porter 1989) as well as a firm-based driver of competition as implied by the RBV (Grant, 1996b; Kogut and Zander, 1992; Pemberton and Stonehouse, 2000). The KBV assumes that knowledge, in both tacit and explicit forms, is an essential organisational resource, which can be shared and modified through strategic partnerships (Grant, 1996b). The view is underpinned by the single factor theory of value in classical economics, which holds that human productivity is organised around critical resources, and the scarcity of such resources is a measure of value. The KBV further proposes that firms are formed when it is more productive, profitable, and efficient to integrate the knowledge resources of different groups towards achieving desired goals (product or service) than to source for individual capabilities separately through markets. Here, ‘the firm’ is conceived as any group of individuals capable of co-creating knowledge and scarce value (product or service) through horizontal or vertical knowledge integration (Grant, 1996a). The theory also suggests that when firms can accumulate sufficient rare capabilities through knowledge integration, they establish a competitive advantage over their contemporaries. Horizontal knowledge integration is required because firm activities like the production of goods/services requires knowledge resources from several specialties, while vertical knowledge integration is used to pursue economies of scale (Aoki, 1986; Gil and Warzynski, 2015). Firms usually do not use all the knowledge capabilities at their disposal in own-production of goods or services. Therefore, there is always a residual knowledge-to-output surplus. On the other hand, firms sometimes require external capabilities to support their activities and to make up for any knowledge-to-output deficits. As such, resulting knowledge-to-output deficits and surpluses are managed through alliances and collaborations with other firms. In other words, the KBV suggests that the boundaries of the firm are determined by the efficiency, effectiveness, and scope of knowledge utilization (Felin and Hesterly, 2007; Gassmann and Keupp, 2007; Sveiby, 1997). Grant (1996) explained that:

“If markets transfer products efficiently but transfer knowledge inefficiently, vertically adjacent stages of production A and B will be integrated within the same firm if production at stage B requires access to the knowledge utilized in stage A. If, on the other hand, the output of stage A can be processed at stage B without the need to access the knowledge utilized at stage A, then stages A and B are efficiently conducted by separate firms linked by a market interface.” (p. 119-120)

This implies that to remain competitive, the knowledge capabilities of firms must be specialised, appropriable (i.e. reproducible and having a standard way of estimating the returns commensurate to knowledge shared), and transferable. However, firms’ boundary integrity and competitiveness are maintained by their ‘sticky’ tacit knowledge resources like the experiential knowledge of professionals, and the safeguards in place to protect easy-to-codify explicit knowledge from leakage (Easterby-Smith et al., 2008; Henttonen et al., 2016; Livanis and Lamin, 2016).

Four interlinked categories of economically useful tacit and explicit knowledge make up a firm's unique knowledge resources. Know-what (or declarative knowledge) refers to knowledge of details about processes, products, or markets. It is similar, but not synonymous to information, and is necessary for every organisational process, particularly for highly standardised tasks requiring large amounts of structured and detailed information (e.g. Legal or financial tasks) (Carud, 1997; Davenport and Prusak, 1998). The second category known as know-why refers to in-depth knowledge of the underlying scientific, socio-economic, or socio-political principles that underpin the development of expertise. The third and perhaps, most commonly researched form of knowledge is know-how (or procedural knowledge), and it entails practical knowledge or skills and capabilities for executing operational tasks (Aldrich and Yang, 2014; O'Dell et al., 1998). The fourth category is called know-who, and it implies meta-knowledge (knowledge about knowledge) about who knows what, why, and how across a firm’s requisite knowledge domains. Know-when and know-where are usually conceptualised as sub-categorises of know-who because the latter is viewed a precondition for acquiring relevant market know-where or know-when. Firms with know-who hold unique repositories of knowledge about market and individual capabilities, often acquired through a combination of experience and access to selective social and industrial networks in different fields of expertise (Grant and Baden-Fuller, 2004; Johnson et al., 2002; Lundvall and Johnson, 1994; O'Dell et al., 1998; Park et al., 2015; Roberts, 2000). In both tacit and explicit forms, know-what and know-why are codifiable, transferrable, and appropriable through different forms of knowledge alliances and propriety agreements (Bstieler and Hemmert, 2015; Grant, 2013; Hagedoorn, 1993; Khan et al., 2015; Wang and Li‐Ying, 2015). In contrast, a firm’s know-how and know-who are more idiosyncratic and require more relational mechanisms for knowledge sharing.

The fundamental argument of the KBV is that although firms are “knowledge constellations” or clusters of individuals capable of effectively deploying and co-creating a unique product, service, or managerial knowledge, knowledge resources of firms are augmented and updated through alliances and collaborations. However, the KBV does not offer sufficient explanations for the decision of some firms to engage in arms-length contracting for knowledge sharing over collaborations. According to classical economics principles, if knowledge is conceived as a critical resource as proposed by the KBV, then firms will pursue external knowledge resources for short-run competition through the market based on cost and availability. However, long-run competition is derived from firms’ internal capacity and capabilities. Thus, firms need to constantly improve their knowledge specialisation to remain relevant, or they may have to exit or change their industry altogether (Brynjolfsson and Hitt, 2003; Chen and Miller, 2015; Davenport et al., 1998; Davidson and Deneckere, 1986; Stein, 1989). Le Breton-Miller and Miller (2015) argued that while such knowledge deficits may arise partly due to poor knowledge sourcing from markets:

“the very qualities of some resources that are purported to bring about sustainable rents, paradoxically, also may make them and their rents more vulnerable, that is, less sustainable. For example, isolating mechanisms that sustain inimitability such as path dependence, causal ambiguity, context dependency and tacitness also increase the challenges of understanding and managing resources and thereby enhance the likelihood that they will lose their value as sources of economic rents for their owner; the latter being defined as the surplus earned by a resource above its costs.” (p. 397-398)

In other words, when critical resources like knowledge are isolated completely from the market, they become vulnerable to leakage and erosion, and the causal ambiguity which makes them difficult for rivals to imitate also increases the difficulty in managing such knowledge resources in the long run, following protracted isolation. Furthermore, alignment with evolving trends in a given knowledge domain makes a firm's offerings popular and competitive. However, knowledge alignment could also be adversely affected by the same isolation strategies designed to preserve the propriety rights of firms from market imitation or erosion. The KBV is a useful theoretical lens because it supports the fundamental premise of this study, that knowledge is a critical resource that defines firm boundaries and drives collaborations. In the following subsection, the relational view of strategic management is examined to make a case for knowledge sharing in collaborations. This view proposes that if critical resources are located outside firm boundaries, a certain “collaborative advantage” beyond firms’ immediate capabilities is achieved through collaboration, and this collaborative advantage allows firms to make super-normal profits.

## 

## **3.3 Relational View of Strategic Management**

Based on a three-year study of successful and failing partnerships involving thirty-seven firms from 11 countries, Kanter (1994) argued that the intrinsic motive of business collaborations goes beyond the anticipated economic benefits of 'the deal.' In addition to such short-term transactional objectives, Kanter observed that collaborative alliances serve as an avenue for securing future business opportunities, and tend to be more beneficial to all parties when they involve some form of collaborative value creation in addition to exchange relationships. As opposed to firm-specific competitive advantages derived from core capabilities, 'collaborative advantage' describes any long-term relationship-specific value that is accruable to businesses involved in mutually beneficial collaborations (Dyer, 2000; Huxham, 1996; Huxham and Vangen, 2013; Kanter, 1994). On close examination, all collaborations – whether in the private sector or public-private consortia - begin with two or more parties having a mutual attraction for each other's corporate direction and potential/realised capabilities (Cousins and Spekman, 2003; Spekman et al., 2016; Spekman and Carraway, 2006).

Top executives of collaborating firms must be willing to get along in the pursuit of specific goals, which neither company is capable of reaching in equal measure if they decided to venture alone. Several levels of rapport are established; first among the owners and employees of participating companies; then among the key stakeholders such as governments, customers, and suppliers; and finally among third-party professionals that serve as the live-wire of productivity, like investment bankers, lawyers, and researchers (Kanter, 1994). Thus, the collaborative advantage resulting from established alliances supersedes the individual competitiveness of allied companies, but this added advantage is not as a direct consequence of signing agreements per se (Dyer, 2000; Dyer and Nobeoka, 2000). Rather, it stems from the vision of executives about the future business prospects of such alliances and is established over time, by the nature and degree of rapport created among the major stakeholders and other parties of interest (Kanter, 1994; Vangen and Huxham, 2003).

The collaborative advantage could be operational (e.g., capacity pooling for manufacturing), location-specific, or in terms of increased access to collaborators networks of suppliers, customers, and investors (Chang et al., 2012; Dyer and Hatch, 2006; Vangen and Huxham, 2003). However, to better understand collaborations, it is important to consider what transpires in basic exchange relationships, commonly termed as *transactions*. Every transaction or exchange relationship between independent parties (firms) requires negotiation and communication, and both these processes constitute significant variable costs, especially in competitive markets where they vary with the number of players and the type of transaction. Williamson (1981) explained that transactions are the smallest unit of measurable activity in exchange relationships, which incur tangible and intangible costs associated with communication, negotiation, and the prevention of opportunism (Grover and Malhotra, 2003; Hill, 1990). Explaining the Transaction cost theory, Williamson (1981) held that:

“If the transaction costs of undertaking an exchange through the market is higher than the bureaucratic costs of managing an exchange within a hierarchy, it is more efficient to coordinate the exchange within a hierarchy.”

The transaction cost theory further argues that the cost of communication and negotiation can be difficult to manage because they are linked to the bounded rationality of transacting parties, which is the natural, neurophysiological, cultural, and language limit or barrier to effective communication (Williamson, 1981). Opportunism, on the other hand, is the tendency for parties to act solely in their self-interests, or at the expense of others in business or social relationships (Grover and Malhotra, 2003). Bureaucratic costs in this sense represent the costs associated with the establishing and managing relationships.

The bureaucratic costs in VE exchange relationships as implied by the transaction cost theory, depends on the ‘relative bargaining power’ of partners in the free market. Although power is a relatively nuanced concept, in collaborative networks, the predominant view is that bargaining power stems from soft qualities like a firms perceived legitimacy, market position, and reputation (Chen, 2016; Cox, 2004; Cox et al., 2001; Crook and Combs, 2007; Hingley et al., 2015; Ireland and Webb, 2007; Williams and Vonortas, 2015). However, in addition to the above qualities, most researchers acknowledge that power - particularly in collaborative networks - is a function of the reciprocal interdependencies among partners. These interdependencies arise from resource complementarities or the ability to reciprocally provide complementary resources to partners in support of their core competencies (Dusana et al., 2016; Lavie, 2006; Matanda et al., 2016; Newell et al., 2003; Xia et al., 2016). According to Crook and Combs (2007): “strong firms’ bargaining power use is tempered by the type of coordination different types of task interdependencies demand.”

Today, most companies engage in simultaneous VEs as an integral part of their business models, and some ‘megatrends’ have been identified as the main drivers of such global interdependencies among firms (Speier et al., 2008; Stank et al., 2015; Williams and Vonortas, 2015). First, global investments by multinationals (globalisation) in infrastructure and multi-modal logistics, have enabled firms to venture the globe in search for new business opportunities and markets. Also, technological advancements have further facilitated globalisation and the high incidence of outsourcing by most companies. In keeping pace with global competition, companies focus on developing core capabilities, while outsourcing other parts of their operations through alliances (Tim et al., 2002; Williams et al., 2015). A direct consequence of outsourcing is the growing number of dense collaborative inter-organisational networks such as VEs. These networks provide firms with the much-needed flexibility, speed, and economies of scale and scope to deal with highly risky and intense global competition through interdependence (Buijs and Wortmann, 2014; Camarinha-Matos et al., 2009; Horeis and Sick, 2007; Williams and Vonortas, 2015).

VEs may be formed between downstream and upstream partners in a value chain, for instance, in R&D for products, services, processes or technology, or among mid-stream and downstream partners for manufacturing, assembly, distribution, and servicing. From the firm perspective, the benefits of such partnering are numerous including; access to new markets, the potential to create new or modified product market segments, risk and cost pooling for large investments, unbundling of firms intangible assets for selective sharing, pooled complementarities in skills, material resources, technologies, people, finance, and increased legal and political advantages in new host countries (Baghalian et al., 2013; Knudsen, 2013; Wang and Chan, 2010; Wiengarten et al., 2014; Williams and Vonortas, 2015).

Drawing on premises from the extended economic theory of exchange and power in inter-organisational networks by Cook, (1977), Dyer and Singh (1998) proposed a relational view of strategic management to explain the factors that diminish bureaucratic costs in collaborative ventures in comparison to the transaction costs of engaging directly with the market. According to this view, most of the critical resources required by collaborating firms to generate super-normal profits – also known as relational rents or assets – are in fact, embedded in shared inter-organisational relationships, processes, and routines. Prior to the relational view, the predominant perspectives on the sources of competitive advantage to firms were the industry structure view by Porter (1989) and the resource-based view by (Wernerfelt, 1984, 1995). Porter (1989) suggested that value creation and the comparative advantage was a product of having industries with relative bargaining power, barriers to entry, infrastructure, and conducive policies. The resource-based view, on the other hand, proposes that competitive advantage is tied to a firm’s ability to build capabilities or accumulate rare, valuable, and inimitable resources. While the former led to an increased focus on industry-level analyses in search of the sources and drivers of competitive advantage, the latter view has fuelled several firm level studies exploring how the competitive advantage of firms based their resource portfolio aids in the process of new value creation. However, according to Dyer and Singh (1998):

“Although these two perspectives have contributed greatly to our understanding of how firms achieve above-normal returns, they overlook the important fact that the disadvantages of an individual firm are often linked to the (dis)advantages of the network of relationships in which the firm is embedded. …….productivity gains in the value chain are possible when trading partners are willing to make relation-specific investments and combine resources in unique ways. This indicates that firms who combine resources in unique ways may realize an advantage over competing firms who are unable or unwilling to do so.” (p.660-661)

In other words, the idiosyncratic nature of knowledge sharing relationships provides a collaborative advantage for value creation. Market driven transactions as noted earlier are characterised by generic asset investments, low information and knowledge exchange, minimal technological and functional interdependencies, and low bureaucratic costs/investments in governance mechanisms (Inkpen and Tsang, 2005; Lavie, 2006; Shipilov et al., 2014). However, the relational view argues that relation-specific asset investments, knowledge sharing and co-creation, and complementarities in scarce resources all contribute towards lowering the overall bureaucratic costs of collaborative alliances by enabling more effective and somewhat symbiotic (or mutually beneficial) governance and knowledge sharing mechanisms (Dyer and Hatch, 2006; Kale et al., 2000; Koka and Prescott, 2002; Nieves and Osorio, 2013; Poppo and Zenger, 2002; Post et al., 2002). Also, when a steep power asymmetry exists among collaborating partners, the potential for extreme knowledge exploitation by stronger partners is offset by the complementarities of weaker ones.

Taken together, the KBV and the relational view of strategic management provide a robust theoretical basis for examining the dynamics that affect knowledge sharing in VEs. While the KBV articulates the critical role that knowledge plays in establishing firms’ boundaries and core capabilities for value creation, the relational view takes a cross-level network perspective to explain the rationale and dynamics of knowledge creation in collaborative networks. While the SECI model is a dynamic process model that simultaneously describes the dynamic spirals involved in the social validation processes of organisational knowledge (the links among the SECI stages) as well as the tacit🡪explicit knowledge conversion spirals, a clear conceptualisation of the enabling conditions that facilitate the dynamism of both spirals is still somewhat lacking. This study advances the model by drawing on these theoretical lenses to support the inclusion of dynamic capabilities into the model, and proposes that these capabilities are required as antecedents or mediators that trigger and propagate the spirals of knowledge sharing from individual through teams, to organisational and inter-organisational the knowledge sharing.

### **3.3.1 Rationale for Adopting the Knowledge-Based and Relational View**

The majority of extant studies on knowledge sharing in collaborative networks reviewed, directly or implicitly draw on the notion of knowledge as a resource that can be shared or transferred in line with the premises of the Resource Based View (RBV) and the KBV. Other theoretical lenses often used such as the network theory and the social capital theory, are predicated on the relational view. The following subsection presents a chronological review of extant studies drawing on these theoretical perspectives to provide additional rationale for adopting these theories in this research.

Dyer and Nobeoka (2000) explored the 'black box' of knowledge sharing using a case study of Toyota's to demonstrate how the company’s network-level institutionalised knowledge-sharing processes have provided a collaborative advantage for Toyota and its suppliers in the automotive industry. Yli-Renko et al. (2001) studied 180 entrepreneurial high-technology ventures in the United Kingdom, to assess the effects of relational social capital in global networks affects knowledge acquisition and exploitation. Likewise, in a study exploring the factors that affect the innovativeness of new collaborative relationships, Marshall (2004) argued that the success of new global collaborations is facilitated by “comparative achievements in negotiation”, “commitment”, and assessments of the project or task execution/performance of partners. They further noted that volatile agreements, continuous re-evaluation, and reorganization based on experience are some of the primary antecedents to relational rent building and the strengthening of relational ties. Henttonen and Blomqvist (2005) examined the impact of relational communication, trust, and commitment on the efficiency and effectiveness of virtual teams, using a global sample of telecommunications companies.

Lavie (2006) used the relational view to distinguish the impact of shared rents (collaborative) from unshared rents (competitive). It was established that relational rents have a greater impact on collaborative success than individual resource capabilities in networked environments. Similarly, based on a survey of 253 suppliers in the equipment industry, Mesquita et al. (2008) examined the drivers of competitive advantage in vertical learning alliances and found that performance improvements are partnership-specific and the relational rents of partnerships enable co-learning among geographically dispersed buyer-supplier dyads. Using two different case studies, Steinle and Schiele (2008) argued that systematically assessing industry clusters can provide firms with a greater collaborative advantage than merely appraising the individual capabilities of potential partners in global or local sourcing decision-making. They further demonstrated how suppliers can serve as valuable knowledge resources by leveraging their independent networks to improves.

Hervas-Oliver and Albors-Garrigos (2009) explored how different combinations of internal and relational resources affect the innovative capabilities of firms in a European ceramic tile cluster. They argued that the absorptive capacities of member firms influenced their ability to access and contribute meaningfully to clusters. They further noted that while partner-proximity and embeddedness helped firms to access external knowledge, neither factor could sufficiently explain how innovation is fostered in collaborative environments characterised by multiple and often transient relationships. Rosenzweig (2009) examined how the level of product complexity and market variability impacts the nature and outcomes of e-collaboration and performance in a study sample of 50 manufacturers.

Gold et al. (2010) demonstrated that partner-focused supply chain capabilities can evolve to become firm-level core competencies as industry competition progresses from inter-firm to inter-supply-chain (e.g. in retail, and manufacturing supply chains where advanced SC level integration strategies are applied). Schilling and Phelps (2007) in a longitudinal study, noted that most firms collaborate to gain access to partners’ knowledge networks, improve their industry knowledge, or leverage on the collaborative knowledge available in alliances. Solesvik and Encheva (2010) applied the relational view in designing a mathematical modelling technique known as “Formal Concept Analysis”, which can be used to match and select potential partners’ capabilities in ship building collaborations.

Zacharia et al. (2011) adopted the relational view to assess the impact of firms’ absorptive capacities and collaborative process competence on the performance of episodic collaborations. Likewise, Prasad et al. (2012) argued based on the KBV and relational view that establishing “relational lateral IT steering committees,” improves the structure and viability of IT-led collaborative alliances. They explained that such committees provide a form of collaborative governance “rent,” which incentivises collaborating firms to synchronise their operational, tactical, and strategic IT resources in collaborations.

Wieland and Marcus (2013) also used the relational view to support their study on the effects relational competencies on supply chain resilience and added-value to customers. Similarly, Walker et al. (2013) explored the enablers and barriers to collaborations in public procurement/purchasing. The main relational barriers identified were local politics, supplier resistance, inaccessible supplier data, and poorly developed knowledge coding systems. They further demonstrated that building strong ties with local firms in host communities is key enabler of successful public procurement in public-private collaborations. Huikkola et al. (2013) also used the relational view to explore the notion of joint learning in episodic collaborations, examining the impact of relational practices on dyadic buyer-supplier R&D collaborations.

Schillebeeckx et al. (2015) investigated the impact of partners’ aspiration (whether firms feel ahead or behind their partners in knowledge capabilities) and relational capabilities on the value placed by partners on potential collaborations. A different study, Howard et al. (2015) used the relational view to explore the manner in which novice technology firms acquired new intra-organizational routines from more experienced allies within their networks. Whipple et al. (2015) drawing on the relational view found that collaborative competence significantly affected the performance of VE partners with little or no shared social capital. Gesing et al. (2015) examined how partner types (market- and science-based partners), governance modes (informal, self-enforcing, formal, and contractual governance), and the capacity for innovation through joint R&D affected firm vulnerability and the not-invented-here syndrome of collaborating VE partners. Maomao et al. (2015) examined how e-business strategic alignment (e-alignment) provided relational rents for e-collaboration in VEs. Bstieler and Hemmert (2015) used the relational view to examine the impact of relational and contractual governance on the outcomes of new product development (NPD) collaborations. Likewise, Batsakis (2016), investigated how subsidiaries’ external knowledge sourcing strategy affects host network operations and innovative performance, and the supporting role of relational rents in locating alternative knowledge sources while maintaining the intellectual property rights (IPR) of multinational enterprises. From the preceding review of prior similar studies, it is evident that the theories selected are suitable for exploring the impact of dynamic capabilities on the stages of knowledge sharing in VEs.

### **3.3.2 Limitations of the KBV and Relational View**

Some of the implicit assumptions of the relational view and the KBV present potential limitations. At the very least, it is important to acknowledge such limitations, and where possible, control for them in developing the conceptual framework for this study based on these theories. First, both views presuppose that organisations engaged in VEs would be willing to share knowledge (Borgatti and Cross, 2003). However, in practice, the willingness to share may be inhibited by perceived competition from rival firms with similar capabilities, or VE partners engaged in other related alliances. Secondly, the relational view assumes that relational rents or unique knowledge capabilities are created through some form of reciprocal resource complementarity (Dyer and Hatch, 2006; Grant, 2013). The shortcoming of this assumption in the context of this study is that relational rent building requires long-term commitments. However, in VEs, inter-firm relationships are episodic, and may fizzle away at the termination of projects unless there are reasonable prospects for future engagements. Thirdly, the relational view assumes that the trust and power asymmetries in collaborative knowledge sharing are managed through complementarities, effective governance structures, and the vision of collaborating partners on the potential for generating super normal profits within alliances.

Concerning the third limitation, a study by Chiu et al. (2006) found that knowledge sharing in VEs is influenced by social ties among partners, trust, and shared language. By considering the role of dynamic capabilities like ACAP, TMS, and OINT, this study indirectly accounts for the role of organisational culture, leadership, and ethos (OINT), as well as the role of established legitimacy and trust (TMS). In the next subsection, a conceptual framework is developed.

## **3.4 Conceptual Framework**

Nonaka and Konno (1998) argued that the structure, processes, culture, expertise and external alliances of firms provide unique social environments or ‘learning spaces’ for the creation of routines. The authors likened these learning spaces to a Japanese metaphysical concept called ‘*ba*’, proposed by philosophers Kitaro Nishida and Shimizu. They explained that:

“Knowledge is embedded in *ba* (shared spaces), where it is then acquired through one’s own experience or reflections on the experiences of others. If knowledge is separated from *ba*, it turns into information, which can then be communicated independently from *ba*. Information resides in media and networks. It is intangible. In contrast, knowledge resides in *ba*. It is intangible. …… [it] is the platform for resource concentration of the organizations knowledge assets and the intellectualing capabilities within the knowledge-creation processes……the concept of *ba* unifies the physical space, the virtual space, and the mental spaces. It is the world where the individual realises himself [sic] as part of the environment on which his life [sic] depends.” (1998 p.40-41)

Argote and Miron-Spektor (2011), noted that the intra- and inter-organisational boundaries of these learning spaces depend on organisational contexts, capabilities, and experiences of employees. The authors explained that context represents the structural, cultural, and strategic factors that determine a firms’ knowledge requirements and scope of business engagements. Experience, on the other hand, comprises repositories of routines acquired over time (Argote et al., 2003; Rosenkopf and McGrath, 2011). In this sense, learning is assumed to occur in spaces determined by social alliances and nurtured by through participation and interactions among players in complex social systems. Employees of firms participating in such social learning spaces have to consciously or inadvertently re-evaluate new ideas against the prescribed technical and socially acceptable standards of competence in their individual firms (Chiva and Habib, 2015; Lave and Wenger, 2002). As such, learning is said to have occurred when the shared experiences of a group lead to noticeable changes in their collective perception of competence (Aggestam, 2015; Frese and Keith, 2015). Wenger (2000) argued that:

“Competence and experience can be in various relation to each other - from very congruent to very divergent……..either can shape the other, although usually the process is not completely one way. But, whenever the two are in close tension and one starts pulling the other, learning takes place.” (p. 227)

Based on the SECI framework by Nonaka and Takeuchi (1996), organisations develop *modus oparandi* over time, for sharing different forms of knowledge within their individual learning spaces. The unique knowledge capabilities acquired as a result of congruence or divergence between competence and experience enables the development of firm-specific problem-solving routines, also known as ordinary or substantive capabilities (Winter, 2003; Zahra et al., 2006). Routines by definition, are a set of rule-like heuristics used by organisations to standardise and transfer decision-making rules for day-to-day operations and administrative processes, norms, and tendencies. For decades, strategy theorists have debated on whether the routines developed by firms are carried on mindfully or applied automatically by employees (Becker, 2004, Cohen, 1991; Kilduff, 1992; Louis and Sutton, 1991). According to Miller et al. (2012):

“Organizational routines are like other psychological and social phenomena – such as human language – that have an unobservable deep structure and an observable surface expression. Unlike spoken language, where a single individual produces a sentence, an organizational routine typically draws on the competencies of multiple individuals, as occurs in a conversation. Because individuals perform different tasks within routines, their experiences and resulting learning are unique.” (p.1536)

Certain organisational routines grow to become widely used as ‘industry best practices’, and although they may be idiosyncratic, research shows that best practices can be transferred, modified, and improved upon by applying the right set of ‘meta-routines’. A typical example is the Just-in-time production practices and Lean philosophy, which was originally based on Toyota’s Production System (TPS), but are now applied somewhat differently by firms across different production, manufacturing, and service industries globally. While best practice routines may remain sticky (Jensen and Szulanski, 2004; Szulanski, 2000), the relational view suggests that they can be transferred by creating unique learning spaces or ba through the agency of alliances (Borgatti and Cross, 2003; Szulanski et al., 2016; Wang and Li-Ying, 2015). In a Nobel Prize winning thesis on Administrative Behavior, Simon (1947) argued that for firms:

“.. . . administration is not unlike play-acting. The task of the good actor is to know and play his role, although different roles may differ greatly in content. The effectiveness of the performance will depend on the effectiveness of the play and the effectiveness with which it is played. The effectiveness of the administrative process will vary with the effectiveness of the organization and the effectiveness with which its members play their parts.” (p. 252)

This argument relates more accurately, to the administration of substantive routines within firms. However, research shows that by applying a different set of higher level meta-routines, companies can effectively administer external substantive routines to augment existing practices or create improved one. These higher level meta-routines or processes are known as dynamic capabilities (Lewin et al., 2011). These higher order meta-routines are called dynamic capabilities, defined as antecedent organisational routines that are required for sustaining own substantive capabilities and developing new ones (Eisenhardt and Martin, 2000; Teece and Pisano, 1994). Dynamic capabilities are not directly linked to specific knowledge-domains, rather, they are generic meta-routines that enable firms to improve or acquire new substantive capabilities.

This research focuses on knowledge sharing among partners in VEs – a special case of episodic virtual organisations that are dynamic, profit-driven, and designed to respond to short-term competitive market opportunities (Hung and Cheng, 2013; Msanjila and Afsarmanesh, 2007). VEs adopt IT-based cooperation strategies as "a way to gain scale without mass" or short-term collaborative advantage among spatially dispersed partners, structurally detached, or time constrained operations. One of the earliest cited examples of VEs is the production capacity VE that was formed between Apple Inc and Sony Corp – one of its then major competitors – for the production of the entire line of PowerBook notebooks in 1991 (Byrne 1993).

Regarding their structure, Tuma (1998) noted that VEs are a “best of everything”, IT supported intermediary between one-off transactional market relationships and structured long-term enterprises. Concerning knowledge sharing in VEs, the distinguishing feature from other collaborative networks is the use of temporary but effective knowledge sharing design/infrastructure owing to the short-termed and market focused nature of VEs (Presley et al., 2001). In most industries like banking, construction, manufacturing, and technology, VEs often bring together “world-class competencies”, which makes them an attractive melting-pot for knowledge sharing even in one-off collaborations (Tølle et al., 2002). Prior studies have shown that knowledge sharing in VEs is partly hindered by the lack of adequate capabilities to set up the temporary managerial, social, and technology infrastructure required for knowledge sharing in an efficient and timely fashion. Consequently, the core theses of this study are articulated thus:

1. For efficient inter-organisational knowledge sharing, collaborating firms must continually assess, invest in, and update requisite meta-routines or dynamic capabilities, in addition to improving their ordinary or substantive skills.
2. Based on a review and assessments of the primary dynamic capabilities that have been linked to knowledge sharing in collaborations, it is proposed that the following capabilities are required for effective knowledge sharing in VEs:
3. The meta-routines for absorbing new knowledge (ACAP).
4. The meta-routines that aid the capture, storage, sorting, comparison, interpretation, and updating of knowledge gathered from prior and on-going collaborations (TMSs), and
5. The meta-routines for acquiring or developing suitable technology, organisational structure, culture and ethos for future interoperation with alliance partners (OINT).
6. These capabilities affect the sharing of both tacit and explicit knowledge relating to know-how, know-why, know-who, and know-what.

To underpin the above thesis, the following subsections review the literature to generate specific hypotheses on the mediating role of ACAP, TMS, and OINT on the processes for tacit and explicit knowledge sharing in VEs.

### **3.4.1 The Impact of Dynamic Capabilities on the Knowledge Sharing Processes of Collaborating Firms**

As theorised by Nonaka and Takeuchi (1996), the process of new knowledge creation and sharing begins with knowledge socialisation. Through socialisation, firms acquire new tacit knowledge from within and across their organisational boundaries, by applying routines that enable the transfer and receipt of current and prior knowledge resources embedded in the day-to-day social processes. Regardless of the form (know-how, -what, -why or -who), tacit knowledge is by its very nature, tedious to formalise, as well as time and context-specific. Therefore, it can only be acquired through processes that enable firms to share direct experiences (Li et al., 2009; Rice and Rice, 2005).

The tacit knowledge acquired in the socialisation stage is then articulated into explicit knowledge through Externalisation processes. Externalisation enables tacit knowledge to be converted into concepts, images, analogies, and written documents and requires the discursive consciousness of knowledge sharing parties for the rationalisation and communication of acquired tacit knowledge (Martínez-Martínez et al., 2015; Richtnér et al., 2014). Through dialogues, VE partners can isolate contradictions between acquired and own tacit knowledge and collectively rationalise any structural differences to arrive at a uniform interpretation of socialised tacit knowledge. Nonaka and Toyama (2003) explained that through externalisation “actors seek to detach themselves from [own] routines by active exposure to a context that enables them to see the inherent contradiction”. In a sense, externalisation affords collaborating firms the opportunity to view the same challenge or phenomenon from contrasting perspectives, and it is this knowledge-to-knowledge sharpening process that births new ways of thinking and applying knowledge to achieve a collaborative advantage (Martínez-Martínez et al., 2015).

According to the SECI framework, externalised knowledge synthesised from various best practices are then combined, modified, and administered or disseminated as systematic, explicit knowledge using combination processes. For effective knowledge combination, computerised communication networks and large-scale databases play a facilitating role. As argued by Nonaka and Takeuchi (1996), combination processes help to expedite the deconstruction of broad organisational concepts like corporate vision, performance indicators, and tactical or operational objectives into stepwise and measurable business or product knowledge in VEs. At this stage, further contradictions are not synthesised in line with the prior experiences or competencies of collaborating partners; rather they are addressed by collaboratively finding the best-fitting solution in the context of the given VE collaboration.

In the last stage of the SECI model, new explicit knowledge created through combination processes is shared across collaborating firms, and through application in the use phase, is transformed back into tacit knowledge and internalised. Internalisation is somewhat synonymous to the concept of praxis in the applied behavioural sciences; meaning the process through which theoretical concepts, or acquired skills are ratified, personified, comprehended and embodied by different collaborating firms in VEs (Foster-Fishman et al., 2001; Gray, 2000; Sharma and Kearins, 2011). Consequently, combined explicit knowledge in the form of product concepts, service delivery processes, manufacturing procedures, or management strategies become actualized through reflection, practice, and further modifications in the internalisation phase of knowledge sharing. By reading and reflecting on manuals and other documents, or by acquiring explicit knowledge embodied in simulations and experiments, VE partners can internalise explicitly coded knowledge to create an enriched version of new tacit knowledge otherwise unavailable to firms outside such collaborative alliances. According to Nonaka and Toyoma (2003), processes that stimulate the pragmatism required to learn-by-doing are effective for internalisation as they enable firms to check, amend, and embody new knowledge.

Like socialisation, internalisation processes thrive on firms' self-transcendence and empathy for partners, which is required for reflection on how to utilise new knowledge within the collaborative venture and how to translate acquired routines to future related collaborations. As explained in the review section, the SECI knowledge sharing processes occur in a dynamic spiral and not in a circular fashion. These spiralling interactions among the stages are amplified in scale and scope acknowledge sharing progresses through different ontological levels, from know-how to know-what, -why and -who (Inkpen, 1996; Nonaka and Takeuchi, 1996; Nonaka and Toyama, 2003). For instance, the knowledge sharing spiral in a manufacturing VE could trigger changes in suppliers' processes in line with new knowledge requirements.

The SECI stages represent generic firm knowledge sharing processes; however, the precise manner in which they are executed can differ significantly from one organisation to the other. Nonetheless, the SECI framework provides a logical and applicable template for assessing and comparing the generic processes of knowledge sharing. Since the delivery mode for each stage is unique to firms, this study proposes that knowledge sharing in VEs is effective only to the degree that collaborating companies are able to evolve their individual SECI processes dynamically. Thus, it is argued that the dynamic capabilities or meta-routines for improving ACAP, TMS, and OINT help to sharpen the SECI processes of collaborating firms, and in so doing, allows and improves the capability to propagate effective knowledge sharing processes in collaborative ventures. The remainder of this chapter focuses on the rationale and research hypotheses for this study, developed in line with the above propositions and supported with relevant research evidence and theory.

## **3.5 The Mediating Role of Absorptive Capacity on Knowledge Sharing Processes and Outcomes in Collaborations**

The literature review makes a case for the importance and prevalence of VEs in today’s globalised business place. However, the successful organisation and administration of VEs according to the relational view, depends almost entirely on partners’ ability to integrate, share, and co-create relevant capabilities using effective knowledge sharing strategies. Knoben and Oerlemans (2006) argued that three main dimensions of proximity tend to impact knowledge sharing in inter-organizational collaborations, namely; geographical proximity, organisational proximity, and technological proximity. Quite like most traditional supply networks today, geographical proximity is not always likely in VEs, therefore collaborating firms need capabilities beyond their core competencies to improve the technological and organisational proximity of geographically dispersed partners.

Proximity also has a cultural dimension, and studies have shown that knowledge sharing across organisational and national cultures is confounded by language, institutional, economic, legal, and political contingencies. Consequently, a crucial challenge in managing cross-cultural knowledge sharing in global VEs and other alliances is the 'cultural distance' among firms. Some researchers have examined cultural distance using several theoretical models to explain how culture affects task-, firm-, and industry related values and capability sharing (Ambos and Ambos, 2009; Carrillo et al., 2009; Ford and Chan, 2003; Hutchings and Michailova, 2004).

Others have focused on the effect of location-driven cultural predispositions on international collaborations (Cadden et al. 2013). Overall, studies show that cultural distance impacts the ability to effectively manage collaborations, share knowledge, and establish long-term strategic alliances (Araujo, 2009; Duan et al., 2010). Björkman et al. (2007) noted that although knowledge sharing is expected to be comparatively more seamless among culturally similar firms, the potential ACAP of partners provides the motivational and relational capacity for culturally distant companies to initiate the relevant processes necessary for inter-firm capability sharing. Perhaps the most pressing problem with proximity in collaborative engagement is the cognitive distance it creates between focal and distal partners. Cognitive distance refers to the differences in individual or collective cognition (reasoning and understanding) of firms resulting from differences in knowledge domains, knowledge ranges (from declarative to procedural), or knowledge gradients (Nooteboom, 2000).

In long-term collaborative relationships such as traditional supply chains, firms can develop strong relative absorptive capacities through shared governance, contractual, and network relational ties. Over time, the cognitive gap among partners’ declines, and their learning and knowledge sharing capabilities become increasingly similar (Dyer and Hatch, 2006; Dyer and Singh, 1998). In a case study of Toyota’s supply network, Dyer and Nobeoka (2000) explored the 'black box' of knowledge sharing in Toyota's network, to understand how Toyota managed to bridge the cognitive distance within its supply network. They found that Toyota's ability to establish, manage, and maintain network-level knowledge sharing stems from the company's investments in relative ACAP building routines for knowledge sourcing, supplier selection, manufacturing, research and development, and sales and marketing. A similar study by Nonaka and Peltokorpi (2006) on the development of the company's Prius brand showed that various strategies for building relational ACAP were deployed and constantly updated throughout the company's supply network. These strategies included cross-functional team building, Joint-R&D, and standardised recruitment policies for employees across the network. The case study revealed that these processes were greatly instrumental in the development and success of the Prius brand.

For episodic collaborations like VEs, while it is not feasible to entirely close cognitive gaps, ACAP has been shown to bridge cognitive distances by enabling firms to align their collective cognitive range with partners’ cognitive domains or areas of expertise (Nooteboom, 2000). In other words, potential and realised ACAP are more or less firm-level filters, through which collaborating organisations gain access, decode, transfer, and utilise otherwise inaccessible external knowledge within collaborations. In an ambitious attempt to become one of the most energy efficient nations, Norway established several Centres for Environment-friendly Energy Research (CEER) to serve as learning hubs for public institutions, local companies, and international partners operating in the country. Initial results from an ongoing study on the benefit of these centres to Norway’s local and global network of companies found that the potential benefits of participating in these centres was directly dependent on the potential and realised ACAP of participating firms. Firms that invested in ACAP building were found to be better able to bridge the cognitive distance between their local competencies and the novel ideas developed at these centres. A review of prior studies on the role of ACAP in both episodic and long-term collaborations from the earliest conceptualisation by Cohen and Levinthal (1989) to recent applications across management disciplines suggests that ACAP is a prerequisite for knowledge sharing among individuals or collectives. Although only a few studies have explored its relationship to knowledge outcomes besides innovation, the overwhelming evidence suggests that ACAP is a useful dynamic capability for knowledge sharing in collaborative settings.

### **3.5.1 The Mediating Role of Absorptive Capacity on Innovation**

Giuliani (2005) explored why some industrial clusters are able to excel at knowledge sharing while others with similar capabilities in the same industry lag behind. It was found that for clusters to acquire requisite knowledge capabilities, participating firms must invest in relative ACAP routines for absorbing intra- and inter-firm knowledge. Ferreras-Méndez et al. (2015) argued that the link between knowledge sourcing and innovation depends on firms’ unique ability to assimilate, translate, and apply external knowledge. Using a survey of 102 biotechnology firms operating in Spain, they found that ACAP fully mediated the relationship between the depth of external knowledge search, innovation, and firms’ business performance.

An important substantive capability that is heralded as critical for supply chains performance is agility. According to Roldán et al. (2015), organizational agility is an aggregate measure of the ability of firms to sense environmental changes and respond in an efficient and effective manner with minimal penalties in cost, quality, flexibility, lead-time and other relational measures such as customer and supplier satisfaction. In their study on the antecedents of organisational agility, they found that information systems capabilities and ACAP fully mediated the ability to develop and enshrine agile strategies for dealing with sudden changes in business conditions (e.g. price fluctuations, supplier capacity challenges and socio-political environmental changes). Likewise, a similar study by Obayi et al. (2015) examined the impact of two forms of flexibility on the performance of retailer-supplier collaborations – the flexibility to change orders and the flexibility to change supplier network configuration. Findings showed that the relative ACAP of retailers (including big-middle, innovative and niche retailers) and key suppliers, partially mediated the ability to achieve expected performance benefits from both forms of flexibility without straining long-term relationships. It was found that retailers with high ACAP could manage the trade-offs between switching suppliers in times of market uncertainty (configuration flexibility) and investing in current suppliers' capacity to meet demands (planning and control flexibility). Likewise, earlier studies by Liu et al. (2013) showed that ACAP and supply chain agility both fully mediated the impact of IT capabilities on firm performance. However, similar to the conclusions reached by Roldán and colleagues and Obayi and colleagues, they found that ACAP exerted an indirect impact on performance by improving supply chain agility.

Tzokas et al. (2015) sampled 158 firms from South Korea's semiconductor industry to identify the factors that enable the transfer of knowledge in collaborative new product development (NPD). Findings showed that in addition to access to state-of-the-art technologies and expertise, the ACAP for identifying and incorporating customers’ insights into NPD led to the development of better aligned products, market performance, and overall profitability NPD collaborations.

R&D investment can be very expensive, and the top 20 spenders in 2011 included companies like Toyota ($9.9), Novartis ($9.6), Roche Holding ($9.4), Pfizer ($9.1), and Microsoft ($9) (top 5). The combined investment of the top 20 was about $153.6 billion, and an average R&D spending as a percentage of sales of 8.3%. However, none the most innovative companies in 2012 (like Apple, Amazon, Facebook, Google, and Genentech) made the list of top spenders. A closer look at the spending portfolio of companies like Microsoft for instance, showed that about 13% of the firm's total revenue was invested in updating its operating systems, which was hardly viewed by tech experts, industry players, investors, and customers as substantially innovative in comparison to the investment made. Interestingly, companies like Nokia, who are currently struggling to keep up with the evolving market trends in the telecoms and electronic industry ranked as high as 7th in R&D investments for 2011 (Hartung, 2012). In a study explaining the relationship between R&D investment and innovation, Tzokas et al. (2015) found that ACAP mediated the relationship between a firm’s cumulative path-dependent R&D investments with external partners and the ability to translate such investments to innovations. They surveyed 165 firms in the information and communication technology industry in Taiwan and found that ACAP accounted for nearly 36% of the innovations derived from R&D investments.

Furthermore, franchising appears to be one of the several reasons why companies today form VEs. Multinationals venture into distant markets to capitalise on the capability of local suppliers in different geographies or location-specific advantages such as the availability of cheaper factors of production or innovative industry clusters. A typical example is the proliferation of VEs between electronics multinationals and clusters of component suppliers in Taiwan, South Korea, and China to capitalise on technological and technical economies of scale efficiency as opposed to superior technological prowess (Bhaumik et al., 2016). Other examples include resource location-driven franchises and subsidiaries typical in production industries like the oil and gas and mining industries. Iyengar et al., (2015) sampled 783 independently owned real estate franchises and found that while information technology was a useful learning platform for franchisees, ACAP mediated the relationship between the use of efficient IT platforms and the financial performance of subsidiaries.

As noted earlier, ACAP requires a substantial degree of information sharing and communication among collaborators. Companies like Toyota have spent decades investing in the development of a socio-technical information and knowledge system with their suppliers and customers (TPS), which has yielded enormous benefits in terms of their ability to collaboratively innovate within their network. However, despite the evident successes of Toyotas TPS approach, several American automakers have been largely unsuccessful at adopting or reproducing similar socio-technological networks with suppliers and customers. Citing the case of the automaker Chrysler, Liker et al. (2004) noted that in spite of investments in capability building, training, and the requisite technology:

“Chrysler tried to build a keiretsu, but the process unravelled after Daimler took over the company in 1998. Not surprisingly, the Big Three [American automakers] have been more or less at war with their suppliers. Having witnessed the American automakers’ abject failure to create keiretsu, most Western companies doubt they can replicate the model outside the culture and society of Japan…… Experts usually emphasize the use of devices like target pricing, but we believe Toyota and Honda have built great supplier relationships by following six distinct steps: First, they understand how their suppliers work. Second, they turn supplier rivalry into opportunity. Third, they supervise their vendors. Fourth, they develop their suppliers’ technical capabilities. Fifth, they share information intensively but selectively. And sixth, they conduct joint improvement activities. (pp. 109)

The six success criteria that distinguish Toyota’s VE collaboration strategy from those of their American counterparts can be likened in many respects to the routines/processes required for building potential and realised ACAP in firms (Ben-Menahem et al., 2013; Dyer and Hatch, 2006; Dyer and Singh, 1998). Recent empirical evidence by Lima et al. (2016) further supports this claim. In their study based on 138 knowledge-intensive Small Medium Enterprises (SMEs) with similar socio-technical systems, they found that the ACAP of individual firms positively mediated the impact of such social information systems on firms’ innovation capability. Similarly, in assessing the impact of downstream/customer-facing socio-technical systems, Raymond et al. (2016) used a survey of 588 manufacturing SMEs to demonstrate that indeed, SMEs with well-developed e-business capabilities were significantly more entrepreneurial than their counterparts. However, contrary to their hypothesis, they found that entrepreneurial orientation had no direct impact on a firm’s innovation. The link to innovation was fully mediated by the ACAP of such SMEs. In a similar study, Dobrzykowski et al. (2015) using a survey of 677 firms, demonstrated that ACAP directly impacted firms’ ability to collect and respond to customers’ ideas on innovation, and mediated the relationship between such responsive strategies and the development of economically viable and customer-focused innovations.

The literature on firm–university collaboration acknowledges two prominent strategies for research-based knowledge and expertise sharing. Firms may opt to engage directly in research collaborations with academic institutions, or deal concomitantly with other firms with established ties to universities acting as knowledge “brokers”. Using published data on patents developed by 33 vertically integrated pharmaceutical firms, Belderbos et al. (2015) argued that in both direct and mediated ties with universities, knowledge sharing for innovation depends on the “scientific ACAP” of firms. They emphasised that ACAP enabled firms to establish a “fit” between their local research and development approaches and the academic process of generating scientific knowledge applied by universities.

Considering the arguments of the KBV and the relational view, the nature of VEs, SECI knowledge sharing processes for tacit and explicit knowledge, and the above cases from related studies, it is hypothesised that concerning innovation in VEs:

*H1a: The ACAP of collaborating firms positively mediates the relationship between the knowledge socialisation processes and innovation.*

*H1b: The ACAP of collaborating firms positively mediates the relationship between the knowledge externalisation processes and innovation.*

*H1c: The ACAP of collaborating firms positively mediates the relationship between the knowledge combination processes and innovation*

*H1d: The ACAP of collaborating firms positively mediates the relationship between the knowledge internalisation processes and innovation*

### **3.5.2 The Mediating Impact of ACAP on Adaptation and Replication**

For innovations to be economically viable for pioneering firms, the products or services developed must adequately compensate for the investment required by providing companies with desired competitive and first-mover advantage. These benefits are achieved through a combination of new knowledge or technological capabilities development, industry leadership, the pre-emption of assets, and the ability to create knowledge assets with high buyer switching costs (the cost of adapting or replicating knowledge). Even before the internet revolution of the early 1990’s, which made information accessibility cheaper and more spontaneous, Mansfield (1985) found that competitors were typically able to access information on new products and processes usually within one year of development. Today, the time taken for second-mover companies to catch on to innovations is probably significantly less because the availability of global information networks, and the near zero marginal cost of acquiring new information via the internet. Besides, the proliferation of boundary spanning suppliers, outsourcing, global labour/expertise mobility, and the various forms of contractual and informal knowledge collaborations has increased the chances for diffusion of explicit and tacit knowledge required for replicating or adapting new innovative ideas.

Zahra and George (2002) noted that in nearly all industries, “the institutional and industry dynamics for protecting innovations from leakage (appropriability) is a key consideration for firms looking to adapt or replicate desired external product, process or service knowledge. They further argued that industries with weak appropriability or high a tendency for knowledge spillovers often require minimal investments in ACAP meta-routine building due to the prevailing rate of imitation in such industries (e.g. bootlegging in the music and movie industries). In contrast, replication and adaptation are comparatively less favourable for second-mover firms operating in industries with high appropriability regimes. Cohen and Levinthal (1990) argued that high ACAP is a prerequisite for knowledge replication and adaptation in such industries because ACAP enables both pioneering and second mover firms to seek out potential partners with whom to advance innovative ideas for sustained first mover advantage. From a survey of 24 petrochemical and 36 food-manufacturing companies, Tsai (2001) explained that firms occupying central network positions such as brokers in hierarchical VEs are more likely to produce innovations because the coordinating role they play gives them easier access to the new knowledge capabilities developed by partners in collaborative endeavours. While this may not necessarily apply to distally located firms, Tsai argued that with high ACAP, firms are better able to replicate successfully and adapt new knowledge whether they occupy a central or distal network position.

It is noteworthy that like innovations, adaption and replication can also be very expensive whether deliberately pursued or occurring through unplanned diffusion. According to Winter (1987), the factors that affect the cost of both deliberate (adaptation and replication) and unwarranted (imitation) transfers are more or less similar. However, the paradox is that while replication and adaptation are distinctive knowledge outcomes in their right, they are also important internal mechanisms used by firms for cross-functional knowledge diffusion. When such firms innovate, the internal SECI processes that result in tacit knowledge explication (socialisation and externalisation) may also increase the likelihood of imitation, which could be perceived unfavourably as a constraint to innovation. Examining this paradox, Kogut and Zander (1992) argued that ACAP helped firms to reduce the costs associated with replication and adaptation while at the same time, enabling them to maintain a certain threshold of idiosyncrasy to diminish the tendency for imitation by second-movers. Other studies have also shown that for operations management, replication and adaptation of highly codified original knowledge templates are facilitated by the level of ACAP of the replicator/adaptor firm (Letmathe et al., 2012; Røvik, 2016; Secchi and Camuffo, 2016; Szulanski et al., 2016).

For instance, in international franchises, the ability of a franchisee to accurately replicate the processes or routines of parent multinationals determines their viability and competitiveness. Winter et al. (2012) found that the relative ACAP of multinational and their franchise units is a critical determinant of the ability of such franchises to replicate best practices accurately. Likewise, Innis and Berta (2016) demonstrated that in health-care operations, well-developed ACAP meta-routines and ACAP training for nurses improved the ability of such nurses to adapt best practices to suit different contexts. Jensen and Szulanski (2004) and Szulanski and Jensen (2006) argued that the stickiness of tacit knowledge is perhaps the most critical determinant of successful knowledge transfers in cross-border collaborations. Several studies on knowledge stickiness have identified ACAP as a critical capability required for codifying highly sticky knowledge to for adaptation or replication in collaborative contexts (Martinkenaite and Breunig, 2016; Ringov et al., 2015; Szulanski et al., 2016; Winter et al., 2011). Overall, adaptation and replication occur almost invariably in all cross-border collaborations as part of the synchronisation of processes required in such extended collaborative networks, and most innovations (excluding those that occur by accident or chance) are rooted in adapted or replicated processes.

Thus in this study, it is argued that for firms to facilitate replication and adaptation of knowledge required for successful VEs, or for the transfer of capabilities and best practices from one collaborative venture to the next, well-developed ACAP meta-routines are a core prerequisite. Accordingly, it is hypothesised that:

*H2a: The ACAP of collaborating firms positively mediates the relationship between the knowledge socialisation processes and adaptation.*

*H2b: The ACAP of collaborating firms positively mediates the relationship between the knowledge externalisation processes and adaptation.*

*H2c: The ACAP of collaborating firms positively mediates the relationship between the knowledge combination processes and adaptation*

*H2d: The ACAP of collaborating firms positively mediates the relationship between the knowledge internalisation processes and adaptation*

And

*H3a: The ACAP of collaborating firms positively mediates the relationship between the knowledge socialisation processes and replication*

*H3b: The ACAP of collaborating firms positively mediates the relationship between the knowledge externalisation processes and replication*

*H3c: The ACAP of collaborating firms positively mediates the relationship between the knowledge combination processes and replication*

*H3d: The ACAP of collaborating firms positively mediates the relationship between the knowledge internalisation processes and replication*

## **3.6 The Mediating Role of Transactive Memory Systems on Knowledge Sharing Processes and Outcomes in Collaborations**

TMSs are cognition-based extensions of project-team memory, gathered from post-project reports, electronic documents, and other repositories, which over time, creates inbuilt interpersonal meta-resources of know-who, know-what, and know-how (Akgün et al., 2006). A TMS comprises three distinct components, namely; internal process transactive memory held in various repositories (employees, routines, and IT systems), transactive memory for locating relevant external expertise, and a retrieval mechanism for finding and combining stored knowledge resources from various repositories in a timely and orderly fashion (Wegner, 1986). According to Hutchins (1991, p.284), TMS provides the required platform for ‘‘the cognition that is the task, and the cognition that governs the coordination of the elements of the task.” Just like married couples store transactive knowledge to enable seamless running of household activities with minimal in-process communication, collaborating firms can also develop TMS meta-routines that allow them to store, process, recombine and retrieve knowledge on current and prospective collaborating partners’ capabilities. As noted in the literature review chapter, the main indicators of TMS in collaborative ventures are expertise specialisation, coordination, and competence-based trust. Yoo and Kanawattanachai (2001) examined the role of TMS in building the "collective mind" in a study involving 38 collaborating virtual teams. They argued that TMS meta-routines are higher order learning capabilities required for the development, upgrading, and transfer of substantive capabilities.

In this study, it is proposed that highly developed TMS meta-routines in VEs are necessary for adequately delegating responsibilities for seamless workflows and diffusion of specialised knowledge across collaborative networks.

Firms with well-developed TMS meta-routines for assessing external network connections, capabilities, and business motives of partners can assign and coordinate tasks to the most competent and experienced partners in VEs (Jarvenpaa and Majchrzak, 2016). Several studies have shown that when individuals, teams, or firms deliberately incentivise the development of communication meta-routines for the transfer of hard-to-codify forms of knowledge like know-who and know-why, their knowledge sharing capabilities are significantly improved. For instance, Athans (1982) showed that military commanders with long-term TMS understand the tactical expertise of other command units, which is a critical success factor for the efficiency and performance of joint task forces, reduction in motion or redundancy of soldiers, and overall tactical effectiveness. For military and emergency response teams like Special Weapons and Tactics (SWAT) and police tactical teams, the penalty of poor collaboration can be fatal. A study by (Marques-Quinteiro et al., 2013) on the drivers of team adaptive behaviours and tactical performance in 42 police tactical teams showed that TMS enhanced the implicit coordination capability of police tactical teams with a positive effect on both routine and non-routine task performance. Likewise, in episodic and outcome-driven rugby teams, a study by Forgas (1981) showed that the TMS meta-routines of sports managers, coaches were the primary driver of the seamless cognitive division of labour and the unspoken consensus among teammates, which is a standard feature of high performing teams.

Firms develop TMSs based on (1) trust gained over protracted periods of relational ties, (2) prior experiences in collaborations with other companies that share similar expertise, location-specific or socio-cultural characteristics, or (3) direct access to repositories of meta-knowledge on other firms ‘experiences. However, a study by Gino et al., (2010) showed that while TMS fully mediated the impact of task-related experience on the creativity, teams with direct task-related experience tended to be more creative than those with TMS based on second-hand experience. The coordinated division of cognitive labour in networks with developed TMS is only possible through investments in both top-down and bottom-up knowledge storage, retrieval, and management of technologies and meta-routines at firm and network levels. Rommel et al. (2012) examined the impact of trust in teammates and top management on the TMS of collaborating teams, perceived job satisfaction, and overall collaborative performance. Findings showed that for highly knowledge‐intensive tasks, trust among teammates had a greater impact on the development of TMS than trust in management. TMS was also found to mediate the relationship between mutual trust among teammates’ regarding their individual capabilities, perceived team performance, and overall job satisfaction. TMS for operational and tactical tasks requires bottom-up knowledge sharing, storing, and retrieval meta-routines. But the provision of IT platforms and enabling socio-cultural incentives for TMS building is primarily a strategic imperative that requires concerted efforts from all management levels (Argote, 2015; Dai et al., 2016).

Leadership in VEs is another important consideration in theorising about the dynamics that affect knowledge sharing. Studies have shown that the entrepreneurial orientation (EO) of a firm is an important predictor of successful new ventures. In a field research examining the precursors of successful high-tech new ventures in China, Dai et al. (2016) examined the impact of venture teams' TMS on EO as well as the moderating effect of team-, firm-, and environment-level factors. They found that TMS was a vital prerequisite for the development of strong EO in firms. Furthermore, the level of intra-team trust, structural organicity in terms of reporting lines, and level of formalisation and centralisation, and industry-specific factors affecting knowledge sharing (e.g. appropriability) were determinants of the level and quality of TMS of firms. Similarly, in a study involving 124 research teams in a Finnish technical organisation, Peltokorpi and Hasu (2016) provided empirical evidence of the partial mediating role of TMS on the positive association between the task orientation of a team and the ability to develop innovative ideas. They also found that a transformational leadership style by top management moderates the impact of team-level TMS on innovation. A survey of 336 NPD engineers from 73 firms involved in 73 different NPD teams by Chiang et al. (2014) revealed that TMS mediates the positive relationship between the high commitment work systems designed for engineers and the new product performance.

Heavey and Simsek (2015) studied several top management teams in technology-based small-to-medium-sized firms, and found that management teams with well-developed TMSs are more ambidextrous in their pursuit of knowledge (i.e. capable of managing current knowledge requirements while simultaneously accounting for changing knowledge demand for future business endeavours). However, the impact of TMS on performance is sculpted by the collective and diverse experiences of tactical and functional experts within such teams. Speculating beyond these findings and applying the same logic to this study, one could argue that VEs also require well-developed TMSs in the individual management teams of collaborating firms. One could also further argue that achieving desired knowledge sharing outcomes in VEs depends largely on the capability of firms to select partners with well-developed, systematic, and transferrable (codifiable) transactive memories to enhance the collective TMS portfolio of such VEs.

Despite the advanced theoretical development of the concept of TMS, the preponderance of existing studies has been carried out with team-level boundary conditions. According to Argote (2015), researchers need to focus on further extending the concept to inter-organisational level studies, since the overwhelming evidence from level team studies suggest that it is a global strategy required for successful knowledge sharing cross-cultural or cross-industry knowledge-based collaborations. Jin et al. (2015) examined TMS in inter-organizational collaborations to determine its effect on the performance of a regional innovation systems (RIS) in central Taiwan. They found that the TMS of firms within the studied cluster was a “catalyst” for successful inter-organizational collaborations. Finally, while the link between TMS and knowledge outcomes like innovation, adaptation, and replication has been conceptually established in nearly all the pioneering studies on the concept, empirical evidence is relatively sparse particularly concerning adaptation and replication (Peltokorpi and Hasu, 2016). Using a computer model simulation Ren et al. (2006) found that TMS were more valuable in dynamic and unstable environments where knowledge is quickly rendered obsolete compared to environments with predictable challenges and relatively stable knowledge requirements. In other words, the model showed that the rate of knowledge adaptation in firms is directly linked to well-developed TMS. Another study by Miller et al. (2012) used a computational model to examine the dynamic capabilities that affected the remembering of organisational routines and firm performance. They argued that TMS enables companies to adapt to new challenges and enhances the ability to replicate useful routines efficiently when similar challenges reoccur.

In line with arguments from the preceding studies reviewed, this study proposes that:

*H4a: The TMS of collaborating firms positively mediates the relationship between the knowledge socialisation processes and innovation.*

*H4b: The TMS of collaborating firms positively mediates the relationship between the knowledge externalisation processes and innovation.*

*H4c: The TMS of collaborating firms positively mediates the relationship between the knowledge combination processes and innovation*

*H4d: The TMS of collaborating firms positively mediates the relationship between the knowledge internalisation processes and innovation*

Also:

*H5a: The TMS of collaborating firms positively mediates the relationship between the knowledge socialisation processes and adaptation.*

*H5b: The TMS of collaborating firms positively mediates the relationship between the knowledge externalisation processes and adaptation.*

*H5c: The TMS of collaborating firms positively mediates the relationship between the knowledge combination processes and adaptation*

*H5d: The TMS of collaborating firms positively mediates the relationship between the knowledge internalisation processes and adaptation*

Likewise:

*H6a: The TMS of collaborating firms positively mediates the relationship between the knowledge socialisation processes and replication*

*H6b: The TMS of collaborating firms positively mediates the relationship between the knowledge externalisation processes and replication*

*H6c: The TMS of collaborating firms positively mediates the relationship between the knowledge combination processes and replication*

*H6d: The TMS of collaborating firms positively mediates the relationship between the knowledge internalisation processes and replication*

## **3.7 The Mediating Role of Organisational Interoperability on Knowledge Sharing Processes and Outcomes in Collaborations**

From its origin as a software optimisation and synchronisation challenge at the turn of 1990’s, interoperability has taken on a broader scope to include other hard and soft dimensions of information and knowledge space synchronisation among collaborating firms. While it constitutes a major enabler of collaborations, a review of the extant management literature indicated an apparent gap in empirical studies on the impact of OINT in the context of collaborative knowledge sharing. Several IT and strategic management studies have alluded to its significance as a dynamic capability for building competencies in e-commerce, data and information mining and networking, and other computer-aided capabilities (inventory management, logistics, distribution and warehousing). However, its direct impact on knowledge sharing among collaborating partners remains a black box (González-Rojas et al., 2016; Pardo et al., 2010). A systematic review by Legner and Wende (2006) on the existing interoperability frameworks showed that the overwhelming focus of existing studies has been on technical and technological aspects of interoperability. They argued that while the impact of softer organisational attributes on the success of technical interoperability is evident, hardly any studies have empirically explored OINT in the context of collaborative knowledge sharing, considering the widely acknowledged process and system synchronisation challenges in inter-organizational relationships.

In military operations, OINT is a critical dynamic capability for the tactical coordination of supervisory and operational personnel in combat teams, synchronisation of technology aided capabilities for knowledge scanning and sourcing, and the operational alignment of different arms and armoury capabilities (Fewell et al., 2004; Kingston et al., 2005). Likewise, public-private sector collaborations need interoperability capabilities to manage the bureaucracies associated with systems, structure, culture, and process alignment in joint public-private operations (Badri et al., 2013; Kazemzadeh and Sartipi, 2005; Kislov, 2014; Pirnejad et al., 2008). As in military and public-private collaborations, the heterogeneity of process, information, and knowledge sharing systems and routines across companies tends to limit the prospects of “instant integration” in VEs. Despite the global dissemination of Internet technologies and bundled enterprise applications like Enterprise Resource Planning (ERP), decades of running secluded business models create “semantic islands” even among firms those operating in the same industry (Legner and Wende, 2006). This is further exacerbated by differences in corporate goals and expectations, as well as tactical and operational standards and capabilities (Braga, 2016). The ensuing review in support of this study’s propositions on the role of OINT in VEs draws on a diverse range of relevant literature, including those related to joint military operations and public-private collaborations where the research on OINT appears to be comparatively more advanced.

In long-term collaborative networks like supply chains, integration is often heralded as a beneficial strategy for aligning partners’ goals, strategies and operations (Gunasekaran and Ngai, 2004). However, strategic integration of internal and external knowledge sharing systems and processes in supply chain management is often pursued as structural response to specific industry or market characteristics, which are somewhat unique to each supply chain (Ralston et al., 2015). In other words, owing to the transaction cost and risks associated with the integration of knowledge management systems and processes, such strategies are only feasible and beneficial with partners with whom long-term strategic business involvement is anticipated or guaranteed. According to Klischewski (2004), regardless of the intended scope of integration at the outset of a collaborative venture, a high degree of OINT is required for successful knowledge management alignment in both short- and long-term cross-organisational engagements. Kubicek and Cimander (2009) noted that one of the main challenges encountered in integrating knowledge management systems in global public service collaborative enterprises is the reconfiguration of the “legacy systems” that support back-office processes. These systems are often challenging to restructure because they are often synced to local knowledge sharing requirements, thus, reorganising from scratch cannot be actualised. They demonstrated that for most public service collaborations, OINT is a precursor and a fundamental dynamic capability for improving the readiness of public service organisations to align their legacy systems with external knowledge sharing requirements in global collaborations.

Regarding the effectiveness of E-Government collaborations, Pardo et al. (2011) argued that OINT is a multidimensional and complementary dynamic capability for successful information and knowledge sharing. In a study examining how nations collaborate in response to transnational challenges, Pardo et al. (2010) noted that: “The future of public administration is clearly linked to the development and management of new forms of collaborative governance and the use of information technologies”. However, they further argued that “collaboration readiness” or OINT bolstered e-government productivity by aligning available assets, policies, and routines. They concluded that collaboration-ready organisations were more successful at short and long-term government led collaborations and had a higher propensity to identify potentially viable opportunities for knowledge sharing in other cross-organisational partnerships (Pardo and Cresswell, 2010).

Ford et al. (2009) found that OINT had a direct impact on the operational effectiveness in Suppression of Enemy Air Defence (SEAD) operations. They further argued that OINT serves as a prerequisite for the implementation of important system upgrades that provide knowledge sharing advantages to collaborative ventures without offsetting the existing KM systems of other important secondary supply chains that indirectly impact the performance of collaborations. Similarly, Stewart et al. (2004) noted that in episodic military operations, system connectivity alone does not necessarily confer the capability to interoperate. They argued that:

“the command and control element of military forces can be characterised as a complex socio-technical system where personnel, processes, procedures, and organisational structures interact with technology to deliver capability [OINT]”.

They developed a multinational force “co-operability Index” which incorporates assessments of soft (culture, routines, ethos, HR policies, and strategic goals) and hard (technological, and technical) systems connectivity as a holistic measure of OINT for efficient knowledge sharing for sudden and unplanned military co-operations.

Although similarities in IT capability improves the OINT of otherwise distinct organisations by improving their disposition and collaboration readiness Scholl (2005), the preparedness of organisations to synchronise people and processes is a stronger determinant of collaboration readiness and knowledge sharing in public-private ventures (Scholl and Klischewski, 2007). Furthermore, studies also show that firms with well-developed OINT meta-routines have greater cross-organizational compatibility when engaged in collaborations interoperability (Dawes et al., 2009; Gil-Garcia et al., 2005; Scholl and Klischewski, 2007). Compatibility in this sense is the degree to which firms are similar in work styles, participation in decision making, interpersonal relationships; conflict resolution approaches, deference to authority and reporting lines, and adherence to rules (Pardo and Burke, 2008).

Panetto and Molina (2008) argued that in knowledge-intensive collaborations, OINT is required for aligning different manufacturing systems with the processes, routines and people from collaborating firms to deliver the best possible knowledge sharing and business performance outcomes. OINT has also been linked to firms’ ability to standardise their routines and technologies across extensive collaborative networks. In a study examining the nature and causes of conflicts at the implementation phase of large multi-national projects, Hellberg and Grönlund (2013) argued that OINT of basic values and governance approaches facilitated the re-operationalization of collective values. For most multi-national collaborations, it is somewhat impossible to negotiate acceptable values and management strategies upfront. These aspects of interoperability, while critical to the success of collaborations, are usually agreed upon over time in line with joint and practical achievements derived through trial and error. In VEs, it can be argued that firms with well-developed OINT meta-routines have the necessary capability to re-operationalise their values with minimal penalties in the quality, cost, and lead-time required for effective knowledge sharing.

Health care; like other knowledge-intensive industries, thrives on the interconnectivity between hospitals, clinics, pharmacies, and patients to reduce the administrative costs associated with the much-needed knowledge and information sharing for timely, accurate, and consistent quality of care. A study by Bose (2003) demonstrated that management-enabled OINT enables the prompt synchronisation of clinical, administrative, and financial routines. In hospitals, although the administrative and clinical knowledge systems are mutually dependent for the successful running of clinical operations, they are often held in disparate knowledge repositories and sometimes localised in different units, organisations, and agencies. The author further argued that well-developed OINT meta-routines help to eliminate the traditional boundaries between intra- and inter-organisational functions, thereby increasing the preparedness of hospitals to engage with other supporting systems including financial, quality assurance, administrative, and logistics systems for efficient healthcare delivery.

Describing interoperability in military operations, Clark and Jones (1999) argued that OINT affords “the ability of systems, units, or forces to provide services to and accept services from other systems, units, and forces and to use these services so exchanged to enable them to operate effectively together”. VEs in many respects can be likened to such military operations because apart from being sudden, project driven, and technology aided, they thrive on the synchronisation of knowledge resources from collaborators. Since the incentive for full integration is not always apparent at the inception of VEs, it is argued in this study that OINT activates the knowledge sharing capability of VE partners by mediating the relationship among the processes involved in each stage of knowledge sharing and the knowledge outcomes of such VEs. Building on the conceptual arguments on the role of OINT in IT enabled collaborations; the following hypotheses are put forward to close a gap in the extant literature on the exact mechanism through which OINT impacts knowledge sharing by examining its impact on the different stages of tacit and explicit knowledge sharing. This study conceptualises OINT as the level of:

(1) Preparedness: The level of infrastructural readiness driven by an embedded interoperability doctrine, experience, and training.

(2) Understanding: The level of inter-organizational communication and information sharing.

(3) Command Style: The style of decision making, governance, and responsibility delegation.

(4) Ethos: The culture, goals and aspiration of an organisation regarding knowledge sharing.

In line with the preceding points, it is argued that OINT is a key business challenge in collaborative enterprises, although it has mostly been viewed as merely a technical one that can be overcome by technology and technical synchronisation. Nonetheless, the evidence from public administration, strategy, and IT studies lend support to its role as an enabler of collaborative knowledge sharing and business performance. Accordingly, it is hypothesised that:

*H7a: The OINT of collaborating firms positively mediates the relationship between the knowledge socialisation processes and innovation.*

*H7b: The OINT of collaborating firms positively mediates the relationship between the knowledge externalisation processes and innovation.*

*H7c: The OINT of collaborating firms positively mediates the relationship between the knowledge combination processes and innovation*

*H7d: The OINT of collaborating firms positively mediates the relationship between the knowledge internalisation processes and innovation*

Also:

*H8a: The OINT of collaborating firms positively mediates the relationship between the knowledge socialisation processes and adaptation.*

*H8b: The OINT of collaborating firms positively mediates the relationship between the knowledge externalisation processes and adaptation.*

*H8c: The OINT of collaborating firms positively mediates the relationship between the knowledge combination processes and adaptation*

*H8d: The OINT of collaborating firms positively mediates the relationship between the knowledge internalisation processes and adaptation*

In addition:

*H9a: The OINT of collaborating firms positively mediates the relationship between the knowledge socialisation processes and replication*

*H9b: The OINT of collaborating firms positively mediates the relationship between the knowledge externalisation processes and replication*

*H9c: The OINT of collaborating firms positively mediates the relationship between the knowledge combination processes and replication*

*H9d: The OINT of collaborating firms positively mediates the relationship between the knowledge internalisation processes and replication*

## **3.8 The Moderated-Mediation Relationships among the Respective SECI Processes for Tacit and Explicit Knowledge Sharing**

The SECI framework provides a useful and logical template for examining knowledge sharing because in addition to accounting for the tacit and explicit knowledge dichotomy originally proposed by Polanyi (1967), the framework is buttressed by contemporary theoretical views on knowledge sharing from the fields of organizational learning, organizational behaviour, and information systems (Nor Shahriza Abdul et al., 2012; Rice and Rice, 2005; Richtnér et al., 2014). Although tacit knowledge is difficult to operationalise, the SECI framework provides a useful heuristic for isolating the processes closely linked to tacit (socialisation and externalisation) and explicit (combination and internalisation) knowledge sharing. According to the original conceptualisation, all SECI processes are somewhat connected in a continuous spiral of tacit and explicit knowledge sharing. However, the framework lends itself to empirical investigation of each form of knowledge because the processes that characterise each stage are fundamentally distinguishable. Consequently, examining the impact of dynamic capabilities on tacit and explicit knowledge sharing processes in this study may provide useful findings to guide process design, investment, and management strategies targeted specifically at improving tacit and/or explicit knowledge sharing in collaborative ventures. As explained, through combination and internalisation processes, explicit knowledge is codified, documented, and re-interpreted in the context of VEs as new tacit knowledge. Compared to the highly practice-based and socially oriented processes for tacit knowledge sharing, explicit knowledge sharing entails mostly impersonal processes. However, the ‘‘stickiness’’ of tacit knowledge heightens the difficulty encountered in codifying knowledge in a timely fashion to manage the ongoing challenges in collaborative ventures, and to attain expected knowledge sharing outcomes (Anand et al., 2010). Thus in addition to examining the impact of the three dynamic capabilities explored on each stage of knowledge sharing, it is hypothesised that there is an interaction effect or moderated mediation of socialisation on the relationships among externalisation processes for tacit knowledge, the dynamic capabilities, and knowledge outcomes. In other words, the socialisation processes and routines moderates the mediated impact of dynamic capabilities on the ability of externalisation processes to bring about useful knowledge outcomes such as innovation, adaptation and replication in VEs (Chou and He, 2004; Li and Gao, 2003). Once knowledge is externalised, the processes that facilitate the combination of different versions of externalised knowledge must be effective for knowledge internalisation to occur. Consequently, it is expected that efficiency of the combination processes adopted would moderate the impact of the dynamic capabilities of partners on their ability to achieve expected knowledge outcomes through internalisation of new knowledge routines and practices in VEs (Anand et al., 2010; Nor Shahriza Abdul et al., 2012; Vaccaro, et al., 2009).

Accordingly, it is hypothesised that:

*H10a: Improved socialisation routines strengthen the positive effect of externalisation routines on innovation in VEs.*

*H10b: Improved socialisation routines strengthen the positive effect of externalisation routines on adaptation in VEs.*

*H10c: Improved socialisation routines strengthen the positive effect of externalisation routines on replication in VEs.*

Likewise, it is hypothesised that:

*H11a: Improved combination routines strengthen the positive effect of internalisation routines on innovation in VEs.*

*H11b: Improved combination routines strengthen the positive effect of internalisation routines on adaptation in VEs.*

*H11c: Improved combination routines strengthen the positive effect of internalisation routines on replication in VEs.*

* 1. **Chapter Summary**

Collaborations provide a useful avenue for firms to acquire new knowledge about products and services as well as new strategic, tactical and operational management routines. Emerging megatrends like globalisation and IT advancements have increased the incidence of outsourcing and alliances, however, the stickiness of tacit knowledge makes knowledge sharing extremely difficult particularly in competitive industries. Nonetheless, the evidence overwhelmingly suggests that the ability to execute effective knowledge sharing in cross-border collaborations is the primary driver of innovation, adaptation and replication. This chapter pooled together arguments from the KBV and the relational view of strategic management to explain the dynamics of knowledge sharing in collaborative ventures. Drawing on prior studies, the chapter articulates a number of hypotheses to explain the pivotal role played by dynamic capabilities or higher order meta-routines like ACAP, TMS, and OINT in the transfer and sharing of substantive organisational routines and processes in VEs for innovation, adaptation, and replication.

Based on the literature review, it was noted that the SECI model of knowledge sharing, although quite detailed in its sequential operationalisation of the processes required for tacit and explicit knowledge sharing has been criticised for not fully capturing the dynamics required for effective knowledge sharing. Nonaka and colleagues in explaining the dynamic nature of the model, outlined certain enabling conditions or microfoundations for knowledge sharing. Reviewing the strategic management literature, ACAP, TMS, and OINT were identified as important microfoundations for achieving innovations, adaptation, and replication in collaborative ventures. Further reviews of studies on these constructs presented in this chapter revealed that while they have been linked to innovation in other organisational contexts, there are limited empirics on their impact on adaptation and replication, despite the wide acknowledgement in the literature of the relevance of knowledge adaptation and replication in highly innovative and competitive industries.

The chapter further presents evidence from which hypotheses were developed to test the mediating impact of these dynamic capabilities in the SECI process-model for knowledge sharing. The proposed framework is a useful extension of the theory on knowledge sharing because it succeeds in incorporating dynamic capabilities into a model that simultaneously explains the processes for knowledge social justification and tacit-explicit knowledge conversion spirals through several scalar levels (individual, teams, firms and collaborations). In the next chapter, the literature is reviewed to outline a fitting research methodology for this study.

# CHAPTER FOUR: METHODOLOGY

## **4.1 Background**

The purpose of this study as captured in the previous chapters, is to examine the dynamics of knowledge sharing for innovation, adaptation and replication in VEs, drawing on the SECI model’s conceptualisation of tacit and explicit knowledge sharing processes, and including three dynamic capabilities that have been implicated as microfoundations of inter-organisational knowledge sharing in previous studies on knowledge sharing.

The preceding chapter proposed a conceptual framework and itemised 11 hypotheses to explore the mediating impact of dynamic capabilities on the ability to achieve innovations, adaptation and replication through tacit and explicit knowledge sharing processes. The proposed research framework builds on the SECI model of knowledge social justification and tacit-explicit knowledge conversion in VEs by proposing the inclusion of three dynamic capabilities as mediators in the model, to account for the dynamism that is required for knowledge sharing processes to be effective. This chapter presents analytical discussions, beginning with a rationale for the critical realism research philosophy, survey design, questionnaire data gathering and structural equation modeling data analyses used in this study. The chapter further explains the analysis steps and procedures, including details on the rationale for the different tests carried out in the factor analyses (exploratory confirmatory) and path analysis stages of SEM. Discussions on the research construct operationalization are also presented.

## **4.2 The Nature of Society and the Nature of Man: Research Philosophy**

Johnson and Duberley (2003 p.1280) argued that:

"….to make unexamined metatheoretical commitments, and remain unaware of their origins, amounts to an abdication of intellectual responsibility which results in poor research practices. Even a cursory examination of the philosophy of science would confirm that while such commitments are unavoidable and lead us to engage with 'management' in particular ways, they are also always contentious and precarious and thus require vigilance………Vigilance must also embrace management education through the inculcation of 'an intimate understanding of the way management knowledge is organized, produced and legitimized' - an agenda which has become all the more important with the 'managerialisation of the world'. So while we cannot eradicate our subjective metatheoretical commitments, we must open them to our inspection through our capacity for reflexivity."

Researchers in the social sciences make several important philosophical assumptions on what can be ‘known’ about social variables, how such knowledge is acquired and quantified, and whether studying their relationships could inform theory and decision-making (Easterby-Smith et al., 2012; Mir and Watson, 2000). In the following subsections, attention will be given to analysing the assumptions behind methodological choices, to provide a rationale for the methodology used. The discussion begins with broad discussions on ontology and epistemology, and how they contribute to shaping methodological choices, through ‘research paradigms’. Subsequently, the distinguishing epistemological features of quantitative, qualitative, and pluralist research paradigms are examined, followed by a rationale for the positivist approach adopted in this study.

Beginning with studies by Kuhn (1962), Burrell and Morgan (1979), and recently, Meredith et al. (1989), methodological choices in the social sciences have been greatly influenced by paradigms. These authors among others argued that meta-theoretical assumptions about reality (ontology), human nature, what constitutes knowledge, and how it can be acquired (epistemology), are unique to each research community. Within each field, such assumptions create 'paradigms', or a consensus held among researchers on acceptable practices, standards, theories, and methodologies for conducting studies (Goles and Hirschheim, 2000). Burrell and Morgan (1979) noted that social scientists make two primary assumptions about the nature of society, and the nature of science. On the nature of society, social scientists are influenced by varying degrees of ‘rational' or ‘radical' worldviews, which affect how they approach and assess research problems. The rational view (modernism) holds that society evolves without the influence of values, traditions, perceptions, and emotions. The radical change view (post-modernism) on the other hand, argues that social structures are influenced by individual perceptions, and are prone to constant change (Shepherd and Challenger, 2013). Concerning the nature of science, the two main paradigms in the social sciences - objectivism and subjectivism- are viewed as opposing ends of a continuum, with a range of slightly different philosophical positions in-between (Bryman and Bell, 2015). Both paradigms also have a number of alternative names; for instance, objectivism is sometimes called quantitative, positivist, scientific, experimentalist, traditionalist, or functionalist; while subjectivism is called qualitative, phenomenological, humanistic, or interpretivism.

Realism is the ontological position or worldview embraced by positivists, which assumes that social variables are independent of human perception or investigation and can be reduced to measurable empirical quantities (Goles and Hirschheim, 2000). The realist ontology assumes that subjective variables can be quantified through sense observation and statistical analyses of data obtained from social actors, and the resulting measures used to model causal relationships (reductionism) (Godfrey and Hill, 1995). Consequently, they rely on mathematical and statistical methodologies from the physical and natural sciences. Positivism further assumes that within specified testable limits (e.g. sampling adequacy and bias tests), data generated from social actors could be generalised (empiricism), and interpreted as value-free or void of biases (Gill and Johnson, 2010). Like the natural scientists, positivists in the social sciences draw on insights from theories to propose causal relationships among social variables to understand them, and further examine or even predict human social behaviour (Easterby-Smith et al., 2012). Large population samples are often required, and ‘hypothetico-deductive models' are used to formulate and test such proposed relationships for ‘falsifiability' (verification/ refutation) of theoretical assumptions against observed data (Walsh et al., 2015).

In contrast, the ontology for interpretivism is relativism, solipsism, or instrumentalism; and it assumes that the interpretation of reality (or what is knowable) is subjective and influenced by the researcher (Johnson and Duberley, 2000). Researchers who adopt this approach make use of in-depth and qualitative methods to explore and perhaps, explain the factors that define and influence social variables. The core argument here is that it is inconceivable to separate the researcher from the subject since personal factors like the investigators’ background, status, skills, interests, and resources could affect studies and their implications (Hussey and Hussey, 1997). In other words, the drive of interpretivism is to find the ‘meaning' rather than measures of social variables, using in-depth investigations of individual cases in place of reductionism.

Critics of the objectivist approach have argued that the complexity and subjectivity of social phenomena make it difficult to explain their nature and interactions with statistical or mathematical models. On the other hand, those opposed to subjectivism have maintained that the main shortcomings are relativism; or its personal and context-specific versions of reality, and incommensurability; or lack of standardisation in variable measurements (Hughes and Sharrock, 1997; Rosenau, 1991). Thus, to capitalise on the strengths of both approaches, some have advocated for an intermediary paradigm called mixed-methods or pluralism (Bryman and Bell, 2015; Clark, 2010). This approach view human nature and social variables as both deterministic (structured/governed by causal laws) and voluntaristic (constantly evolving) (Creswell, 2013; Shepherd and Challenger, 2013). Its proponents have argued that through methodological or philosophical ‘triangulation’ of qualitative and quantitative findings, theory building is made more robust (Johnson et al., 2007; Shepherd and Challenger, 2013). However, triangulation is not at all a straightforward solution to the paradigm debates, because it's deterministic and voluntaristic assumptions and approaches could be opposing and might present challenges in interpreting research findings (e.g. the classical debates on leaders being are born or made) (Shepherd and Challenger, 2013).

C*ritical realism* is a moderate ontological position held by some positivists and most pluralists in the social sciences. Its main premise is that social reality can be empirically studied by deriving measure for the structures and mechanisms that govern individual and collective human decisions and actions (Miller and Tsang, 2011; Tsang and Kwan, 1999). For instance, to innovate, replicate, or adapt new knowledge, companies must possess qualified experts, relevant capabilities, and an enabling environment. These factors represent the underlying structures and mechanisms that produce what is viewed as innovation. From a critical realist perspective, subjective data that is gathered in a theoretically rigorous, well-defined, and systematic way from a good number of experienced managers, could be statistically analysed to yield useful correlations. The second premise of critical realism holds that observable empirical events or relationships (e.g. the relationships explored in this study) within social structures are contingent upon several factors (location, industry, type of virtual enterprise). It further argues that it is possible to understand empirical relationships within real structures such as organisations, by drawing on established theories (Miller and Tsang, 2011). Thus, the fundamental difference between realism and critical realism is that the latter assumes that observing interactions within social structures can produce empirical outcomes, and the measures do not need to be observable to exist (e.g. ACAP, TMSs, and OINT). As explained by Tsang and Kwan (1999):

"The critical realist agrees that the search for quantitative social laws that can accurately predict social events is not feasible. The exclusive emphasis on prediction will even obscure the important role of explanation in natural science. Although verification and falsification are never conclusive, critical testing of theories is still important".

Reflecting on the above arguments, study takes the perspective that the real world exists independently of our perception (realism), but it is possible to create hypothetical models of ‘real' interactions among variables like dynamic capabilities, knowledge sharing processes, and knowledge outcomes. Although the hypothesized model is tested using actual primary data, it is not intended as an absolute representation of reality, but rather, a logical and applicable one (Goles and Hirschheim, 2000). The next subsection examines the design decisions and rationale for this study.

### **4.2.1 Rationale for a Correlation-Based Research Design**

Research design is defined as the series of guidelines that help researchers to decide the type of data to be collected, the sampling strategy, the data collection tools and procedures, and a suitable analysis approach (Boyd et al., 2012). As shown in Table 4.1, there are three broad types of quantitative research designs. Descriptive studies present static pictures of existing relationships among variables as they occur. Correlational studies examine the nature of relationships among variables, while experimental studies establish causality by measuring changes in relationships among variables before and after interventions (Scandura and Williams, 2000). Other frequently used sub-categories of quantitative design include; quasi-experimental; survey-based; and evaluation research.

***Table 4.1:*** *Types of research design (Stangor, 2014)*

|  |  |  |  |
| --- | --- | --- | --- |
| Research design | Goal | Advantages | Disadvantages |
| Descriptive | To create static representation of the relationships between and among variables. | Provides a comprehensive picture about a construct, which enables the development of research questions, hypothesis, and frameworks for further studies. | Relationships among variables are not assessed. Is usually suited for studies in research domains with nascent theories.  Usually requires several levels of ethical clearance, particularly if participants are going to be observed. |
| Correlational | To test and assess the relationships between and among variables. | Allows developed frameworks with hypotheses on expected relationships between and among variables to be tested. Results usually aid in predictions and decision making. Predictions about variables that affect operations and supply chain management performance can be made, which could lead to important findings with implications for theory and practice. | Cannot be used to infer about causal relationships among variables. |
| Experimental | To assess the causal effect of experimental manipulations of a predictor variable on an outcome. | Enables researchers draw conclusions on the nature of causal relationships among variables. | Some important variables cannot be experimentally manipulated, and social experiments are often very expensive to conduct and time consuming. |

In selecting an appropriate research design for this study, it was important to achieve ‘methodological fit'. As shown in Table 4.2, three archetypes or patterns of methodological fit have been described in management research. The first pattern involves nascent theory— or research problems for which there is little or no previous formal theorizing. Research questions are designed to probe for insights into new or unusual phenomena, or relationships among variables, towards theory building. Consequently, a grounded theory approach is taken to enable the development of new concepts (Burton-Jones et al., 2015; Edmondson and McManus, 2004). Furthermore, studies involving nascent theory are best suited for designs like ethnographies, action studies, and longitudinal studies, and use mostly open-ended questions, exploratory interviews, and observations (Edmondson and McManus, 2007).

The second pattern of fit is seen in management studies involving mature theory. Such studies use statistical or mathematical model based designs to examine relationships among variables, drawn from prior research and validated (Burton-Jones et al., 2015). The objective is often to stimulate further debates on theories relationships concepts within a growing body of literature. Consequently, the rationale for such studies can be articulated logically from the outset, and the research methods used are often reasonably thorough and quantitative. Research questions are articulated in a manner that clarifies, or challenges theories or existing relationships among variables, or in a manner that replicates previous studies in different contexts. A hypothesis-testing approach is usually used to examine relationships such as interactions, mediation, or moderation effects between previously developed latent variables, to arrive at a variance theory – or a statement of logic asserting that changes in a predictor variable (X) are directly or inversely associated with observed changes in an outcome variable (Y) (Anderson et al., 2015). Construct development for such studies typically involves adopting a set of measures directly from previous studies, or adapting pre-defined measures to suit the context of the study in question. Therefore, the characteristic research design for studies predicated on mature theory tends to be either descriptive, correlational, experimental, meta-analytical, or review-based (Edmondson and McManus, 2007). Furthermore, data collection for mature theory testing is usually done through surveys (quantitative questionnaires or closed-ended quantitative interviews), and the collected data is typically analysed using a variety of statistical methods to support or refute a set of falsifiable hypothesis. Although experimental research arguably produces the most compelling findings towards mature theory development because independent variables can be manipulated to highlight the effect of changes in outcome variables, controlled social experiments are practically and technically difficult to execute in management research, owing to access, resource, and time constraints (Amit et al., 1993; Flynn et al., 1994).

In some cases, researchers may attempt to reinvestigate relationships among variables domiciled in one mature research domain or by combining separate but related bodies of management theory. Such intermediate theory-building studies draw on approaches from different streams to arrive at provisional theories and in some cases, define new research variables (Edmondson and McManus, 2007). Accordingly, intermediate theory building often uses preliminary quantitative studies to explore research questions generated from field work, expert opinion, or nascent theory. In other words, it combines variance theories - which predict how changes in named variables directly or inversely affect known outcomes - with process theories – which deal with the qualitative details of how a given phenomenon works. Intermediate theory building applies mixed approaches, however as noted, researchers risk compromising the strengths of each approach, particularly in blending different analytical approaches and logics through triangulation. As highlighted in the literature review, the variables examined in this study were drawn from the following mature streams of management;

1. Organisational studies and strategic management studies on dynamic capabilities.
2. Knowledge management studies on (a) inter-organisational knowledge sharing; specifically, the widely researched SECI model by Nonaka and Takeuchi, (1996); and (b) the outcomes of inter-organisational knowledge sharing.
3. Operations and supply chain management research on collaborative networks, with emphasis on VEs.

***Table 4.2:*** *Description of the archetypes of methodological fit (Edmondson and Mcmanus, 2007)*

|  |  |  |  |
| --- | --- | --- | --- |
| Prior Theory in research domain | Nascent | Intermediate | Mature |
| Research questions | Adopts open-ended questions regarding a phenomenon | Makes propositions regarding relationships between established constructs and new ones. | Asks specific questions and/or hypotheses regarding relationships among theoretically established constructs. |
| Data required/collected | Usually requires open-ended data to enable further analysis and interpretation. | Uses hybrid/mixed methods (both  qualitative and  quantitative) | Usually quantitative data or qualitative measures interpreted quantitatively (e.g. ACAP, TMSs).  Measures for constructs often adopted and/or adapted from the extant literature. |
| Data collection | Interviews; observations; field documents; notes; diaries; and other relevant materials collected from the field. | Interviews; observations; surveys; other relevant materials collected from the field. | Surveys; interviews systematically quantifiable observations; systematic reviews; obtaining relevant historical data from field that could aid in the measurement of salient constructs. |
| Constructs and  Measures | Usually new constructs with very few established measures | Few new constructs and/or new measures alongside established measures. | Relies extensively on existing constructs and adopted/adapted measures. |
| Goal of data analyses | Pattern identification | Exploratory testing of propositions about new constructs. | Formal hypothesis  Testing |
| Data analysis methods | Thematic content analysis; coding for evidence of constructs that could help explain a given phenomenon. | Content analysis,  exploratory  statistics, and  preliminary tests | Statistical inference, standard statistical analyses; statistical modeling. |
| Theoretical  Contribution | Proffers suggestive theories to attract further debates, and confirmatory research interests. | Develops provisional theories to bridge gaps between separate bodies research. | A supported theory that may add specificity, new mechanisms, or new boundaries to existing theories. |

Dynamic capabilities like ACAP, TMS, and OINT, have been studied in different contexts; as predictors, mediators, moderators, or outcome variables, and several useful frameworks have been developed using descriptive, correlational, and experimental research designs. Some examples of research designs used in recent studies include Heavey and Simsek (2015), who examined how the link between external social network ties and the rate of change within an industry affects the TMS and performance of top management teams, using a survey of 467 SMEs and Hierarchical Regression Analysis. Similarly, Choi et al. (2010) in a study on the impact of TMS on knowledge sharing and team performance, conducted a field study involving 139 on-going teams. For ACAP, Xia and Roper (2016) explored the relationship between ACAP and growth in small and medium scale biopharmaceuticals, using a global survey of 349 biopharmaceutical firms. Likewise, Denicolai et al. (2016) examined the role of internal R&D in facilitating or hindering the ACAP for external inbound knowledge over time, using a panel data of 325 firms collected over five years. Zhang et al. (2015) statistically verified a model describing the relationship between ACAP and mass customisation capability, using structural equation modelling (SEM) to analyse data collected from 276 Chinese manufacturing firms. The extant theories on organisational interoperability (OINT) are comparatively less advanced but sufficient frameworks and measures exist to support a quantitative empirical study. For instance, Maheshwari and Janssen (2014) presented a framework for measuring, benchmarking, and improving interoperability using emergent global capabilities such as open data, big data, and knowledge/information crowd sourcing. They empirically examined the applicability and usefulness of the framework with case studies. Similarly, Zutshi et al. (2012) evaluated the factors that affect business interoperability in collaborative ventures, taking an analytical network process approach, and using two cases. Likewise, Pirnejad et al. (2008) used interviews, document analysis, and observations to evaluate the impact of OINT on ‘medication data’ communication between primary and secondary healthcare providers, and Campos et al. (2013) proposed an interoperability maturity model, a methodology, and set of parameters for capturing ‘interoperability potential’ in collaborative ventures.

The SECI spiral of knowledge sharing has also received significant empirical attention, with qualitative, quantitative, and mixed studies published across different management domains. A few examples of the research designs used in such studies include a study by Hubers et al. (2016), examining the processes involved in the stages of the SECI spiral, in two data teams over a two-year period. Similarly, through a survey of 87 Spanish hospitality companies, Martínez-Martínez et al. (2015) examined how the stages of the SECI knowledge sharing spiral enables the reuse and updating of environmental knowledge. Anand et al. (2010) used the SECI framework to classify six sigma practices into tacit and explicit practices. Using hierarchical regressions, they examined how the explicit- and tacit-knowledge-sharing practices affect process improvement, using a cross-sectional survey sample of 98 Six Sigma black belt projects. Likewise, Richtnér et al. (2014) used the SECI model in a longitudinal study on the impact of changes in organisational slack on knowledge sharing for NPD in six running projects, over a two-year period. Li et al. (2009) examined the relationships among entrepreneurial orientation, the SECI stages of knowledge sharing, and firm performance, using a survey of 165 entrepreneurs and LISREL analysis. Also, Tsai and Li (2007) explored how the SECI knowledge sharing stages affect the development of new venture strategies in a survey of 165 Taiwanese new investments.

Prior studies on knowledge outcomes such as Ringov et al. (2015), examined how replication of productive routines affect firm growth and profitability, by using longitudinal data on ‘template-based replication’ in 2,038 outlets of a large franchise from 1991 to 2001. Williams, (2007) explored the role of replication and adaptation in knowledge transfer relationships using a survey of 62 telecommunications firms, sampled from a database, and analysed using SEM.

Jensen and Szulanski (2004) investigated the relationship between the adaptation of organisational practices and the ‘stickiness’ of cross-border transfers using a survey sample of 122 internal transfers of best practice. Likewise, Forés and Camisón (2016) studied the relationships among internal knowledge creation, absorptive capabilities, and incremental versus radical innovation performance, with survey data from 952 Spanish firms, and SEM. Tortoriello (2015) investigated how individuals in an organisation utilize external knowledge to generate innovations, using survey and archival data from 276 scientists, researchers, and engineers in R&D for a high-tech multinational.

The majority of studies on VEs focus on developing optimisation models for effective communication, information transfer, and partner selection. Partner selection is a major success factor for VE coalitions and is often viewed as a multi-attribute optimisation problem. For instance, Mikhailov (2002) developed a fuzzy approach to partner selection in virtual enterprise formation, using the Analytic Hierarchy Process. Niu et al. (2012) used an ‘enhanced ant colony optimiser (ACO)’ to address the partner selection problem, accounting for key attributes like cost, lead-time, quality, reputation, and risk. There are also some survey-based study designs, like Cao and Dowlatshahi (2005) who explored the impact of the alignment of VE strategies and information technology capabilities on business performance, using a survey sample of 102 advanced manufacturing companies, using bivariate analysis. They extended the study to include surveys from five different industries in a subsequent study (Dowlatshahi and Cao, 2006).

Based on the foregoing, the most consistent methodologies used in previous studies to examine similar relationships involving the dynamic capabilities, SECI knowledge sharing processes, and knowledge outcomes examined in this study are experimental and correlational designs. The advantage of experimental designs for examining variables like innovation, replication, and adaptation is that controlled experiments enable the researcher to examine causal relationships between independent and dependent variables drawing on different sources of data, including big data (e.g. analysis of NPD/sales and customer satisfaction using sales patterns), and historical/ archival data. Correlation studies on the other hand, are limited because they only show if correlations exist between variables (Boyd et al., 2012; Flynn et al., 1990; Ketchen et al., 2008). However, the limitation is that experimental studies in management are difficult to run under the time and resource constraints of a doctoral research. Correlation studies have thus been used to identify key correlation among social variables that are worth exploring further (Bryman and Bell, 2015). In this study, a correlational design was chosen to test the study's hypotheses on the existence and direction of mediated relationships in the knowledge sharing processes in VEs. SEM was used for the analyses because of the capacity it provides to model and test ‘statistical causality’ among subjective variables. It allows the researcher to build correlation or covariance based causal models of interactions between variables predicted in line with theory, and then, check if such models fit the correlation matrices in the data collected. If a model fits, then it can be used to verify specific hypotheses (Bollen and Pearl, 2013; Eisenhauer et al., 2015; Henseler et al., 2015). As explained in an early publication on path analysis by Wright (1921:557),

“The method [of path analysis] depends on the combination of knowledge of the degrees of correlation among the variables in a system with such knowledge as may be possessed of the causal relations. In cases in which the causal relations are uncertain the method can be used to find the logical consequences of any particular hypothesis regarding them.” (Bollen and Pearl, 2013 p.12)

Details on the SEM approach are provided in later subsection of this chapter. The next subsection examines the data collection approach.

### **4.2.2 Rationale for Adopting a Survey Data Collection Approach**

Surveys are a systematic method of collecting ‘samples’ or representative subsets of a population (Bryman and Bell, 2015). Population sampling involves collecting data from persons, or other population entities (e.g. teams, households, companies) in a uniform and consistent way. Surveys are considered as less costly and more accurate than similar population sampling approaches like censuses and polls, which are usually more painstaking and require comparatively larger samples to run (Forza, 2002; Greenlaw and Brown-Welty, 2009). Nonetheless, there are two general defining characteristics of surveys. First, they use samples to make generalisations regarding specific conditions/relationships within a population, and secondly, they gather information with the aid of systematic instruments— most often, a structured questionnaire or interview (Bryman and Bell, 2015).

Understanding the target population is an important consideration in selecting the right survey approach (Flynn et al., 1994). The target population for this study was organisations with previous or recent engagements in cross-national/regional VE projects. As explained in the literature review, VEs are a form of episodic CNOs (CNOs) (Camarinha-Matos et al., 2009) established by a group of firms from structured and long-term collaborative networks like virtual organisation breeding environments (VBE) and professional virtual communities (PVC). These environments are designed to provide the infrastructural and relational support required for speedy and efficient short-term collaborations as opportunities arise (Gunasekaran and Ngai, 2004).

Some have noted that sharing knowledge in ‘breeding environments’ is enhanced by the existence of shared operating rules, interoperable infrastructure and long-term cooperation agreements (Camarinha-Matos et al., 2009; Romero et al., 2007). Several forms of VBEs are established across different industries such as industry clusters, industry districts, business ecosystems, disaster rescue nets and collaborative virtual labs (Camarinha-Matos et al., 2009; Connell et al., 2014). Obtaining data from such VBEs was the first population sampling option considered because they afford a higher propensity to sample organisations with the relevant VE experience and capabilities required when compared to a random sample of firms drawn from different industries.

However, the challenge with this option was the availability of contact details for potential participants. Although the researcher was able to find a few relevant contacts of industry clusters from internet sources, it was rather challenging, given the time and resource constraints of this study, to get direct contact details for relevant respondents from the participating firms within such clusters and breeding environments. The second challenge with sampling breeding environments is the tendency for ‘response bias’, which is a general term for a class of cognitive biases that affect survey responses. Companies sampled from VBEs would show a greater tendency for acquiescence bias (agree with all the questions), demand characteristics bias (alter responses to align with their perception of what they think the researcher wants), or extreme responding bias (responding to all questions with absolute values).

The other available sampling option was to exclude companies without VE experience, from a random population of firms in different industries. This approach required ‘screening questions’ to determine whether respondents were qualified to answer the questions posed. Questionnaires with several layers of screening can be tedious and confusing for those surveyed, particularly if the survey approach used is impersonal (online or mail) (Hair et al., 2015). For this study, the screening was only used to exclude respondents in line with the research context (those knowledgeable about VE execution and management). This approach yielded a more varied dataset because although some companies may not be actively involved in clusters or breeding environments, they often form hierarchical or holarchical VEs in line with market, capability, or infrastructural demands. Thus, the researcher obtained a multi-group dataset, which allowed for comparisons between the responses from firms within and those outside VE clusters or breeding environments. Furthermore, in selecting a survey approach, it was important to select a survey approach that enabled access to a global sample of companies engaged in the two forms of VEs identified from the review (Hierarchical and Holarchical). As noted, the choice of VE type is driven by the nature of VE operations, the presence of boundary spanning suppliers (e.g. in the retail, food processing industries), and the level of complexity in the supply chain. Table 4.3 outlines the advantages and disadvantages of different survey options considered.

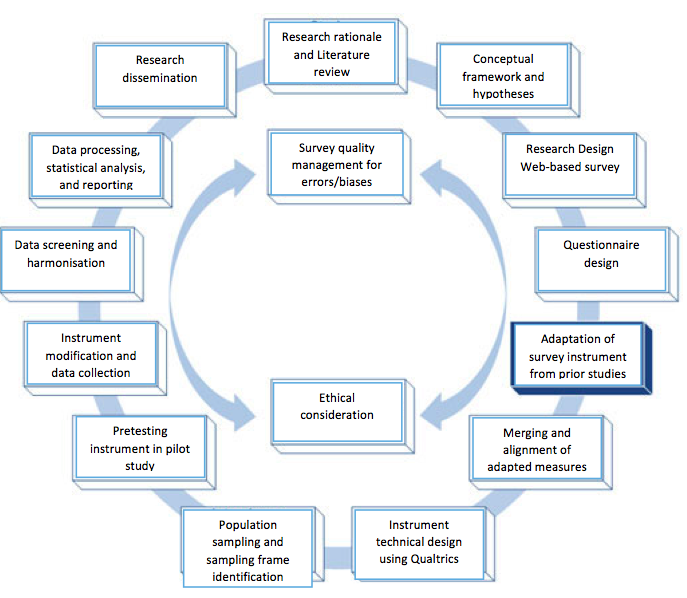
***Table 4.3:*** *Description, advantages, and disadvantages of different survey approaches (Rea and Parker, 2014)*

|  |  |  |  |
| --- | --- | --- | --- |
| Survey type | Description | Advantages | Disadvantages |
| Mail-Out Surveys | A survey format involving the dissemination of printed questionnaires through the mail to predesignated respondents. | Access to respondents by mail is less expensive than telephone surveys or in-person interviews.  The questionnaire can be completed at the respondent’s convenience.  Respondents have enough time to elaborate on answers and consult with others, where necessary.  *R*espondents are allowed to make their own judgements regarding the meaning of questions, thus reducing clerical or administrative interviewer-induced errors.  .  Mail-out questionnaires can be more explicit, and utilize definitions, and visual aids to guide respondents, unlike telephone survey. | • *Comparatively long response time period and difficult to follow-up.*  *R*espondents with reading or language  Deficiencies would more often, exclude themselves from mail-out surveys than interviews (self-selection).  .  L*ack of interviewer involvement*  *Open-ended questions are* more likely avoided. |
| Web-Based Surveys | An alternative to traditional mail-out surveys where respondents are contacted via e-mail. | It is a convenient option with the proliferation of the internet, computers and similar devices.  Enables quick and robust *data collection because it:*   * Reduces geographical dependence in sampling strategy * Can be used to collect a broad range of data from a large number of respondents collected (e.g., attitudes, opinions, beliefs, values, or behavior). * Numerous questions can be asked about a subject because of the extensive flexibility in data analysis * Uses survey software and advanced statistical methods to analyse survey data for validity, reliability, and statistical significance of multiple variables * Standardized surveys are comparatively free from the common types of survey errors.   Respondents have enough time to elaborate on answers and consult with others, where necessary.  Respondent enjoy more anonymity compared to survey formats such as interviews.  Surveys sent via credible email domains tend to attract legitimacy and credibility.  More cost-effective and possibly more sustainable than mail-out surveys since no postage or paper is required. It is also not as labour intensive as telephone or in-person surveys.  *Ease of follow-up p*otential respondents through reminder emails.  *Confidentiality and security of p*ersonal or sensitive information through secure servers.  Useful in reaching specialized and well-identified and structured populations with readily available e-mail addresses (e.g. employees). | Limited to populations with access to the internet, emailing services, and computers.  Requires a minimal level of computer literacy for completion and return of questionnaires.  Self-selection bias could arise if potential respondents are not comfortable with web-based technology.  L*ack of interviewer involvement could* compromise the scientific reliability of the survey in cases where the respondents are unclear about the questions asked. |
| *Web Panels* | The use of large banks of potential survey respondents with different specialisations recruited by web companies to complete surveys. | Similar advantages to web-based surveys. | Again, self-selection could affect the requirement for random selection, if it is a crucial study consideration. |
| Telephone Survey | Telephone surveys are used to sample populations using telephone interviews.  *The random digit dialing* (RDD) method utilizes random samples of telephone numbers, while the f*ixed list approach:*  draws a random sample of in-person  Interviews. They numbers from a fixed list. | Timely *data collection*  *Possible cost savings*  A telephone survey provides more anonymous than  are less threatening for both interviewer and respondents.  A reasonable degree of interviewer participation. | The interviewer has less control compared to in-person interviews, as the respondent could opt out abruptly by hanging up.    *Less credibility than in-person or email surveys from credible email domains.* |
| In-Person Interviews | Face-to-face surveys require an interviewer to collect information directly from respondents, using personal interviews. | • Unclear questions can be explained, and the interviewer can probe for details.  Highly complex subjects are better handled via in-person interviews because they could be confusing or even intimidating if administered through questionnaires or other means.  H*ard-to-reach population are easier to reach via in-person interviews.* | In-person interviews can be very costly (time per interview, travel time, interviewer training, and field  Supervision)  There is a greater tendency for i*nterviewer-induced biases.*  High r*espondents’ reluctance to cooperate at different stages of the sampling and data collection.*    In-person interviews are more tasking and stressful for the respondents and interviewers.  *Less anonymity compared to* mail-out, email and telephone surveys. |
| Intercept Surveys | The intercept survey is a type of the in-person survey where information is gathered from passers-by in populated public areas. | High i*nterviewer involvement for clarification, context provision, and human interaction.*  Can be used to i*nform further studies or improved questionnaire development.*  Personal characteristics of respondents like age, gender, disability, and race can be observed by the reviewer to avoid sensitive questions.  *More cost-effective* than telephone, mail-out, and in-person surveys. | *Interviewer errors and biases could affect the reliability of data.*  *Limited information can be gathered s*ince out of necessity, intercept surveys are usually very short.  *Lack of anonymity* |

Drawing on the preceding discussions, the web-based questionnaire approach was used. Computerized self-administered questionnaires (CSAQ) are a form of survey, which is designed to be completed and returned by respondents via email or an online survey portal (Bourque and Fielder, 2003). As much as possible, good online surveys should minimize any ‘survey errors’ that could diminish the reliability and value of research findings for future studies and decision-making. Self-selection bias is one of such errors typically associated to web-based questionnaires, and it arises when potential respondents are either not comfortable with web-based technology, or drawn randomly from regions where internet technology is not as readily accessible. Discussions on sampling errors, and how were managed in executing the survey for this research are provided in a subsequent subsection.

Cobanoglu et al. (2001) compared mail-out, fax, and web-based surveys using parameters like response speed, response rate, and cost. They found that the fax and web-based approaches appeared to be the fastest, with an average response time of 4.0 and 5.97 days respectively. The slowest approach appeared to be the mail-out surveys, with an average response time of 16.46 days. The web approach also gave the highest response rate of 44.2%, while the mail-out (26.27%) and fax (17.0%) options showed comparatively lower response rates. Gosling et al. (2004) examined the data quality of internet-based surveys and found that they tend to be comparatively more diverse on gender, socioeconomic status, geographic region, and age than other survey formats. Denscombe (2006) compared the completion rates and data content of web-based and paper-based questionnaire delivery modes and found little evidence of any ‘mode effect’ associated to web-based questionnaires on the examined criteria.

More recent studies like Gnambs and Kaspar (2014) compared the prevalence of misreporting for sensitive questions in web-based and paper-based self-reported surveys and found that computerized surveys produced significantly less misreporting compared to surveys administered on paper. Similarly, in a comparative study on response quality, Rada and Domínguez-Álvarez (2014), found that web-based self-administered questionnaires produced fewer unanswered questions, better response rates, and more consistent and detailed answers to open questions, in comparison to mail-out questionnaires. Likewise, Ramsey et al. (2016) examined respondents’ attention to detail in web-based surveys in a controlled lab experiment using “item recognition accuracy” as a measure of attention to detail. Results indicated good item recognition but suggested that researchers provide clear instructions on the meaning and nature of the latent variables explored. The studies cited above, along with previous studies that have explored similar variables using web-based surveys provided further rationale for using the web-based self-administered questionnaires approach for this study. Figure 4.1 below shows a summary of the life-cycle of web-based questionnaires from administration and execution to analysis and reporting. The stages outlined are analysed and explained in the succeeding sections of this chapter.



***Figure 4.1:*** *Survey Research Lifecycle (Harkness, 2011)*

### **4.2.3 Questionnaire Instrumentation**

For questionnaires to be effective, respondents must be able understand the purpose of the study, interpret open-ended, multiple choice, or Likert-scaled questions, and translate their assessment of each question into a scaled response (Krosnick and Presser, 2010). The structure and clarity of the instrument, task difficulty, respondent ability, and respondent motivation have a combined impact on the effectiveness of a questionnaire instrument in collecting useful data (Krosnick, 1999). Task difficulty could arise from question-specific issues such as difficulty in following or interpreting questions; or administration issues such as the accessibility or format of the online questionnaires (Bryman and Bell, 2015; Krosnick and Presser, 2010). Respondent ability is the extent to which sampled respondents are able to provide informed answers, while respondent motivation refers to the effect of personal interest in the topic, perceived relevance, the required duration for questionnaire completion, and other administration issues like the researcher’s approach to follow-up emails.

Respondent ability and motivation are both greatly enhanced by the structure, user-friendliness, and clarity of questionnaire instruments. The questionnaire instrument used was designed on a web-application known as Qualtrics, and a web link to the questionnaire was then emailed to potential respondents. Compared to similar web-based platforms (e.g. Surveymoneky), Qualtrics was chosen for its user-friendliness, reliability, attractive graphical interface, and free access to the software licence provided by the university. Qualtrics is also well synchronised with the statistical packages used in subsequent analyses, and has built-in features to prevent multiple answers from a single respondent (the “Prevent Ballot Box Stuffing” option), and improve data security and anonymity in line with the ethical requirements of this study (Boas and Hidalgo, 2013).

Similar to the measures adapted from prior studies, closed-ended questions on 5 point Likert scales were used. Categorical questions (with options representing different objects, rather than different points on a continuum) were used to capture demographic data (e.g. region, industry, size etc.) (Krosnick and Presser, 2010). In most cases, demographic information requires categorical judgement of options from an exhaustive list. For the demographic data collected, open questions were included to enable respondents add new categories (e.g. industry, job title). Likert scales are interval measurements rather than actual measures of quantities, and there are suggestions in the literature that certain scale lengths are preferable for achieving good variable reliability and validity. The rationale is that because respondents are expected to capture their perceptions on the scale, finer-grained intervals (like 10 points or higher) may present challenges in interpreting and analysing responses (Gannon and Ostrom, 1996; Garland, 1991; Ostrom and Gannon, 1996). Krosnick and Presser (2009) noted that while studies suggest that longer scales are less prone to “question order effects”, they are susceptible to context effects (where responses to later questions are influenced by prior responses for related latent variables). Dawes (2008) found that high interval likert scales produced slightly lower relative means compared to 5 or 7 point Likert intervals. Taking the above considerations together, a 5 point scale was used consistently for all the variables measured, to provide an optimal number of intervals for mapping respondents’ perceptions into neutral, moderate, or extreme intervals (Gannon and Ostrom, 1996).

Furthermore, in line with recommendations from business methodology texts and articles on effective questionnaire item wording, questions were presented in straightforward, and familiar language, and all technical or jargon terms explained. The researcher also ensured that words with ambiguous meanings and double negations were avoided, and examples were used where necessary for clarification. Since most of the study variables are multi-faceted and complex, care was taken to avoid ‘double-barrelled’, compound, or leading questions that could prompt respondents towards certain answers (DeHoratius and Rabinovich, 2011; Denscombe, 2006). Screening questions and demographic questions were presented first to strengthen the rapport between respondents and the researcher regarding the research context and aim; albeit remotely (Krosnick and Presser, 2010). The first page of the questionnaire as shown in Appendix A, contained a request for informed consent, which outlined the research title, purpose, type of participants required, the type of information required, ethical considerations, and the researcher’s contact details for further clarifications were required. Since the term ‘virtual enterprise’ was used, a definition and context of VEs was included in the consent letter. The consent page is followed by the initial screening question, with the option to continue or opt out freely from the survey.

Another best-practice convention adopted in the instrumentation phase was grouping the questions for each variable together, and in each group, progressing gradually from general questions to more specific ones (Krosnick and Presser, 2010). A single questionnaire instrument was used to collect data on all the variables examined (SECI knowledge sharing stages, ACAP, TMS, OINT, innovation, replication, and adaptation). The instrument was divided into four subsections; the first subsection labelled (A) was captioned ‘Background’, and comprised 10 questions, of which 7 examined sample demographics such as region, size, industry etc., while the other three included two (2) screening questions to exclude respondents without VE experience, and to identify multi-groups (types of VEs and involvement in industry clusters or breeding environment). The second subsection labelled (B) was captioned “Examining inter-organisational knowledge sharing drivers and capabilities in virtual enterprise joint projects”. The perception-based questions in this subsection examined the experience and practice related perceptions of respondents on the three dynamic capabilities examined. Subsection B of the instrument contained 18 question adapted from previous studies on; ACAP (7), TMS (5), OINT (6).

The third section labelled (C) was captioned “The dynamics of knowledge sharing among virtual enterprise partners”. The questions in this section examined respondents’ perceptions on the various knowledge sharing processes in previous or current VEs. A total of 15 questions were asked to capture respondents’ perceptions on processes involved in the socialisation (4), and externalisation (4) stages of tacit knowledge sharing; and the combination (3), and internalisation (4) stages of explicit knowledge sharing respectively. The final subsection labelled (D) was captioned “Examining the possible knowledge sharing outcomes of virtual enterprise projects”. It contained a brief explanation of the three meso-level knowledge outcomes, and included a total of thirteen questions measuring innovation (4), Adaptation (4), and replication (5), also adapted from previous studies. The operationalisation of each variable is presented next.

## **4.3 Research Construct Operationalisation**

As explained in the introductory chapter, the objectives of this study include:

RO1: To propose and test hypotheses on the mediating role of dynamic capabilities on the ability to achieve broad knowledge goals through tacit and explicit knowledge sharing in VEs.

RO2: To develop and validate a conceptual framework based on the above hypotheses to enrich the current theoretical and practical understanding of knowledge sharing in VEs.

Following the literature review and conceptual development, a number of hypotheses and a conceptual framework were proposed to examine the mediating impact of ACAP, TMS, and OINT on tacit and explicit knowledge sharing for innovation, adaptation, and replication. Two categories of hypotheses were proposed:

1. Hypotheses on the mediation effect of dynamic capabilities (ACAP, TMS, and OINT) on the relationship between the SECI stages of tacit and explicit knowledge sharing, and the three meta-level knowledge outcomes.
2. Hypotheses on the interaction effect among the phases of tacit (socialisation and externalisation) and explicit knowledge sharing (Combination and Internalisation) on the modelled mediation relationships.

The main variables examined (like knowledge outcomes and the dynamic capabilities), have been operationalized slightly differently across domains. Consequently, measures were modified/adapted from prior research and aligned to the present study context. Adopting questionnaire items directly from prior relevant studies does offer some advantages, such as saving time and resources, and the option to retain reported variable reliability and validity. Adaptation of variable measures on the other hand, is driven by (a) new research contexts (b) development of new measurement scales and metrics, (c) the need to enhance grammar or comprehension, (d) desire to improve conceptual coverage and capture new research insights, and, (e) to synthesize robust measurements for variables that cut-across different domains (Agarwal, 2011; Flynn et al., 1990). In spite of the outlined motives for adaptation, the steps taken in new construct development were followed in adapting the items used. They include:

1. Identify and define the key study variables based on a comprehensive review of the extant literature, taking into account the measurement parameters used in previous studies.

2. Consider the population for which the new instrument is developed, and align the adapted items to the specific population requirements.

3. Draft the new instrument and revise accordingly to improve clarity.

4. Pilot the draft with a few respondents from the new sampling frame or research context.

5. Revise the draft to reflect any changes inferred or suggested after piloting. Lesage et al. (2011).

### **4.3.1 Operationalizing Absorptive capacity**

In dynamic and uncertain environments, knowledge is a crucial resource for creating value and sustaining competitive advantages. Inward looking strategies for knowledge sourcing based on a firm’s resources and competencies, appears to be less favourable in the long-run as a strategy for innovation, replication, and adaptation, particularly in fast-paced industries (Camisón and Forés, 2010; Teece, 2007; Teece and Pisano, 1994). These industries thrive on the dynamic interaction between internal and external knowledge; in terms of know-how, know-what, know-why and know-who (Park et al., 2015; Park et al., 2011). The significance of ACAP has grown in the last two decades because it is one of few capabilities possessed by firms for the infusion of external knowledge into the creation of new, distinct, and inimitable firm competencies (Angeles, 2010; Ben-Menahem et al., 2013).

Lane and Lubatkin (1998) redefined ACAP to capture its ‘relative’ quality, which was not captured in the original conceptualization of the construct by Cohen and Levinthal (1989) in their paper titled Innovation and learning: The two faces of R&D. They defined ACAP as a firm's ability and inherent capacity to absorb relevant external knowledge, whereas Lane and Lubatkin (1998) argued that ACAP is a relative measure of the capacity of firms to value, assimilate and accurately apply external knowledge from organizations with whom they collaborate. Likewise, in this study, ACAP is conceptualised as the relative, internal, dynamic capability, which allow participating firms in VEs to identify, assimilate, and exploit external know-how from their partners (Lane and Lubatkin, 1998; Sun and Anderson, 2010). In practice, recognising the value of new external knowledge relies heavily on the prior related knowledge that firms share with their VE partners; such as knowledge of each other’s’ core competencies, and a shared technical/social language (Park et al., 2015; Sun and Anderson, 2010; Weinberger, 2014).

Most of the measures of ACAP to date have been partly based on Zahra and George (2002) identification of the organizational processes that underpin the two forms of ACAP (potential and realised) explained in the literature review chapter. As explained, investments in routine organisational practices to promote a firm’s coordination capabilities (e.g. cross-functional team building, interfaces, participation in decision making, and job rotation) contribute towards the development of potential ACAP by honing the skills required to recognize new value. On the other hand, a firm’s core routines for knowledge socialisation (e.g. organisational layout and structure, proximity, connectedness, and routine cross-unit socialisation opportunities) activate a firm's realized ACAP (Jansen et al., 2005; Zahra and Hayton, 2008). Both potential and realised ACAP are complementary, and require firms to have unique strategies and processes for acquiring (e.g. exploiting or exploring) (Sun and Anderson, 2010; Zahra and George, 2002), assimilating (Szulanski, 2000; Tsai, 2001), transforming (Kogut and Zander, 1992), and applying (Zahra and Hayton, 2008) new knowledge in collaborative ventures. Like the other dynamic capabilities examined in this study, the outlined coordination and socialisation processes that underpin ACAP are developed and applied somewhat arbitrarily when required, throughout the evolution and growth of a firm. However, when systematically and deliberately developed to aid knowledge sharing, these processes play a critical role in firms’ ability to absorb new knowledge from episodic projects like VEs (Argote, 2015).

Potential ACAP requires companies to possess robust acquisition and assimilation processes and capabilities while realised ACAP requires knowledge transformation and application capabilities. The measures used in this study were adapted from the process-based conceptualization of potential and realised ACAP by Jansen et al. (2005) (coordination processes for acquisition and assimilation, and socialization processes for transformation and application of new knowledge). As outlined in the questionnaire (Appendix A), a total of seven (7) measures were adapted; ACAP processes for exploration and exploitation (2), ACAP for Assimilation (2), ACAP for transformation (3), and ACAP for knowledge application (1).

### **4.3.2 Operationalizing Transactive Memory Systems (TMS)**

TMSs (or group mind) are systematic processes, practices or systems through which companies capture, store, and utilize previous transactive memory (strategic, tactical, or operational) to inform decision-making for current and future business ventures (Argote, 2015; Hood et al., 2014). It is somewhat analogous to the sort of ‘cognitive division of labour’ (or the collective cognitive ability to spontaneously match available tasks to a partner’s capability to deliver) that exists between married couples; developed over time through trial and error, experience, and practice. In collaborative ventures, it is a capability for partners to manage and update (i.e. through learning and unlearning) shared memory and experiences that help them to identify correctly, partners with the right skill and capability mix to deliver expected project outcomes in collaborative ventures (Lewis and Herndon, 2011). These systems directly or inadvertently influence the selection of current and future partners, identification of competitors, and thorough assessment of partners’ capabilities based on prior knowledge about their capacity, quality, resources, flexibility, and delivery lead time.

TMS is different from other socially shared cognitive capabilities in three fundamental ways. First, unlike field specific group cognition, TMS are not expertise specific since firms interact with partners from different industries. Rather, TMS tend to be driven by business trends and emerging knowledge requirements (e.g. manufacturers need TMS to update the financial knowledge required to enter joint projects with finance partners). Secondly, in contrast to other socially shared cognition, TMS require deliberate, organised, and transactive processes of encoding, storage, and retrieval of different categories of knowledge acquired from relevant partners and project experiences (Argote and Ren, 2012; Lee et al., 2014). Thirdly, because TMS are dynamic and constantly updated with new experiences, they require a coordinated updates achieved through learning and unlearning in line with prior experiences or new project/business requirements (Sankaran et al., 2013). For example, updates in TMS based on assessments of a specific functional unit, say finance or sales; must be systematically shared with other units such as R&D, quality control, marketing etc., whose activities, learning, or judgement calls may not directly impact one another in the short-term, but may have devastating long-term consequences (Sankaran et al., 2013; Wegner, 1987).

TMS contribute towards improving intra and inter-organisational credibility, by establishing mutual trust in the expertise of partners. They further support the coordination and harmonisation processes necessary for prompt decision-making across functional units and between partners in a VE (Heavey and Simsek, 2015). As noted in the review, TMS has been shown to enhance communication openness and operational performance in cross-regional/ cross-expertise teams, and it significantly impacts on the ability of teams to develop expertise directories, as well as their willingness to share such directories with partners for successful VE projects (Kanawattanachai and Yoo, 2007; Yuan et al., 2005). In addition to the direct impact on knowledge outcomes, TMS are also meta-resources that contribute towards diminishing any unnecessary expenditure on knowledge sourcing and conflict resolution in VEs (Heavey and Simsek, 2015).

According to Moreland and Myaskovsky (2000), TMS depends on the specialisation, credibility, and coordination that exists between such firms and their partners in collaborative ventures. In a sense, these qualities collectively demonstrate that such firms actively use their ‘cooperative memory’, which is characteristic of TMSs. Lewis (2003) noted that an organisation’s level of specialization, credibility, and coordination supports the advancement specialized collective memory systems for accurate division of cognitive labour, which is needed for the smooth running of projects (e.g. cognitive division of labour in a construction project that requires collaboration among firms with diverse technical capabilities). The measures used to capture TMSs were adapted from:

1. A paper by Lewis (2003) on developing scales for measuring TMS
2. Research by Heavey and Simsek (2015) on the impact of TMS on the performance of top management teams.

The measures developed by Lewis (2003) (a total of 15 measures comprising: five measures each, of specialisation, credibility, and coordination respectively) have gained wide applications in several team studies exploring TMS. These measures were mostly developed to capture perceptions on the three aspects of TMS outlined, as an aggregate team-level construct. However, as noted by Lewis (2003 p. 590), a good measure of TMS must be (1) consistent with the original conceptualisation by Wegner’s (1987), (2) appropriate for field studies, and (3) applicable to several organisational settings (cross-team interactions and cross-firm interactions). In justifying the use of responses from individuals to assess a group level construct like TMS, Lewis (2003 p. 591) noted that:

“In general, items that focus members’ responses on the team remain meaningful when aggregated. For example, if one sums members’ responses to the item, “Different team members are responsible for expertise in different areas,” the aggregate represents the extent to which members believe the team has developed the specialized and differentiated expertise characteristic of transactive memory”

Of the 15 measures developed by Lewis (2003), 5 of the most relevant and applicable to VEs were adapted - (2) for specialisation, (2) for credibility, and (1) for coordination (see Appendix A).

### **4.3.3 Operationalizing Organisational interoperability (OINT)**

OINT is a measure of the extent of preparedness of virtual enterprise partners to synchronise their culture, rules, goals, and processes, using compatible technology, routines, and procedures (Kazemzadeh and Sartipi, 2005). While the research community often conceptualizes collaboration as an inevitable strategy for business success, the utter complexity of businesses today as a result of globalisation, boundary spanning suppliers, and extensive networks, makes collaboration practically difficult to achieve (Bailey and Francis, 2008; Bititci et al., 2004; Chan et al., 2012). As such organisations that invest in preparing and positioning themselves to interoperate with others when the need arises, often have the business upper-hand in terms of strategic and tactical competitiveness, as well as operation and relational performance (Geerts and O'Leary, 2014; Mouzakitis et al., 2009; Rezaei, Chiew et al., 2014). Sadly, the research on interoperability as demonstrated in the literature review, has been confined to the realm of IT (information technology) infrastructures and analogies (Rezaei et al., 2014).

To run a successful VEs, one approach for improving the ease of collaboration is to invest in network-wide standardisation. However, owing to the cost of standardisation, most firms focus solely on IT compatibility to minimize systems standardisation/ synchronisation costs while enabling some degree of interoperability (Lei et al., 2004). Nonetheless, IT is often of little practical consequence for engaging in, and excelling at spontaneous VEs, if other core enablers of smooth interactions across business boundaries such as strategic goals, organizational culture and ethos, and employees, are not interoperable (Zutshi et al., 2012). In the literature, two broad groups of studies on OINT were identified. Some exploratory studies investigated the available OINT solutions, used by firms to improve their propensity to interoperate with a wide range of partners at short notice. Other studies are constructivist in nature, and centre on developing architectures, models, methodologies, and typologies of OINT.

Depending on the type of VE (hierarchical or holarchical), the industry, the nature of product or service, and the technical capabilities of collaborating partners, three types of interdependence are possible in collaborative ventures. Pooled interdependence is the loosest form, where each organisation carries out a different function as stand-alone operations, which are then pooled together with the operations of other partners towards achieving a collective goal (Jones and Hill, 1988; Kembro and Selviaridis, 2015; Saavedra et al., 1993). An example of this sort of interdependence is seen in the Special Purpose Vehicles (SPVs) used in Engineering, Procurement and Construction (EPC) projects in the oil and gas industry (Grimsey and Lewis, 2007). Sequential interdependence occurs when the output of one VE partner is a necessary input for the performance of the next, the most common example being modular product manufacturing and assembly in advanced manufacturing (Battisti et al., 2015; Kembro and Selviaridis, 2015; Lin, 2014). Reciprocal interdependence is similar to sequential interdependence, but instead of sequential operations, the interaction between partners is a cyclical process, as seen in global service VEs like banking and aviation (Ellway, 2016). For this study, the measures of interoperability were adapted from:

1. The maturity model by Clark and Jones (1999), Fewell and Clark (2003) and Fewell et al. (2004), developed for assessing advanced military OINT, with wide application in several interoperability studies. They defined OINT based on four key attributes:

a. Preparedness: The infrastructural readiness of the organisation to interoperate. It is driven by an interoperability doctrine, experience and training.

b. Understanding: Measures the level of intraorganisational communication and information sharing.

c. Command Style: Measures the management, decision making style and responsibility delegation of organisations. Organisations with rigid governance structures and minimal interaction across units may be less interoperable in collaborative ventures.

d. Ethos: measure of the effect of organisational goals and aspiration on their ability to share knowledge.

2. A study by Maheshwari and Janssen (2014) on interoperability measurement, benchmarking and improvement, conceptualized to account for the role of big data, open data, and crowd sourcing on interoperability. They outlined 15 measurement outcomes for OINT including collaboration, policies, standards, formal communication, human resource (HR), process alignment, service level agreements, constitutional, jurisdictional, and political constraints, change management, environmental factors, and ethics.

Overall, six measures were adapted for this study, four (4) from the maturity model by Clark and colleagues, and two (2) from Maheshwari and Janssen (2014). Questions on the role of service level agreements, constitutional, jurisdictional, and political constraints were adapted from the latter study because other measures conceptualised are captured under aspects of ACAP, and TMS.

### **4.3.4 Conceptualizing Tacit and Explicit Knowledge Sharing in Virtual Enterprises**

Nonaka and Takeuchi (1996) argued that knowledge sharing occurs in a dynamic spiral comprising four generic processes – socialisation, externalisation, combination and internalisation. Describing the stages, they noted that *socialisation* processes allow firms to share their experiences and expert knowledge with partners. The tacit knowledge shared/acquired is *externalised* as mental models, mind maps, analogies and so on. Over time, different aspects of externalised knowledge from various partners’/project experiences are *combined* to form new explicit organisational routines and practices, which can then be *internalised* and standardised. With use and practice, internalised routines become even more idiosyncratic/unique to each organisation, and subsequently results in knowledge outcomes such as innovation, adaptation, or replication (Anand et al., 2010; Martínez-Martínez et al., 2015).

1. *Socialisation (tacit 🡪 tacit):* Consistent with the original conceptualisation, socialisation is operationalized in this study as the interactive inter-organisational practices, processes, and routines that enable VE partners to incorporate each other’s perspectives and expertise into idea generation and problem solving (Martín-de-Castro et al., 2008; Nonaka and Von Krogh, 2009; Walker and Wardleworth, 2016). The argument here is that inter-organisational socialisation processes over time, facilitate the sharing tacit knowledge, or the merging different organisational insights acquired from VE projects to create new knowledge in form of innovation, adaptation, or replication.
2. *Externalisation (tacit🡪 explicit):* Likewise, externalisation is operationalised in terms of the inter-organisational practices, processes, and routines of firms engaged in VEs, which enable them to express, capture, and summarise explicitly, the hard-to-codify tacit knowledge jointly acquired or created via socialisation routines in current and previous VE projects (Von Krogh et al., 2012). This facilitates joint understanding and ‘knowledge co-creation’, and represents the initial phase of translating or explicating tacit/idiosyncratic knowledge (technical, managerial or experiential) acquired from VE projects.
3. *Combination (explicit🡪explicit):* Combination is operationalised as the practices, processes, or routines that enable the “blending together” of multiple streams of externalised knowledge from different subunits, different projects phases, or different project experiences. Through combination, VE partners are able to generate explicit and systematic accounts and records of new or improved practices as a result of externalised knowledge (Vaccaro et al., 2009). In the course of a VE project, combined knowledge on best practices drawn from different partners evolves to become new and unique processes, routines, and best practices. Such practices/ processes can then be translated by each participating firm in the VE, *internalised* and transferred to similar projects. In other words, combination essentially serves as a means of converting externalised knowledge from different VE partners into differentiated forms of knowledge repositories for each partner.
4. *Internalisation (explicit🡪 tacit):* Internalisation represents the last phase of knowledge sharing conceptualised in the SECI spiral, and is operationalised in this study as those practices, processes, and routines that facilitate the co-opting of new knowledge produced thorough combination, into the individual operations of participating firms on a VE project, as well as future collaborations (Tsai and Li, 2007; Von Krogh et al., 2000). It is defined as the degree to which a recipient takes ownership of, makes commitment to, and derives satisfaction from acquired or transferred knowledge (Nonaka, 1994; Nonaka and Von Krogh, 2009; Tsai and Li, 2007).

A number of studies have adopted this conceptualisation to measure and assess knowledge sharing in collaborative ventures. Notably, Bock et al. (2005) developed useful questionnaires scales to examine the factors that support or inhibit knowledge-sharing intentions. Although the scales were developed for knowledge sharing among individuals, they have been tailored to suit organisation-level studies as well (Tsai and Li, 2007). Other examples of studies that have developed useful measures include studies by Becerra-Fernandez and Sabherwal (2001) and Sabherwal and Becerra-Fernandez (2003).

Studies by Johnson and Johnston (2004) extended the measurement scales for tacit and explicit knowledge in two significant ways, which partly informed the development of the measures used in this study. First, they adapted the measures of knowledge sharing developed by Nonaka and colleagues to inter-organisational context, and secondly, they examined a collaborative network for a university-industry research and development (R&D) project, which in many ways, is similar to the sort of VE projects examined. More recent studies by Anand et al. (2010), Richtnér et al. (2014), Martínez-Martínez et al. (2015) and Hubers et al. (2016), based on the original conceptualisation by Nonaka and Takeuch (1996), also adapted measures in line with Johnson and Johnston (2004) and Bock et al. (2005).

Although each stage of the SECI spiral is operationalized independently, it is duly acknowledged in line with the original conceptualisation, that knowledge sharing is a dynamic and continuous spiral, rather than a static series of processes. To capture this dynamism would require a controlled experimental and longitudinal study, involving observations of VE teams and how they go about developing new processes and expertise in the course of a project. However, consistent with the survey approach used in studies by Anand et al. (2010), Hubers et al. (2016), and Martínez-Martínez et al. (2015), the SECI stages are operationalised to capture generic and distinguishable processes associated to each stage of the SECI spiral. These stages have been identified and isolated from previous action studies, case studies, and longitudinal studies examining the SECI model. The processes are categorised as (1) technically oriented practices/processes for Combination and Internalisation, and (2) socially oriented practices/processes for Socialisation and Externalisation (Anand et al. 2010). Identifying and measuring these processes could inform strategic process improvement initiatives targeted at maximising tacit and explicit knowledge sharing in collaborative ventures.

Some prior empirical studies focused on validating the theoretical/conceptual authenticity of the SECI model (Chou and He, 2004; Chou and Tsai, 2004; Nonaka and Toyama, 2005). Accordingly, this study does not focus on further validation of the assumptions of the SECI spiral, rather, it draws on the premise that each stage of the model represents a series of distinct processes for tacit and explicit knowledge sharing, and applies those assumptions as a basis for examining how organisational dynamic capabilities can contribute towards improving both tacit and explicit knowledge sharing in VE projects (Anand et al., 2010; Shamsie and Mannor, 2012). Overall, four (4) items for Socialisation, four (4) for Externalisation, three (3) for Combination, and four (4) for Internalisation were adapted from studies by Becerra-Fernandez and Sabherwal (2001), Sabherwal and Becerra-Fernandez (2003), Anand et al. (2010), and Martínez-Martínez et al. (2015).

### **4.3.5 Operationalizing Innovation (INOV)**

Innovation is well covered in the extant literature on knowledge sharing- particularly in relation to new product development (NPD). In operations and supply chain management literature, it is often conceptualized either as administrative/organisational innovation or technological innovation. Administrative or organisational innovation refers to the generation of new ideas or strategies to improve the efficiency of organisational structures and systems of operations. In contrast, technological innovation refers to the creation of new technological and technical knowledge in product, service, or process development (César et al., 2010; Kim et al., 2012). Both forms of innovation are triggered by economic uncertainty, changing consumer preferences, competition, and growing sophistication in market conditions and requirements (e.g. corporate social responsibility) (Kim et al., 2012). Furthermore, innovation could be incremental or radical, depending on the level of change (minor or major), target market impact (existing or new), and level of risk involved (low or high) (Gregor and Hevner, 2015; Kim et al., 2012). The four (4) measures of innovation used in this study were adapted from Kim et al. (2012), César et al. (2010), and Goodale et al. (2011). These perceptual measures assess innovation in terms of (1) the rate of new products or service development, (2) the rate of change in core operational, organisational, and managerial processes.

### **4.3.6 Operationalizing Replication (REPLIC) and Adaptation (ADAPT)**

Williams (2007 p.869) explained that adaptation entails modifying a receiving units’ operations to integrate or conform to local contexts or requirements. In other words, it involves making targeted and incremental changes in organisational structures, products, or processes in line with standard industry best practice (technological, organisational, or managerial), to (a) align firms with industry best practices for legitimacy, and (b) distinguish them from their competitors. Corredoira and McDermott (2014) found that suppliers in emerging markets with compelling non-market institutions (regulatory bodies and supra-national institutions), can adapt knowledge from subsidiaries of multinational corporations, and tailor such knowledge to suit local market requirements. Replication, on the other hand, implies “changing the receiving unit’s operations to be more like its partner’s” (Williams, 2007). Although replication and adaptation are often examined as separate variables, they are complementary and often pursues concurrently in practice. For knowledge on tasks such as accounting, finance, and health and safety, replication is often sought because such practices are usually standardized and highly dependent on industry and regulatory requirements (Kogut and Zander, 1992; Ringov et al., 2015). In contrast, the practices like customer service delivery, marketing, sourcing, supplier selection, logistics, and sales are frequently adapted because they require a great deal of knowledge from the local environmental or operational context of specific projects (Corredoira and McDermott, 2014; Gurtoo, 2009; Nag and Gioia, 2012; Williams, 2007). In a study examining how executives search or scan for competitive knowledge in different industries, Nag and Gioia (2012) interviewed the CEO of a Foundry, who described how knowledge adaptation improved his company’s operations. Regarding the Foundry process, the CEO noted that:

“The basic is the same. You are melting iron and steel and you are pouring into the sand moulds. That concept is the same in every foundry. What you do along the way, the little things to refine the process is what makes the difference. We are good at developing little advances by tweaking of the equipment and process. That is an in-house competitive advantage.”

Some argue that transfer of technology as complete templates (replication) and imitation are somewhat similar in terms of cost and effect, irrespective of whether replication is the desired outcome or if imitation occurred through the unaided diffusion of technology to partners in collaborative arrangements (Ringov et al., 2015; Winter et al., 2011). However, studies show that in uncertain and fast paced collaborations; firms can deter imitation by constantly innovating and updating their products, services, and processes. The difference between replication and imitation is the relational component that must exist between parties sharing knowledge, which grants the replicator access to certain tacit aspects of knowledge not otherwise available to imitators who have to depend in large part on already explicit knowledge. As explained by (Rivkin, 2001):

“Facing simple problems, both replicator and imitator generate good information through their incremental search efforts. At high levels of complexity, when decisions depend on one another in an extremely delicate way, small errors in information spoil replication attempts altogether. The replicator’s slightly imperfect knowledge then has little more value than the imitator’s highly imperfect knowledge.”

To capture adaptation in this study, four (4) items were adapted from a study by Jensen and Szulanski (2004) who developed seven items to examine the impact of adaptation on the stickiness of knowledge adaptation in franchises of multinationals operating in different geographical locations. For replication, four (4) items were adapted from Winter et al.'s (2011) study on the impact of inaccurate replication on the failure of franchises.

### **4.3.7 Control Variables**

Control variables are often included in statistical analyses to enable researchers to observe the effect of the variables of interest in a model, while holding constant all other potential predictors in the model. Controls are extraneous variables with no direct relationship to the hypotheses or theories under investigation, but may confound or distort the observed measures; through a process called contamination or method variance (Becker, 2005). Regarding control variables, Spector and Brannick (2011) argued that:

“Rather than being included on the basis of theory, control variables are often entered with limited (or even no) comment, as if the controls have somehow, almost magically, purified the results, revealing the true relationships among underlying variables of interest that were distorted by the action of the control variables. This is assumed with often little concern about the existence and nature of mechanisms linking control variables and the variables of interest” (p. 288)

They further argued that if control variables with significant connections to the variables of interest are included, rather than purifying the results, they could, in fact, remove some expected effects and lead to incorrect interpretation of results. Becker (2005) suggested that the nature, mode of operationalization, and theoretical reasons for choosing controls must be clearly articulated before inclusion in statistical analyses. Four control variables were considered for this study; namely, (1) the types of VEs (Hierarchical and Holarchical), (2) Involvement of respondents in industry clusters (3) the cognitive characteristics of the respondents (years of experience), and (4) industry.

Hierarchical VEs as explained in the review, are coordinated by a lead company or product/service integrator (usually a substantially larger firm than its partners), responsible for allocating tasks, resources, and costs. Since the lead company coordinates the entire network of firms, the primary task of knowledge and information flow management is often carried out by such firms. In the holarchical VE on the other hand, partners act as separate self-organising entities, and the management of knowledge and information flows is based on ‘mutual adjustment processes’, where firms systematically align their capabilities to those of others in the network towards achieving set network targets (Esposito and Evangelista, 2014). Based on these differences in nature, mode of operation, and knowledge management approaches used in both forms of VEs, it was important to determine if the responses gathered for all variables were in any way, influenced by the type of VE experience the surveyed companies had.

Similarly, industry clusters and virtual breeding environments provide firms with the necessary infrastructure and capabilities to form effective VEs, since the selection of capable partners from such clusters is based on prior transactive memory and in many cases, prior established interoperability (Romero and Molina, 2011). For instance, Romero et al. (2015) found that Green Virtual Breeding Environments (VBEs) provided partners with standardized working and knowledge sharing principles for collaboratively establishing sustainable operations when they venture into specific VE projects. This could imply that a clear difference exists in the ACAP, TMS, and OINT of such firms compared to their counterparts who form VEs at random based on assessments of the individual capabilities of prospective partners.

In certain industries like advanced manufacturing and services, VEs are a standard approach for collaboration with partners on ‘episodic projects’. This is largely because the capabilities and resources required, and the availability of project opportunities in these industries are geographically dispersed, hence making VE formation inevitable. Banks for instance, often finance several projects in a diverse array of industries concurrently. As explained earlier, financing such projects in highly risky and uncertain business environments, provides financial institutions with ample strategic incentives for establishing VEs. These incentives include; project financing risk pooling, mitigation, and management, transfer of technology, and capability pooling among others. Regarding project financing, although bond debts are still the key sources of finance for big projects, "trader financing" is increasingly becoming a predominant option, because of the competitive pricing offered, the turnaround speed, and comparatively fewer documentations required (Smyth and Edkins, 2007).

In financing projects in the oil and gas and construction industries for instance, banks usually form VE alliances rather than the traditional approach of advancing loans, because of the complexity, cost, and inherent risk exposure of such projects. Thus, it is common to see hybrid collaborative alliances, or orphan ‘special purpose vehicles’ (SPVs), which are essentially contractual virtual enterprise or a "bankruptcy-remote entities", whose operations are limited to specific projects (Gorton and Souleles, 2007; Grimsey and Lewis, 2007). The asset/liability structure of such VEs secures and separates project obligations from the obligations of the parent companies involved, consequently, partners in such VEs usually have established and standardized interoperability platforms and TMSs compared to those in less complex industries, with comparatively lower project risk profiles (e.g. food processing) (Gorton and Souleles, 2007; Turner and Müller, 2003; Zhao et al., 2013).

Finally, in line with previous studies, the effect of respondents ‘cognitive quality on the variables explored was also considered as a control variable. Qualities like years of experience and the organizational role of respondents, have been shown to affect the manner in which research questions are addressed, particularly in self-administered surveys (Couper, 2000). The cognitive qualities controlled for in this study include years of experience working in the surveyed firm and years of experience working in a managerial capacity.

The controls included (with the exception of industry and years of experience) were measured as binary variables (e.g. 0=part of VE cluster, 1= not part of VE cluster; 0=Hierarchical VE, 1=Holarchical VE). Since industry and years of experience were measured using more than two categorical scales, they were recoded into ‘binary dummy variables’ by assigning the numbers ‘0’ and ‘1’ to the affiliation of respondents to one of two mutually exclusive and exhaustive categories. In line with Fisher (1997) categorization of supply chains based on their risk profiles as ‘innovative’ or ‘functional’, the industry variable was recoded as (1) companies in highly risky operating environments (assigned the code 0) and (2) companies in moderately risky operating environments (assigned the code 1). Likewise, years of experience was recoded into highly experienced (0) for respondents with 10 or more years of experience, and moderately experienced for those with less than 10 years (1).

Before selecting the controls included in the model, all the above variables were examined using multi-group invariance testing on SPSS, to evaluate whether significant differences existed between the segments (1 and 0). Segments that showed “substantial, differentiable, actionable, stable, and parsimonious” characteristics with “high degrees of within-segment homogeneity” were considered as multi-groups within the data (Sarstedt and Mooi, 2014). The multi-group invariance test was run in the confirmatory factor analysis phase, before deciding whether or not to include multi-groups as controls in the model. Details on the process and relevance of invariance testing are provided in a later subsection on confirmatory factor analysis.

### **4.3.8 Pre-testing the Questionnaires**

The questionnaire developed was pre-tested on a representative sample of 28 respondents from the 12 key industries surveyed, and academic experts in the areas of knowledge sharing (1) and collaborative enterprise management (1). Some industry experts were sampled from the researchers’ industry contacts (24) while the others (including the academic respondents) were identified and surveyed at the EUROMA international conference, which held in Italy in 2014 (Forza et al., 2005). The EUROMA conference is organised annually by an international network of academics and practitioners, with interests and stakes in the development of Operations and Supply Chain Management research and practice. Based on the feedback received, and brainstorming sessions with the supervisory team, the questionnaire was revised to reflect the contributions of respondents. The main changes resulting from this process were the inclusion of definitions for constucts like VEs, and the dynamic capabilities, and the refiniement and reordering of some questions in conjuction with the supervisory team, to improve the overall clarity and flow of the questionnaire.

## **Sampling and Data Collection**

### **4.4.1 Population Sampling**

In keeping with the focus of this study, the researcher set the boundary condition or level of analysis to include only organisations with current or previous VE collaboration experience. Since VEs exist in the majority of industries, the researcher sought to gather a global sample of companies to represent the population of existing VEs in terms of industry, size, and forms of VE. As explained, the questionnaire was designed using Qualtrics, and the respondents were asked to either complete the survey via a link sent to their personal emails, or an attached word document copy, also returned via email. This flexible approach was taken following the feedback received from the pilot stage, where respondents pointed out the benefits of having both options (flexibility, ability to answer questionnaires offline and at respondents’ pace). Following the literature review, the researcher identified and itemized the key industry categories in which VE are relatively common. The key industries identified and incorporated in this study include Aeronautics and Aerospace, Automobile, Construction, Electronics, Metal-mechanics, Oil and gas, Food Processing, Telecommunications, Banking, Consultancy services, and logistics and transport (Camarinha-Matos et al., 2009; Hung and Cheng, 2013). The researcher also provided an option labelled “others, please specify”, to enable respondents to include their industry where the available options were in exhaustive.

### **4.4.2 Sampling Frame and Sample Selection**

The next sampling decision was about the respondent categories to be included in the study. Since the focus of the study is knowledge sharing and the role of dynamic capabilities, it was important to include a representative sample of industries to compensate for possible industry effects arising from variabilities in processes, management, competitive forces, degree of virtualisation needed, and spread of VE partners. Also, within each industry, the scope and nature of production processes can vary extensively. For instance in manufacturing, knowledge sharing requirements would likely differ significantly depending on whether the production process is a job shop, batch production or line production (Harinder et al., 2001; Jagdev and Browne, 1998). Thus, it was important to target and include companies of different types, formats, and sizes. Dynamic capabilities and the knowledge outcomes are strategic management level conceptualisations, which manifests at operational and tactical levels as standard performance indicators such as flexibility, cost saving advantages, pooled expertise and resources, quality, and product/service/process lead-time. Consequently, the targeted respondents were managerial level staff from different company formats, VE types, sizes (determined by number of employees in line with previous studies), and regions. The broad categories of respondents sampled included executive or ‘chief’ level manager e.g. Chief Engineering managers, Mid-level managers, and Operations or project level managers. The option was also provided for respondents to specify their titles where necessary. Accordingly, the research sampling frame was developed with the following in mind:

1. To capture industries with a high disposition for VEs
2. To sample companies within such industries with recent or previous VE experience.
3. To target managerial level employees from such companies with a good number of years of working experience in the sampled companies and as managers
4. To achieve a global sample of companies.
5. Regarding location, it was important to include companies from the highly industrialised countries in Europe and North America, as well as emerging economies in South America, Asia, the Middle East, and Africa.

In sourcing for respondent contacts that passably matched the above sampling frame described, the researcher used a data management and global B-to-B Data Management Company (Kompass), and a request for quotation was sent, detailing the sampling frame requirements. The information requested included Company name, address, telephone number, opt-in email address, specific managerial/executive contact email addresses, in line with the sampling frame specifications. Using VE experience as a precondition for sampling, the data company returned a total of 1,310 contact details (at a fixed cost of £600 per 1000 contacts pro rata) of strategic, tactical, and operational managers from companies with past or ongoing VE project experience. The sample included Russia (60), United States (150), United Kingdom (150), Brazil (50), Japan (50), South Korea (50), China (150), Peru (50), Mexico (60), Canada (60), Spain (50), Germany (100), Portugal (50), France (50), Italy (50), South Africa (40), Belgium (45), United Arab Emirates (30), Oman (25), Turkey (40).

The researcher sought to obtain a random sample as possible (i.e. selection of respondent companies from the data population entirely by chance), given the restrictions of the sampling frame and available distribution of company contact information from the different countries sampled. Two ensuing sampling challenges were considered:

1. How to determine a significantly representative sample size from the randomly distributed companies sourced from the data mining company.

2. Since the population was drawn without replacement (i.e. selecting only one respondent per company) and the overall population size was known beforehand, it was important to ensure that the data from different countries had uniform inclusion probabilities (Rossi et al., 2013).

In light of the above considerations, the researcher opted to send questionnaires to all available contacts (1,300). The questionnaires were sent in 3 batches, with each batch containing equal proportions of companies from the countries sampled. A total of 98 emails were inaccessible and returned to the researcher’s email unsent (predominantly from Russia (43), Turkey (22), Oman (19), and South Africa (14)). Of the remaining 1,217 potential respondents emailed, 96 responses were received within the first 6 to 8 weeks. After sending two follow-up/ reminder emails, an additional 67 responses were received, bringing the total number of returned questionnaires to 163 responses. One of the contact opted to participate in future studies based on a request made in the questionnaire. Using this contact, the researcher was able to gain further access to 100 more contact details of potential respondents, from a mineral and mining cluster comprising predominantly of mining and oil and gas companies with operations in the Middle-East, South America, and Africa. Questionnaires were sent out and a total of 49 completed responses were received from this batch of respondents. This brought the total number of companies sampled to 212. Details on the sample demographics are provided in the Analysis chapter.

Sample size is a common cause for concern in survey-based studies because inadequate or excessive sample sizes could affect the quality and accuracy of findings. According to (Kotrlik and Higgins, 2001), three criteria need to be specified to estimate an appropriate sample size. They include, the level of precision, the level of confidence (or risk), and the extent of variability in the measured attributes. They further argued that an appropriate sample size should minimise the tendency to find differences in the sample that do not exist in the population (alpha or type I error), or fail to detect differences which exist (beta or type II error). A comparison of the sample sizes used in similar studies, showed that sizes ranged between 120 and 300 respondents, with an average response rate of about 38%. Dawson (2014) explained that statistical power and precision (finding interactions where they exist), are important for sample size determination, and that about 135-154 cases may be required to detect a relatively large effect among variables in correlational studies, with 90 % power. For SEM analysis in particular, a common ad-hoc rule of thumb exists regarding adequate sample size estimation.

The rule requires researchers to set a lower boundary of 10 observations or responses per variable to achieve sample size adequacy. Justifications for this rule of 10 can be found in a number of publications as reviewed by (Westland, 2010). The rule was first articulated by Nunnally et al. (1967) who opined that in SEM analysis “a good rule is to have at least ten times as many subjects as variables”(Westland, 2010). Other pioneering researchers in SEM like Bollen (1989) argued that ‘‘though I know of no hard and fast rule, a useful suggestion is to have at least several cases per free parameter” (Marsh et al., 1998). Bentler and Mooijaart (1989) advised researchers to apply a ratio of 5:1 for sample size to free parameters (variables). Marsh and Bailey (1991) suggested using a similar ratio of questions to latent variables. In this study, there were a total of 64 indicators and ten latent variables. Applying any of these rules of thumb would suggest a lower sample size boundary of 200 to 600. Westland (2010) however argued that since the number of measured parameters and the number of observations are non-linear quantities, sample size should not be treated as a linear function of indicator count. Nonetheless, such heuristics have been widely applied for sample size determination and justification in SEM. For this study, sample size adequacy was assessed with statistical tests of significance and the findings are reported in the next chapter.

## **4.5 Data Screening**

The collected data was sorted and analysed with the statistical and analytical packages SPSS, and AMOS. One advantage of online questionnaires is the ease of data transfer and translation across platforms; from the collection phase on Qualtrics, through the processing and inferential analysis phase on SPSS, to the SEM phase on AMOS. Before embarking on the SEM analyses on AMOS, the raw data file was screened using SPSS. The basic statistics applied in the data screening stage (e.g. mean, standard deviation, variance, correlations, and regressions) are concisely explained in the section on data analysis. The screening was done to check for the existence of statistical issues, all of which are discussed in the following subsections (Byrne, 2013).

### **4.5.1 Checking for Multicollinearity**

Collinearity or multicollinearity occurs when predictor variables purported to measure different variables are highly correlated or appear to measure the same construct in a multiple regression model (Wang, 1996). The steps taken in this study to detect and address multicollinearity using the regression diagnostics procedures of the SPSS program include:

1. Estimating a squared multiple correlation (R2 smc), which is the fraction of variance in the outcome variable that is explained by the predictor variables. Basically, this estimation involves running several multiple regressions with a different variable as the criterion and the rest as predictors in each regression run. If R2 smc > .90 for a particular variable, multivariate collinearity may exist.
2. Another statistic called tolerance can be estimated by subtracting the value of R2 smc from 1 to determine the proportion of the total standardized variance that is not explained by all the other variables. Values of tolerance < .10 indicate extreme multivariate collinearity.
3. The variance inflation factor (VIF) estimated as 1/(1 – R2 smc) or the ratio of the total standardized variance (1) to the unique variance or tolerance of a given variable. VIF > 10. Indicates that some multivariate collinearity may exist (Kline, 2015; Schroeder, 1990).

In cases of multicollinearity, the solution is to eliminate the redundant variables or combine them to form a single composite, which can be redefined as a new construct if the existing theory supports.

### **4.5.2 Checking for Outliers**

Outliers are scores that are obviously different or lie far out (extreme values) from the rest. Outliers could be univariate or multivariate depending on whether they occur in one or multiple variables respectively. An ad-hoc rule of thumb for dealing with outliers holds that if a score is more than three standard deviations away from the mean, it might be an outlier. Given that standard deviation and mean values are themselves sensitive to outliers, (Leys et al., 2013) proposed another approach, which involves checking for the absolute deviation of each response from the median.

Outliers can also be detected by manual observation or using the ‘conditional formatting’ feature of spreadsheets like EXCEL to isolate outliers. In addition to the manual approach used in this study, the approach proposed by Leys et al. (2013) was also used. Once detected, extreme outliers may be removed (although not advisable), or if they are retained, they could be converted to a closer value within the limit of three standard deviations from the mean. In extreme cases, advanced mathematical transformation of variables with outliers can be performed using SPSS. In this study, no significant outliers were detected following a manual check of the data distribuition using the conditional formatting feature of the EXCEL program.

### **4.5.3 Dealing with Missing Data**

It is possible for some data to be missing, either randomly (called ignorable missing data) or systematically from the dataset. While it is quite difficult to tell if the pattern of missing data are random or systematic, there are two common approaches for dealing with missing observations. The first approach involves deleting all incomplete cases/respondents using listwise deletion or complete case analysis (i.e. excluding entire cases with missing scores on any variable from analyses). The second approach called pairwise deletion or available case analysis, involves excluding only missing values and not entire cases (Little and Rubin, 2002; Vriens and Melton, 2002). Another widely used approach is the single-imputation method of replacing missing scores through mean substitution or regression based substitution (Arbuckle et al., 1996; Little and Rubin, 2002). However, according to Arbuckle, (1996, p. 243), listwise, pairwise, and single imputation approaches all “attempt to make the best of a bad situation in ways that are seemingly plausible but have no theoretical rationale”. For this study, the mean substitution, which entails substituting missing scores with the sample mean was adopted in order to preserve as many cases as possible (Vriens and Melton, 2002). For cases with several missing scores for important variables, the listwise deletion approach was adopted.

### **4.5.4 Managing Survey Errors**

There are two generally acknowledged types of survey errors that the researcher remained mindful of throughout the design, execution and interpretation of the survey for this study. The most commonly referenced type known as *sampling error*, is the degree to which a survey sample differs from the population. This could result from estimation errors from using probability sampling techniques and is minimized in larger samples. Sampling errors could also arise when the wrong selection probability (e.g. simple random, systematic, stratified, cluster, or multistage sampling) is used to derive the sample estimator (Bryman and Bell, 2015). To avoid selection errors, the sampling frame was thoroughly investigated before the surveys were run.

Non-sampling errors are the second type of survey errors, and they often occur in the process of obtaining answers to questions in the survey instrument. They could be *observation errors* (made during the process of obtaining and recording answers) or *non-observation errors* (made in designing the sampling frame). An example of an observation error is measurement error, which is the degree to which a survey is affected by inadequacies in the mode of data collection (e.g. poor question wording, faulty assumptions, and flawed scales). Another example is processing error, which could occur during data entry and processing. Examples of non-observation errors include coverage errors, or the variability in surveys that results when the sample used does not appropriately represent the population being measured (Bryman and Bell, 2015). In this respect, the growing access to the internet and online survey panels globally has improved the accuracy with which researchers can reach and represent target populations.

A common non-observation error is non-response error, which occurs when some sampling units (companies) still do not complete the questionnaires after follow-up emails have been sent. This could be as a result of wrong or inactive email contact details (as noted earlier), refusal to participate, or erroneous inclusion of companies that are irrelevant to the study. If a pattern exists to non-responses, or if they differ meaningfully from collected responses - for instance, if there is no response from companies in certain industries or regions – then a non-response bias may exist (Bryman and Bell, 2015). To check for non-response bias, responses from different quartiles or categories in the dataset were examined for discernible patterns (e.g. industry, region).

## **4.6 Data Analysis: Structural Equation Modeling**

As noted, structural equation modeling (SEM) was used for the analyses. SEM refers to a collection of related statistical procedures used to test hypothetical models of interactions among predictor variables (e.g. the SECI stages of knowledge sharing, and the dynamic capabilities) and outcome variables (e.g. the knowledge outcomes) (Bollen, 2005). This technique is also known by other terminologies such as, covariance structure analysis, covariance structure modeling, analysis of covariance structures, and causal modeling (Kline, 2015). The SEM analysis approach appears to have become quite avant garde among empirical reserchers in recent years partly due to advances in computation capabilities and advanced software applications that aid researchers in estimating the necessary statitics. SEM allows the researcher to determine causation among predictors and outcomes within a hypothesized model of interactions, if the overall ‘structural model equation’ derived from the hypotheses (each represented by a regression model), fits the data collected (Bollen and Pearl, 2013). A typical structural equation model comprises of two distinct parts:

1. *Measurement model:* The measurement model is comprised of a set of equations linking the observed variables or indicators (i.e. the questionnaire items used to measure each variable) to their respective substantive latent variables.
2. *Path Model*: This comprises of a set of equations describing the hypothesized causal relationships among the predictor and outcome ‘latent variables’. These variables are called ‘latent’ because they are not directly observable quantities (e.g. ACAP, TMS, and OINT). The researcher developed a conceptual model on the mediating impact of dynamic capabilities on the stages of tacit and explicit knowledge sharing, and knowledge outcomes in VEs. The model was derived after reviewing the related theory on knowledge sharing (the Relational View and the KBV), and prior empirical research involving the study variables.

Since it is impractical to measure social variables without external interference, differential terms (also called residuals or errors) were included in the model. As such, the purpose of model-testing in SEM is to ascertain the *‘goodness-of-fit’* between the hypothesized model and the observed data – in other words, to determine how well the observed data fits the imposed hypothesized structure of interactions among the predictor and outcome variables in the study (Bollen and Pearl, 2013; Hair et al., 2011). The model-fitting process can be represented thus:

Model fitting equation:

***Data = Model + Residual***

Where:

**Data**: are the scores or measurements of the observed variables (questionnaire items) obtained from the research sample.

**Model:** comprises all equations linking the observed variables to the latent variables and, the equations on the causal relationships among the study latent variables in line with the research hypotheses.

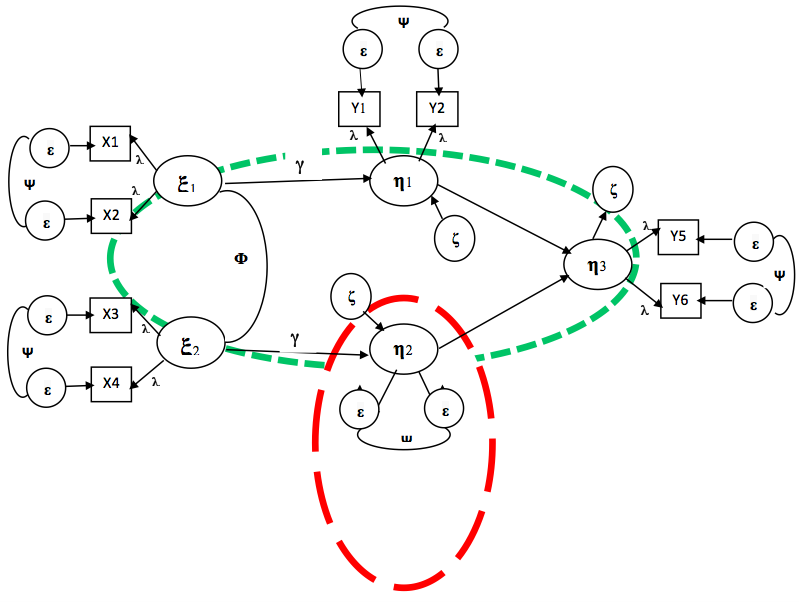
**Residual**: is the discrepancy between the hypothesized model and the observed data. For observed variables, the residual (also called disturbance or error) is any variance that is unexplained by the factor that the indicator is assumed to measure, partly due to random measurement errors. This is a useful attempt to somehow compensate for some psychometric measurement flaws, and although it is by no means a comprehensive accounting for errors, SEM analysis appear more realistic compared to other standard statistical procedures such as multiple regressions, where it is assumed a priori that variables are measured error free (Byrne, 2013; Hair et al., 2006; Kline, 2015).

There are three known approaches to model fitting in SEM. If the data is found to be inconsistent with the model, the researcher has the option to change the specifications of the model or adjust the underlying hypotheses altogether in line with theory. Such SEMs are called *“strictly confirmatory”* (SC), and are used quite rarely in management studies, except in replication studies where experimental data is used to validate an existing model (Byrne, 2013). In the second approach, more than one a priori model is developed in line with sufficient supporting empirical and theoretical evidence, to examine the fit of a preferred model in comparison to an alternative one (e.g. comparing the fit between a mediated and moderated model). In the alternative model approach, the most fitting model is selected ( Kline, 2015). The third approach to model fitting known as *‘model generating’* was the most suitable approach for this study, and is perhaps, the most commonly used in the social sciences. As explained by Byrne (2013) model generating:

“….represents the case where the researcher, having postulated and rejected a theoretically derived model on the basis of its poor fit to the sample data, proceeds in an exploratory (rather than confirmatory) fashion to modify and re-estimate the model. The primary focus, in this instance, is to locate the source of misfit in the model and to determine a model that better describes the sample data.” (p.8)

Overall, the ability to analyse both observed and latent variables in SEM sets it apart from other statistical techniques, such as the analysis of variance (ANOVA) and correlation and multiple regressions (MR), where only observed variables can be analysed (Bollen and Pearl, 2013). The SEM approach essentially involves estimating the covariance among continuous observed variables. Two patterns of covariance can be estimated from the data through the SEM approach:

1. The patterns of covariance among the observed variables (questionnaire items).
2. To examine whether the variance in the observed variables matches the covariance (relationship) structure of the hypothesized research model.



**Where:**

**ξ** = the latent exogenous (predictor) variables

**λ** =Factor loadings

**η** = the latent endogenous (mediator and outcome) variables

**X** = the observed variables for the predictors

**Y** =the observed variables for the mediators/outcomes

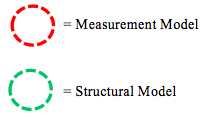
**β** = standardized regression coefficient

**Φ =** the covariance matrix of the predictors

**Ψ =** the covariance matrix of disturbance/error

**ζ** =disturbance (error) in the latent variables resulting from other effects outside **η**

**ε** =the disturbance or error in predictor and outcome variables



***Figure 4.2****: Annotated Structural Equation Model*

Covariance is a measure of the degree to which scores obtained in the measurement of two or more random variables deviates from their mean scores. Any deviation from the mean score the variance. Since Likert scale questions were used in this study, the covariance is unstandardized (i.e. the 1-5 scale has no unit). Thus, the *standard deviation*, a standardized unit in statistics (squared of the variance from the mean score), was used to compute the *correlation coefficient (r),* or the covariance among the variables in standard deviation units, and expressed as a value between +1 and −1 to represent the direction of variable relationships (Bollen and Pearl, 2013; Kline, 2015).

*covXY = rXY SDX SDY (2)*

Where:

covXY = Covariance

rXY =Pearson correlation

SDX = Standard deviation of x

SDY = standard deviation of y

While correlation quantifies the degree to which variables in a model are related, it does not attempt to fit a line through the data points, but simply computes a correlation coefficient (r) to show how much change would occur in one variable with a unit change in another (positive or negative). In order to produce a line through the data that best predicts the causal relationship from a predictor to an outcome, SEM estimates regression weights (R2) to measure how changes in a predictor variable (say SOC) affects the value of an outcome variable (say INOV), while holding other predictors constant. For each predictor in the SEM model, the unstandardized regression coefficient (B) and the standardized coefficient (β) measured in standard deviation units from sample mean, is estimated (Byrne, 2013; Kline, 2015; Lubke and Muthén, 2004).

Some have argued that using Likert scale data in general linear modeling (GLM) techniques violates the basic assumption of multivariate normality required for such statistical approaches (i.e. the assumption that independent variables have interval measurements e.g. kilogram or pound) (Kline, 2015). The variables for this study for example, were measured on a 5 point scale to estimate the degree to which respondents agreed (1) or disagreed (5) with each question/statement. Nonetheless, the intervals on the scale are not uniform increments but simply ordered categories (Jamieson, 2004; Van der Eijk and Rose, 2015). Others hold that in techniques like factor analyses and SEM, Likert data could be considered as continuous if certain conditions are fulfilled. In this regard, Lubke and Muthén, (2004) noted that:

“Given certain requirements pertaining to the number of categories, skewness, size of the factor loadings, and so forth, it seems nevertheless possible to recover true parameter values [from Likert scales] if the data stem from a single homogeneous population.”

In GLM, predictor variables are either introduced into the model together, sequentially according to rational theory, or empirically using statistical estimates. In alternative techniques like hierarchical regression and canonical regression analyses, the rational approach is used to introduce predictors in line with theory (Bollen and Pearl, 2013). For other statistical techniques like MR, predictors are introduced one at a time into a model until no significant increase in the R2 of the model is attained with the introduction of additional predictors. In SEM, all the regressions among variables are first entered into the model simultaneously, then attempts are made to statistically ‘fit’ the model by adding (forward inclusion) or removing (backward elimination) predictors until the best fitting model is obtained. Specification of the relationships among predictors and outcomes is guided a priori, by theory and previous studies, and although SEM allows for model fitting, this is not the goal, as the decision to include or exclude predictors from the model should be driven by theory (Kline, 2015).

After obtaining a fitting model, the statistical significance of the variance among variables, and the significance of the entire model was assessed. The literal meaning of significance is “importance”, but in this sense, it is estimated by calculating the ‘p-value’, or the probability that an observed effect (e.g. a covariance, correlation, or regression) is true and not due to chance, error, or other confounding factors (or the probability of rejecting the null hypotheses) (Barrett, 2007; Fritz and MacKinnon, 2007).  For instance, it was hypothesized that ACAP would positively mediate the relationship between SOC and INOV. The null hypothesis in this example is the probability that any observed change in INOV is due to some other factor (e.g. chance, error, etc.). The null hypothesis is rejected if the p-value estimated for the SOC🡪INOV relationship is less than a pre-set significance or α level (pre-set to 5% 0.05), the result is considered “statistically significant” and the null hypothesis is rejected. Otherwise, the result is considered “not statistically significant” and the null hypothesis (observed effect due to chance and confounding factors) is accepted (Kline, 2015; Motulsky, 2015).

The measure of statistical significance (i.e., p values) of relationships among latent variables in SEM is calculated using estimation algorithms. Of the available options, the software package AMOS, was chosen over Mplus and LISREL, for its user-friendliness, minimal coding requirements, and its compatibility with the statistical package SPSS (Byrne, 2013). It is noteworthy that while the estimation algorithms used in other packages are similar, they could result in slightly different p-value estimates which could affect the results hypothesis testing (Steiger, 2007). The general cautionary note in this regard is that researchers using SEM (and other similar approaches) in the management and behavioural sciences, should be more concerned with the magnitude (increase or decrease) and direction (positive vs. negative) of hypothesized effects in line with the research hypotheses and theory, rather than judging the model strictly based on the outcome of statistical significance tests (Hair et al., 2011; Henseler et al., 2015; Kline, 2015; Ringle et al., 2012).

### **4.6.1 Rationale for Selecting Structural Equation Modeling**

In general, there are some advantages of SEM over similar approaches in regards to statistical significance and interpretation of findings. First, unlike other methods, SEM enables the researcher to evaluate a complex series of relationships in a hypothesised model as a whole, compared to testing for statistical significance of relationships individually. Consequently, SEM enables higher level analysis compared to similar approaches, because holistic ‘causal inferences’ can be made about hypothesised relationships in line with theory, and statistical estimates of the goodness-of-fit of the model with the data. As explained by Kline (2015 p. 13) “there is a sense in SEM that the view of the entire landscape (the whole model) has precedence over that of specific details (individual effects)”. Finally, SEM was used in this study because it gives clearer estimates of effect sizes than other comparable techniques like MR and ANOVA. This is an important consideration, given the size of the model and the number of hypotheses examined.

Since structural equation models are hypothetical models of theoretical relationships among variables validated using real data, the fundamental concern is whether the questions asked actually measured the variables they were intended to, and whether under similar conditions, the test can be replicated with the same model. In other words, if all the factors considered in the hypothetical model used in this study hold true based on theory, then a similar factor structure (questions) can be used to examine the same relationships in different populations (Brown, 2015; Kline, 2014).

Addressing this concern is the fundamental logic behind factor analysis, a technique that is used in the natural sciences, psychometric studies, and social sciences, to isolate ‘common factors’ from a large number of questions or items. Factor analysis assumes that the total variance among a large number of items in a model is made up of shared or common variances among smaller groups of items. In line with the definition of reliability, it could be assumed that a set of previously validated measures adapted from prior studies are more or less reliable. However, there may be new, or confounding factors affecting how the newly surveyed population perceive and respond to previously used and validated measures (Kline, 2015; Thompson, 2004). Hence, factor analysis is used to ensure that the items purported to measure the factors in the study ‘load’ together or share the highest covariance among themselves than with other items. Decades ago, Guilford (1946) vividly explained the importance of factor analysis and factorial validity, noting that:

“….the terms “reliability’’ and “validity” require better definitions. Statistically defined, reliability is the proportion of non-error variance in the total-test scores. From this point on, there is often disagreement as to which contributions to total variance should be considered as error variance and which should not. The various operations by which reliability is estimated - internal consistency, alternate forms, and test-retest - rest upon different assumptions on this question…….an estimated reliability coefficient will vary from one population to another, and will depend upon other factors, including the testing conditions and the scoring formula. Validity, in my opinion, is of two kinds: factorial and practical. The factorial validity of a test is given by its loadings in meaningful, common, reference factors. This is the kind of validity that is really meant when the question is asked “Does this test measure what it is supposed to measure?” A more pertinent question should be “What does this test measure?” The answer then should be in terms of factors and their loadings…..It is one of the definite convictions of the writer that factorial conceptions of tests give us the most illuminating and useful basis for drawing conclusions regarding the issues involved in test practice...... I predict a time when any test author will be expected to present information regarding the factor composition of his [sic] tests.” (pp. 428-429, 437-438).

Factor analysis has been used in previous studies for theory development, and for the validation of measurement items for variables in order to explain the nature of existing relationships. It enables a parsimonious summarisation of the relationships among numerous survey questions, by generating a set of ‘factor scores’ or ‘factor loadings’, used to group questions under the theoretical factors (latent variables) they measure (Kline, 2014). A factor loading is the correlation between the observed variable and the latent variable. Generally, the higher the correlation, the better, because the squared of the factor loading of an observed variable on its latent variable estimates the reliability of the observed variable as a good measure (Winter, 2000). In a practical sense, the loadings give some indication of how well the underlying latent factors (e.g. INOV, TMS, and ACAP) are captured by the observed variables. These factor loadings are then used in subsequent SEM analyses (such as ANOVA, regression, and path analyses). The next subsection examines the two forms of factor analyses carried out to arrive at a measurement model of factors (latent variables) and corresponding item loadings (observed variables).

### **4.6.2 Building Latent Variables from Observations with SEM: Exploratory and Confirmatory Factor Analysis**

Two forms of factor analysis were carried out in this study as a preliminary step towards developing a hypothesised SEM model for the mediating impact of ACAP, TMS, and OINT on the relationship among the stages of knowledge sharing and three meso-level knowledge outcomes –INOV, REPLIC, and ADAPT. The two-factor analyses procedures carried out – Exploratory and confirmatory factor analyses- resulted in a measurement model showing the latent variables and their associations to the underlying observed variables. Exploratory factor Analysis (EFA) is often used when researchers have no theoretical expectations regarding the number of factors (latent variables) that would emerge from a series of questions investigating a set of relationships (Williams et al., 2012). Considering the arguments above on factorial validity, the EFA conducted in this study was carried out as an ‘exploratory validity investigation’ of the measures adapted from prior research. The observed variables were correlated to generate factor loading, without specifying the theoretical number of factors expected from the analyses (Kline, 2014).

In the second form of factor analysis, known as Confirmatory factor analysis (CFA), the number of expected latent variables are specified, and questions are fixed or assigned to their respective latent variables to check whether there is sufficient correlation among them to support the theoretically specified factor structure (Bryant and Yarnold, 1995; Thompson, 2004). Thus in a sense, CFA directly tests the theoretical basis/soundness for bringing together measures to capture specific variables by assessing the degree of fit between the data and a given theoretical factor structure. The result of CFA is a measurement model, which is then used in the final steps of the modeling to test the study hypotheses through path analysis (Kline, 2015). It is however possible to find that a presumed theoretical factor structure does not fit the data after the CFA. In such instances, the researcher may have to repeat the EFA procedures, or explore the possibility of statistically modifying the model to obtain the best possible fit. For this capability, Kerlinger (1979, p. 180) referred to CFA as "the furthest logical development and reigning queen of the correlational methods" (Thompson, 2004). The steps for the EFA and CFA carried out in this study are outlined in the following subsections.

### **4.6.3 Factor Extraction/Reduction**

The factor extraction phase of EFA uses a form of matrix algebra performed by the Statistics package (SPSS). Although the mathematical details are unnecessary for this purpose, the logic behind the approach is explained briefly. As noted, the responses to questions (Likert scale 1-5) are observed variables for the hypothesised latent variables. By estimating the correlations of the observed variables with each other (pairwise), a multivariate correlation matrix is obtained. Different statistical analyses are then carried out on the matrix, such as ranking the number of rows and columns, transposing the columns and rows in the original matrix, and multiplying the whole matrix by its sub-matrices (conformability) (Thompson, 2004). The purpose of these analyses is to isolate ‘common factors’ or fewer patterns of covariance matrices among the items that sufficiently explains the covariance structure of the whole matrix. Factor loadings (or the percentage variance in each item that is explained by any common factor), are computed and used to aggregate the items into few groups, with each sub-group representing a distinct factor or latent variable. The sum of the variances in the factors or latent variables extracted should collectively explain nearly all the variance in the whole covariance matrix of observed variables. The latent variable (factor) that reproduces the highest variance is extracted first, and extraction of latent variables continues in that order until the most possible variance in the matrix has been explained (Bryant and Yarnold, 1995; Byrne, 2013; Kline, 2015). The common factors or latent variable are determined by isolating vectors or clusters of factor loadings, called eigenvectors, whose direction stays unchanged throughout the linear transformations of the matrix (i.e. ranking, transposition and multiplication of sub-matrices) (Hair et al., 2011; Hair et al., 2015; Muthén, 2002). Figure 4.3 below is an illustration of two linear transformations on a matrix with three vectors. In both transformations, the red vectors are eigenvectors because their direction remains unchanged. Expressed mathematically, if a matrix A is multiplied by a vector X and the direction remains unchanged, then the linear transformation is represented as:

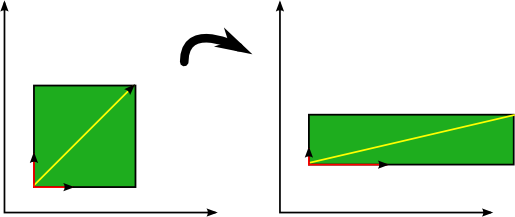
 AX=lambdaX  (3)

Where:

A =The Matrix

X=The Vector

λ= A scalar or physical quantity of known magnitude but no direction called the *eigenvalue.*

[](http://www.visiondummy.com/wp-content/uploads/2014/03/eigenvectors.png)

Note: The eigenvectors (red lines) maintain the same direction after a linear transformation while other vectors (yellow lines) change.

***Figure 4.3:*** *Illustration of a Matrix transformation showing eigenvectors (Spruyt, 2015)*

SPSS offers a number of options for carrying out the transformations required for factor extraction such as *Unweighted Least Squares*, *Generalized Least Squares*, *Maximum Likelihood*, and *Principal Axis*. In this study, the eigenvectors (factors) were extracted using the Principal Axis approach, in line with prior similar studies (Christopher Westland, 2010; Grapentine, 2000; Hoe, 2008).

### **4.6.4 Factor Rotation**

From the description of the matrix algebra process, it is evident that to extract factors manually from a plot of factor loadings is a daunting task, and over the years, several algorithms that enable the ‘rotation’ of eigenvectors to fall on the centroid of clusters of factor loadings have been developed. The factor rotation process is illustrated in figure 4.4 below. According to Bryant and Yarnold (1995, p. 132-133), the aim of rotation is to arrive at a simple factor structure, defined as:

“A condition in which variables load at near 1 (in absolute value) or near 0 on an eigenvector (factor). Variables that load near 1 are clearly important in the interpretation of the factor and variables that load near 0 are clearly unimportant. Simple structures simplify the task of interpreting the factors.”

There are two categories of rotation, distinguished based on the angle of rotation between the X and Y vectors. Orthogonal rotations maintain a 90o angle between axes and is often used when the extracted factors are not expected to correlate. Oblique rotations on the other hand allow for the vectors to be rotated above or below 90o and is often used where factors are expected to have some correlation (Osborne, 2015; Zhang and Preacher, 2015). As with all social science research, it was expected that some correlation would exist among the items, therefore the oblique rotation was selected. Oblique rotations produce a ‘pattern matrix’ of factor/item loadings, and a factor correlation matrix showing the correlations among the latent variables. In the pattern matrix (shown in Table 5.2), item loadings are captured in rows while the latent factors they load on are captured in columns. In line with prior studies, the oblique rotation technique used in this study is called the Direct Oblimin. The researcher first tried out the three available oblique rotation options on SPSS (direct oblimin, quartimin, and promax), and the direct oblimin gave the simplest (most parsimonious) factor structure with the highest eigen values (Zhang and Preacher, 2015).

Factor 1

Factor 1

Rotated Factor Matrix

Factor 2

Factor 2

Un-rotated Factor Matrix

***Figure 4.4:*** *Un-rotated and rotated Factor Matrices*

### **4.6.5 Assessing Reliability and Validity in EFA**

Including measures with poor validity or reliability in the model could lead to wrong or misleading conclusions by distorting the statistical outcome of the theoretical relationships examined. This is of particular concern when the study contains several latent variables measured with multiple items (Flynn et al., 1990; Hayes and Preacher, 2013). Validity checks whether the latent variables are measured using the right set of questions or items, while reliability checks for the consistency and dependability of the measurement items, or if the items developed could be used to measure the same latent variables under different settings or by different researchers (Flynn et al., 1990; Rossi et al., 2013). Measures lacking in validity lead to *systematic errors* while unreliable measures produce *random errors* (Bryant and Satorra, 2012; Forza, 2002). In the SEM analysis approach, construct validity is determined in the CFA phase where the researcher tries to ascertain if items belonging to a single summated scale (i.e. items loading together) all measure the same latent variable (convergent validity) and nothing else (discriminant validity) (Cable and DeRue, 2002). Reliability or internal consistency is the capability of items to stay together as a set (homogeneity), yet independently measure different aspects of the same construct (inter-correlation) (Cable and DeRue, 2002; Forza, 2002). It is a measure of the degree to which responses from different respondents are consistent for each of the items purported to measure a latent variable. If internal consistency is low, it implies that the items are probably too heterogeneous. In this study, initial variable reliability was tested using the Cronbach coefficient alpha (Anand et al., 2010). While there are slight discrepancies in the acceptable cut-off points for this statistic, reliability coefficients greater than or equal to .70 are considered adequate (Kline, 2015). If the value of the coefficient is less than .50, it could mean that over 50% of the variance in the observed scores, is as a result of some form of random error.

### **4.6.6 Assessing Measures of Sampling Adequacy**

The Kaiser-Mayer-Olkin (KMO) index and Bartlett’s Test of Sphericity are the two measures of sampling adequacy used to check the ratio of cases (responses) to research variables, to determine if the data is suitable for factor analyses (Bryman and Bell, 2015; Kline, 2014). If the KMO index (ranges from 0-1) is close to 1, it typically indicates a high sample adequacy for factor analyses, whereas values less than 0.50 indicate low sample adequacy. Bartlett's test of sphericity checks if the matrix used in the extraction of factors is an ‘identity matrix' (Kline, 2015). In standard multiplication, the number 1 is considered as the ‘multiplicative identity’ of other numbers, because the product of 1 and any given number (n), is always the same value as (n). Likewise, in matrix algebra, a matrix which is a multiplicative identity of other matrices is called an identity matrix (Byrne, 2013). The Bartlett's Test examines (and attempts to reject) the null hypothesis that the correlation matrix used in factor extraction contained an identity matrix. If the Barlett’s test is significant at p <0.05, the matrix is considered unsuitable for structure detection using factor analytic techniques. This is a minimum adequacy requirement for using a dataset in factor analysis.

### **4.6.7 Assessing Communalities**

Another important statistic estimated in the EFA process is the *communality* among the items. The communalities for each latent variable is the sum of the squared of all factor loadings on that latent variable. It represents the percentage of variation in the latent variable that is explained by all its underlying factor loadings (observed variables). The standard cut-off is to achieve communalities above 0.5 (Implying that at least 50% of the variance in the latent variable should be explained by its observed variables) (Hair et al., 2011; Little et al., 1999). The communalities for all latent variables were estimated using SPSS.

### **4.6.8 Criteria for retaining Factors in EFA for further analysis in CFA**

As noted earlier, the number of factors to be extracted was not indicated a priori in carrying out the EFA, because the purpose was to determine factorial validity and reliability of the measures adapted from previous studies. Consequently, the four main criteria outlined in the literature for retaining factors were used in this study to decide the number of factors that were retained after the Principal axis extraction and direct oblimin rotation of the eigenvectors in the overall correlation matrix of observed variables.

1. Although there are different perspectives on the adequate cut-off value for factor loadings, the commonly used convention of retaining factors with average loadings of 0.5 and above (or 50% average) was adopted. In other words, the average factor loadings of all items on each latent variable had to be 0.5 or above to be retained (Zhang and Preacher, 2015).
2. Kaiser’s criterion (Eigenvalues >1): Factors with eigenvalues greater than 1 were retained (see Pallant, 2010).
3. Factors meeting the above conditions, and collectively explain a minimum of 60% of the cumulative variance in the whole correlation matrix of observed variables were retained (see Hair et al., 2011).
4. Factors with eigenvalues above a standard threshold of 1 were retained (Kline, 2015)
5. A graphical plot of the eigenvalues for all factors in descending order of magnitude known as Scree test was estimated using SPSS. All the factor eigenvalues falling in the steep slope just before the levelling off begins were retained (D'Agostino and Russell, 2005).

The resulting pattern matrix with questions loading on each latent variable was then used in the next stage of the analyses – CFA.

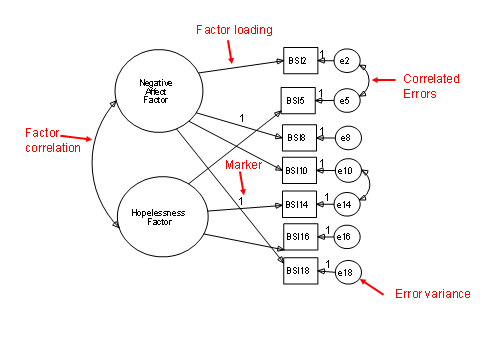
## **4.7 Research Measurement Model: Confirmatory Factor Analysis (CFA).**

After the observed variables were rationalized and reduced to a few factors or latent variables, CFA was carried out to confirm if the latent variables and their theoretically deduced observed variables ‘fit’ together in a constrained/ fixed measurement model. A well-fitting hypothetical model must possess five main qualities. First, a good measurement model must be *parsimonious*. Parsimony is the scientific philosophy that when more than one solution to a problem exists (for instance, if there are several fitting theoretical iterations of a measurement model), then the simplest and most consistent scientific explanation that fits the data is the more reliable and plausible explanation (Barrett, 2007; Bollen and Pearl, 2013). Secondly, the model must be *Identifiable*. For a set of data, identifiability means that only one unique set of observed variables load together for each of the latent variables in the model (i.e. no cross-loading) (Kline, 2014). Thirdly, the model must achieve *goodness-of-fit*. Here, statistical tests are used to determine if the correlation matrix of all the items in the data collected is consistent with the hypothesized distribution of item correlation with latent variables in the measurement model (Barrett, 2007; Kline, 2015). Fourth, an adequate measurement model must be *consistent with the underlying theory*. Finally, the model must have sufficient *predictive power*. As opposed to explanatory and descriptive power, which is the focus of EFA, predictive power is the quality of a model to correctly test theoretical relationships among variables (Kline, 2015). In order to assess the loading or items on latent factors against the five criteria outlined above, five consecutive steps of CFA were carried out, namely; model *specification and identification, estimation*, *testing (goodness-of-fit)*, and *modification*.

### **4.7.1 Model Specification and Identification**

Model specification is the a priori decision made by the researcher to fix observed variables to latent factors and estimate the relationships among the latent factors freely (Kline, 2015). Such specifications are driven partly by theory, and partly by the results of the EFA. A poorly specified model leads to poor model fit in CFA because unlike EFA, the multiple correlation solutions in CFA are fixed, unique, and unrotatable since the observed variables are assigned a priori to their corresponding latent variables before covariances are estimated. Model specification (or the a priori fixing of parameters) enables the researcher to then *identify* the model.

Identification in CFA is the process of estimating the theorised covariance among the parameters in the model in line with the research hypotheses (Byrne, 2013). In other words, after fixing the observed variables to specific latent variables (specification), identification is the process of estimating the hypothesised relationships among the latent variables themselves. Figure 4.5 below is an illustration of a specified CFA model with two latent variables, each having 2 specified and identified observed variables respectively. The squares in the figure above represent the observed variables, while the circles represent the latent variables and the residuals or errors associated with each observed variable. The single-headed arrows depict the presumed direction of causation, while double-headed arrows signify the covariance between latent and residual variables (Kline, 2015). As explained earlier in the discussions on EFA, single headed arrows (or factor loadings) proceed from the latent to the observed variables, since it is assumed that the latent variables (common factors or eigenvectors) cause the observed variables. Such models are called *reflexive models* because the covariation among the observed variables is theoretically presumed to arise due to the latent variables, and each observed variable reflects a portion of the variation in its underlying latent factor (Jarvis et al., 2003). Another type of model (not applicable in this study) is known as the *formative model*. In such models, there is no prior assumption regarding how the groups of observed variables should load on each latent factor, rather, each observed variable is assumed to have a distinct and unpredictable impact on the latent variables. In such models, the direction of the single-headed arrows is reversed (Jarvis et al., 2003; Kline, 2015).



**Soc 4**

**Com2**

**Com2**

**Com3**

**Soc3**

**Soc2**

**Soc11**

COM

SOC

***Figure 4.5:*** *Illustration of a specified and identified 2-factor model*

In identifying the theoretical model specified for this study, residual or error terms were computed for each observed variable. These residuals represent the unique errors associated with the measurement of each observed variable, and accounts for the residual variance in each observed variable that is not explained by the underlying latent variable (Schermelleh-Engel et al., 2003). Given that the latent variables in this study are all highly subjective, errors or residuals could arise from uncontrollable factors such as the respondents’ qualification, mood, perceptions on the questions asked and so on.

Regarding measurement model specification and identification, Bagozzi (1981, p. 376), argued that:

“…..convergence in measurement should be considered a criterion to apply before performing the causal analysis because it represents a condition that must be satisfied as a matter of logical necessity.” (Jarvis et al., 2003).

If the model is wrongly specified (model misspecification) or incorrectly identified (model misidentification), the resulting measurement model will fit poorly with the data when standard statistical tests for fit are applied (Kline, 2015). Model specification and identification was done by manually constructing (drawing) the theorised correlations among the latent variables and their observed variables in line with the pattern matrix produced from the EFA and the underlying theory supporting the questions asked for each construct.

### **4.7.2 Model Estimation**

After model specification and identification, the relationships among the latent variables in the constructed measurement model were statistically estimated using the SEM Analysis of Moment Structures (AMOS) program (Byrne, 2013). The analyses in AMOS employs several statistical techniques to estimate the relationships, including path analysis, causal modeling with latent variables, ANOVA, and multiple linear regressions (Kline, 2015).

## **4.8 Assessing Model ‘Goodness-of-Fit’**

If the constructed model is consistent with the correlation/covariance matrix in the data, it is said to have achieved a good fit and would not require re-specification. Such a model is then used to examine causal paths in line with the research hypotheses (Bandalos, 2002; Schermelleh-Engel et al., 2003). The standard statistical test for assessing goodness-of-fit between observed variable covariance/correlations and hypothesized models is called the *chi-squared test* (X2), which is based on assumptions of normal data distribution (Hoe, 2008; Steiger, 2007). However, since the model contains several variables, multivariate non-normality has been shown to overestimates the X2 statistic for such models (Kline, 2015). Consequently, other corrected normal-theory test statistics that are adjusted for chi-squared bias due to multivariate non-normality were also used to assess the model fit in this study (Bryant and Satorra, 2012). Table 4.4 outlines the details and cut-off requirements for the main fit indexes used in this study to examine the model fit. The fit indexes used fall into three broad categories, (1) fit indexes that account for population discrepancies (CMIN/DF, RMSEA, and PCLOSE), (2) comparative fit indexes that benchmark the model to a baseline model (CFI, NFI, GFI, and TLI) (3) parsimony adjusted indexes that account for the complexity of the model in estimating fit (PNFI, and PGFI) (Bryant and Satorra, 2012; Byrne, 2013).

### **4.8.1 Assessing Model Validity and Reliability in CFA**

In addition to the reliability and validity tests carried out on the observed and latent variables in the EFA, model Validity and Reliability was also estimated using three additional statistical tests; *Composite Reliability* (CR), *Average Variance Extracted* (AVE), and *Average Shared Variance* (ASV). Although the Cronbach’s alpha computed is traditionally used to assess reliability, Bollen (1989, p.221) argued that the alpha coefficient "makes no allowances for correlated error of measurements, nor does it treat indicators influenced by more than one latent variable." Thus in line with best practice conventions, a slightly different statistic called the Coefficient of Determination or the composite reliability (CR) was computed to capture the reliability of the latent variables, to account for any shortcomings in the alpha statistic estimates. The suggested cut-off for CR according to methodology texts on SEM is 0.8. Likewise, the AVE is the average amount of variance in the observed variables explained by the latent variables. It was used to assess *convergent validity,* or how well the observed variables correlated with each other within their common factor and the suggested acceptable cut-off for all variables is 0.7 (Kline, 2015). If the estimated AVE for each variable falls below .50, it suggests that over 50% of the variance in the observed variables is due to measurement errors, and raises questions regarding the convergent validity of the latent variables. The Average shared Variance (ASV) was used to estimate the *discriminant validity*, or the extent to which the observed variables for each latent variable correlated with other latent variables. If the ASV is higher than AVE for a given latent variable, it implies that the variance in the observed variables for that variable is better explained by other latent variables.

|  |  |  |
| --- | --- | --- |
| Acronym | Explanation | Critical values |
| CMIN/DF  χ2/degrees of freedom | This index is called the relative chi-square or normed chi-square, and it estimates the chi-square index divided by the degrees of freedom (or the number of variables in the model that are free to co-vary or not identified/fixed). It is not very sensitive to sample size. | CMIN/DF ~ 1=good fit, 1-3 = acceptable fit |
| Root Mean Squared Error of Approximation (RMSEA)  √ (χ2 - df) | This index adjusts for sample size in the interpretation of chi-square statistics. | RMSEA 0 = exact/good fit, <0.05 = close fit, >.10=poor fit |
| PCLOSE  p-value of close fit | This measure is a one-sided test of the null hypothesis that the RMSEA equals .05 or a *close-fitting model with minimal* specification errors. | PCLOSE > 0.5 = good fit, < 0.05 = no fit |
| Comparative Fit Index  (CFI) | Compares the fit of a target model to the fit of an independent model--a model in which the variables are assumed to be uncorrelated. In this context, fit refers to the difference between the observed and predicted covariance matrices | CFI >.90-.95 = good fit |
| The Normed Fit Index (NFI) | Compares the minimum discrepancy of the model being evaluated to the minimum discrepancy of a baseline independent model. NFI may underestimate fit for small samples and does not reflect parsimony. | NFI 0=poor fit, close to 1= good fit |
| Parsimony Normed Fit Index (PNFI) | This is a parsimony adjusted NFI measure. | PNFI 0=poor fit, close to 1= good fit |
| Goodness-of-Fit Index (GFI) | Analogous to the multiple R square in multiple regression. It measures the covariance among the observed variables accounted for by the hypothesized model. | GFI 0=poor fit, close to 1=good fit |
| Parsimony Goodness-of-Fit Index (PGFI) | This is a parsimony based fit index that takes into account the complexity of the model in assessing goodness-of-fit | PGFI 0=poor fit, close to 1=good fit |
| Tucker-Lewis Index (TLI) | Similar to NFI and CFI in its sensitivity to models with misspecified factor loadings but not sensitive to sample size | NFI 0=poor fit, close to 1= good fit |

***Table 4.4****: Description of goodness-of-fit indices and cut-off criteria*

### **4.8.2 Assessing Common Method Bias**

Common method bias (CMB) arises in a dataset if there are factors outside the ones considered that significantly influence the responses provided. Since a single instrument was used to collect data on a variety of latent variables, several types of biases resulting from the common method of data collection could affect the responses (Conway and Lance, 2010). Such cognitive response biases as explained earlier, could lead to over or underestimated responses. To check for CMB, a ‘dummy’ common latent factor (CLF) was introduced into the model to determine if the majority of the variance in the model could be explained by a single external dummy variable. If CMB is detected, then the dummy variable must be retained in the model in the creation of multi-item composites for the structural model used in the final (hypotheses testing) stages of SEM (Podsakoff et al., 2012).

### **4.8.3 Assessing Measurement Model Invariance**

Since the data for this study included different potentially significant sub-groups (e.g. companies from industry clusters vs. independent companies in VEs), it was important to determine whether the factor structure and loadings in the hypothesized measurement model were sufficiently equivalent across the different sub-groups (Cheung and Rensvold, 2002). This is known as model invariance. Variations could manifest as between-group differences in the patterns of factor loading; known as *configural variance*, or between-group differences in the strength of associations among the observed and the latent variables; known as *metric variance* (Dimitrov, 2010). To test for measurement invariance (metric and configural), two tests were run using AMOS.

1. A multi-group moderation test to compare the ‘critical ratios for differences’ in the multi-groups to assess whether the respondents from different groups accorded the same meaning to the questions measuring each variable (Dimitrov, 2010). If there is no observed difference, it implies that the conditions for metric invariance are met.

2. The second test involved creating measurement models using only the data from each group and comparing their model fit using AMOS (Dimitrov, 2010; Milfont and Fischer, 2015). If model-data fit is achieved for the multi-groups, it implies that the conditions for configural invariance are met.

### **4.8.4 Addressing Model Fit Issues in CFA using Modification Indexes**

Although the logical solution for a poorly fitting model is re-specification, AMOS computes an additional statistic – known as *modification indexes* – with which the researcher could detect if and where variable(s) misspecification may have occurred (Bentler, 2007). Modification indexes are probability estimates of possible changes in the value of the model’s chi-squared goodness-of-fit if the free/unidentified variables in the model such as the residual/errors are correlated/covaried. In some cases, residuals are theoretically expected to covary, but since error relationships are not usually hypothesized, they are often left as free parameters in the model (Kline, 2015). By using the modification indexes provided on AMOS, the researcher checked for potential improvements in the model fit attainable by covaring relevant residual or error variables. Some cautionary steps were adhered to in line with recommendations from authors on SEM (Bentler, 2007; Byrne, 2013; Hu and Bentler, 1999; Kline, 2015). They include:

1. All modifications applied must be theoretically justified.
2. The residuals from different latent variables cannot be correlated since the observed variables have been theoretically fixed or specified to their respective latent variables.
3. While improving model fit, modifications should only be made if the resulting impact on other estimates in the model is minor.

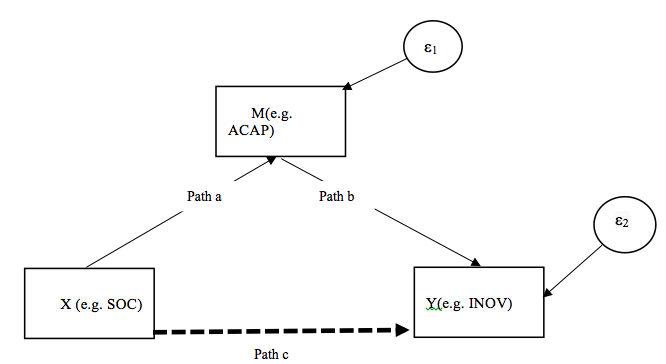
## **4.9 Testing the Hypothesized Mediation and Interaction Effects: Path Analysis of Structural Equations**

There are two techniques for building structural models based on a review of previous studies and methodology texts. The first approach involves including directional paths to link the latent variables in their fine-grained or *disaggregated* state (i.e. with all the observed variables and factor loadings still retained). The second approach involves collapsing the observed variables for each latent variable into coarse-grained or *totally aggregated* multi-item composites (Hu and Bentler, 1999; Podsakoff et al., 2012). The disaggregated measurement model allows more flexibility to evaluate each observed variable, however, it is only worthwhile (i.e. achieving stable estimates) when the sample size is reasonably large (above 600). Thus in this study, the structural model was obtained using the second approach of collapsing items for each latent variable into multi-item composites (Landis et al., 2000). The resulting composite variables were then covaried to estimate the mediating impact of the dynamic capabilities examined on knowledge sharing and outcomes in VEs. *Composite residuals* were assigned to account for any variance that may arise from external factors (Kline, 2015). The resulting composite structural model was then examined for model fit, using the same fit statistics applied in the CFA.

### **4.9.1 Mediation Analyses**

After obtaining a well-fitting model, the study hypotheses were analysed. The structural equations examined included (1) the hypothesized mediating effect of ACAP, TMS and OINT on the SECI stages of knowledge sharing and the knowledge outcomes, and (2) the impact of the interaction effects of the Socialisation and Externalisation (tacit knowledge sharing), and Combination and Internalisation (explicit knowledge sharing) on the model.

In a mediation analyses, the objective is to understand how an intermediary variable affects the relationship between a predictor and an outcome variable. Mediation is typically characterised by three important relationships. As shown in figure 4.6, the direct effect (c) is the path from the predictor variable to the outcome variable; controlling for the mediator. The indirect effect (a x b) is the path from the predictor to the outcome variable, via the mediator. The total effect (c1 = (a x b) +c) for each hypothesized path (iˆth) is the sum of the direct and indirect effects (Hayes and Preacher, 2013). In essence, mediation examines whether the effect of a predictor variables on a given outcome can be facilitated or hampered by altering a mediating variable.



***Figure 4.6****: Mediation Model*

The regression equations are given as:

1. Regression of the mediator on the independent variable

M = i1 + aX + ε1 (1)

1. Regression of the dependent variable on the independent variable

Y = i2 + c1 X + ε2 (2)

1. Regression of the dependent variable on both the mediator and independent variable

Y =i3 + cX + bM + ε3  (3)

This approach to mediation was proposed by Baron and Kenny (1986) and is the most frequently used. According to the authors;

“A variable functions as a mediator when it meets the following conditions: (a) variations in levels of the independent variable significantly account for variations in the presumed mediator (i.e., Path a), (b) variations in the mediator significantly account for variations in the dependent variable (i.e., Path b), and (c) when Paths a and b are controlled, a previously significant relation between the independent and dependent variables is no longer significant, with the strongest demonstration of mediation occurring when Path c is zero………….To test mediation, one should estimate the three following regression equations: first, regressing the mediator on the independent variable; second, regressing the dependent variable on the independent variable; and third, regressing the dependent variable on both the independent variable and on the mediator. . . . To establish mediation, the following conditions must hold: First, the independent variable must affect the mediator in the first equation; second, the independent variable must be shown to affect the dependent variable in the second equation; and third, the mediator must affect the dependent variable in the third equation.” (1986, 1176-1177)

When there is a significant indirect effect without a corresponding significant direct effect, they argued that such a mediation is strong and can be viewed as *full mediation*. When both the indirect and direct effect are significant, it is called *partial mediation*. The fundamental assumption of the Baron and Kenny approach is that before a mediation test can be run, the ‘effect to be mediated’ or total effect of a predictor on an outcome must be significant. However, Zhao et al. (2010) argued that the total effect of a predictor on an outcome variable (designated as c1 ) is statistically equivalent to the sum of the mediated effect (a x b) and the direct effect (c). Thus, when both the mediated and direct effects are the same sign (direction), c1 would intuitively be significant, and they referred to this type of mediation as *complementary*. However, if the direct effect is reasonably different from the indirect effect, then the resulting total effect (c1) of a predictor on an outcome may be close to zero, and fail the significance test; even where the direct effect is significant. They referred to this often overlooked type of mediation as *competitive*. According to them:

“Competitive and Complementary mediations are equally likely and of equal theoretical interest a priori. Both point to a theoretically interesting indirect effect. Both identify an unexplained direct effect and guide future research to look for alternative mediators that match the sign of the revealed direct effect. It is nonsensical that only complementary mediations should be judged to be publishable, yet this is the consequence of [consumer] researchers’ reliance on Baron and Kenny’s X-Y test………. the Baron and Kenny classification of full, partial, and no mediation is somewhat coarse and misleading due to a one-dimensional conception of mediation better seen as two-dimensional.” (p. 199-200).

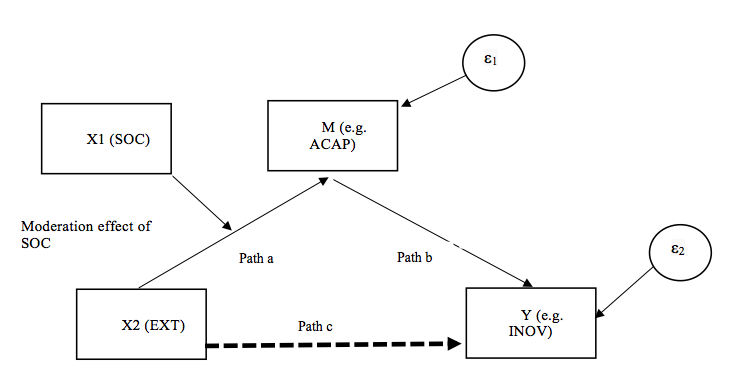
In line with these arguments, this study explores for the existence of three forms of mediation from five possible outcomes:

1. *Complementary mediation* where the indirect effect and the direct effect are both significant and the product of their coefficients is positive.
2. *Competitive mediation* where the indirect effect and the direct effect are both significant and the product of their coefficients is negative.
3. *Indirect-only mediation* where the indirect effect is significant, but the direct effect is not significant.
4. *Direct-only non-mediation* where the indirect effect is not significant, but the direct effect is significant.
5. *No-effect non-mediation* where neither the direct effect nor the indirect effect is significant.

The Sobel test is the traditional test for estimating indirect (axb) or mediated effects, however, it has been argued that it produces more accurate estimates for models that are run with large sample sizes (Hair et al., 2011; Hair et al., 2006; Hayes and Preacher, 2013). To address this shortcoming, Preacher and Hayes (2004) developed a non-parametric test known as *bootstrapping*, which involves sampling, replacing, and resampling observations from the same dataset to compute indirect effects. The AMOS program was used to run up to 2000 bootstraps of the dataset to estimate the indirect effects for the hypothesized mediated relationships.

### **4.9.2 Estimating the Interaction Effects for Tacit and Explicit Knowledge Sharing**

In line with Nonaka and Takeuchi’s (1996) conceptualization, socialization and externalization processes represent tacit knowledge sharing, while the externalization and combination processes capture explicit knowledge sharing. However, since all the stages are distinct and important in their right, previous studies have measured and conceptualized them separately. To empirically examine how the interaction between the processes for tacit and explicit knowledge sharing changed the hypothesized mediation model, further hypotheses were proposed to capture the positive interaction effect of the tacit and explicit processes respectively, on the overall mediated model. Interaction effects are also known as moderated mediations as shown in Figure 4.7 below. A moderated mediation occurs when the effect of a predictor (e.g. SOC) on a mediator (e.g. ACAP), and/or its partial effect on an outcome variable (e.g. INOV) through the same mediator is affected by another predictor variable (e.g. EXT), which act as a moderator (Hayes and Preacher, 2013; Muller et al., 2005). The moderated mediation (or interaction) analyses carried out in this study would contribute towards improving the current understanding of the dynamics of knowledge sharing, by shedding light on how the processes of tacit and explicit knowledge sharing in VEs affect knowledge outcomes. For clarity and parsimony, the mediation and interaction tests were conducted independently on the full model. A latent product variable for the interaction effect was computed by standardizing and multiplying the coefficients for the stages representing tacit knowledge sharing (i.e. SOC\*EXT) and explicit knowledge sharing (i.e. COM\*INT).



***Figure 4.7****: Moderated-Mediation (interaction effect) Model*

### **4.9.3 Chapter Summary**

In this chapter, the key phases of the research methodology were examined and discussed. The reflective analyses on the researcher’s philosophical considerations (positivist epistemology and critical realist ontology) covered arguments on the nature of man and the nature of science, and the combined impact on the development of research paradigms in the social sciences. The chapter also covered the rationale, construct development, and execution of the survey research design (web-based questionnaires) used in the study. Detailed discussions and justifications for the statistical tests and procedures used for the data analyses (SEM) were also provided. The next chapter provides details on the findings from the data analyses, including the results obtained from each of the tests outlined in this chapter. Findings on each research hypothesis on the mediating impact of dynamic capabilities on knowledge sharing and outcomes in VEs and the interaction effect of the knowledge conversion processes for tacit and explicit knowledge sharing are presented.

# CHAPTER FIVE: FINDINGS

## **5.1 Background**

In the preceding chapter, details on the research methodology were presented, including the steps for the SEM analysis conducted in this study. Eleven hypotheses were proposed following the literature review and conceptual framework development, to examine the mediating impact of ACAP, TMS, and OINT on the ability to achieve innovation, adaptation and replication, drawing on the SECI knowledge sharing processes for tacit and explicit knowledge sharing conceptualised by Nonaka and Takeuchi (1996). This chapter presents the findings on the preliminary data screening, research demographics, EFA results on the fit and validity of measurement model, CFA results on the fit and validity of the hypothesised dynamic capability mediated knowledge sharing process-model, findings from the path analysis of the mediation and interaction effects for all the proposed research hypotheses.

## **5.2 Preliminary Data Screening**

* + 1. **Descriptive Statistics**

As noted earlier, a total of nine sample background characteristics were captured, including:

1. Seven (7) demographic measures: industry, organisational size, job title, years of experience in firm, years of management experience, industry and region.
2. Two (2) screening questions used in grouping respondents based on VE experience: type of VE experience (Hierarchical and Holarchical), and whether or not respondents were part of an industry cluster or breeding environment.

Table 5.1 shows estimates of the mean distribution of respondents across the sub-categories of each background variable and estimates of the standard deviations for each variable. As shown, the data appears fairly normally distributed and appears to reflect a suitable sample demographic for valid responses on the processes and outcomes of knowledge sharing in VEs. For instance, based on the distribution of the data, the highest number of respondents were from the food processing (31 firms), Oil and Gas (30 firms) and Construction (23 firms) industries. The data was fairly distributed across other sub-categories, with the least amount of respondents in the Aeronautics and Aviation industry (6). The sample also included a fairly even distribution of small, medium, and large scale organisations, with most of the data coming from firms with more than 500 employees. In terms of the respondent’s job titles, majority of responses came from project managers (71 responses) while the least number were C level managers, with 26 responses. Likewise, majority of the respondents (51) had between 11 to 15 years of work experience with the surveyed firms, and the majority surveyed had between 16 to 20 years of overall management experience. A comparatively higher number of respondents were more experienced in Hierarchical VEs than Holarchical VEs, which is not surprising, given the distribution of the industries sampled (See Appendix B). Howard (2009) noted that there have been significant structural changes in the food processing industry globally, with a growing spate of horizontal integrations (acquisitions) among complementary firms in the food production/processing and related industries. However, the author acknowledged that the industry has also seen a growing number of horizontal integrations realized through other forms of strategic alliances, “often hidden from consumers through 'stealth' ownership”. These trends are also characteristic in the Oil and Gas (due to the prominent role of national Oil companies) and construction (due to the fragmentation and specialisation) industries where the successful execution of projects relies extensively on global hierarchical collaborations.

Nonetheless, the sample contained other industries like the electronic, metal and mechanics, aviation, telecoms, and logistics and transport industries, where Holarchical VEs are significantly prominent. Likewise, most of the firms sampled belonged to global industry clusters (109). As a control measure, an invariance test was carried out prior to fitting the structural equation model to ascertain if the responses were significantly different across the sampled industries for firms that were more accustomed to hierarchical VEs vs. Holarchical VEs and for those that were part of global clusters vs. those that engaged in VEs by pooling partners from the open market. Findings from the invariance tests carried out are reported in a later subsection of this chapter.

***Table 5.1:*** *Mean distribution and Standard Deviation of Demographic Variables*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Number of sub-categories | Mean distribution | Std. Deviation |
| Industry | 11 | 6.17 | 2.733 |
| Organisational size | 4 | 3.04 | 1.007 |
| Job title | 4 | 2.75 | .988 |
| Years of experience in Org | 5 | 2.83 | 1.357 |
| Years of management Exp | 5 | 3.09 | 1.388 |
| Part of a regional or global industry cluster | 2 | 1.46 | .500 |
| VE type | 2 | 1.62 | .486 |
| Region | 6 | 3.60 | 1.708 |

As shown in Appendix C, all variables showed low multicollinearity, meeting the threshold for both the tolerance test and variance inflation factor test. The results show that none of the predictors significantly correlated with the dependent variables or mediators, implying that linear predictions of the dependent variables from the independent variables could be made with considerable accuracy. Consequently, no variables were eliminated or condensed into composites at this stage of the analysis (see Kline, 2015; Schroeder, 1990).

### **5.2.2 Outlier Screening Test Results**

To check for univariate and multivariate outliers or extreme values, the researcher first manually observed the data with the aid of the ‘conditional formatting’ feature in EXCEL spreadsheet to identify outliers. Since all items were measured on a five point Likert scale, there were no extreme outliers detected in the data and no mathematical transformations were required at this stage (see Leys et al., 2013)*.*

## **5.3 Structural Equation Modeling Results**

The structural equation modeling (SEM) was used for the analyses was run in line with the detailed description of the steps and processes provided in the methodology section. For clarity, the results are reported in the same order as the explanations for the steps provided in the preceding chapter. The SEM modeling process involved fitting of two distinct models with the data:

1. *The measurement model, which stipulates* the regression equations linking the observed variables or indicators (i.e. measures for each variable) to their respective substantive latent variables.
2. *A path model*, which stipulates the regression equations linking the variables in the hypothesized causal mediated model.

The resulting measurement model was tested following the steps for EFA and CFA to ascertain the ‘goodness-of-fit’ between the measurement model and the observed data (see Bollen and Pearl, 2013). Likewise, as explained, all the resulting variables from the measurement model were condensed into composites of their measures and captured as latent variables in the SEM path model. Differential terms (or errors) were included in the measurement model for all observed variables and in the path model for all endogenous variables (mediators and outcomes). The results obtained are as follows.

## **5.4 Exploratory Factor Analysis Results**

### **5.4.1. Sampling Adequacy Test Results**

Prior to carrying out the factor reduction and extraction steps described in the methodology chapter, the ratio of cases (responses) to research variables was estimated to determine if the data was suitable for factor analyses (Bryman and Bell, 2015; Kline, 2014). Results showed that the Kaiser-Meyer-Olkin measure was satisfactory, meeting the stipulated cut-off of >0.5. This result indicates that the sample used is sufficiently adequate for an exploratory factor analysis – [KMO=0.924, chi-square=10055.017, degree of freedom (df) =999]. Furthermore, the Bartlett's test of sphericity was used to test (and attempt to reject) the hypothesis that the covariance matrix used for the factor extraction was an identity matrix (see Kline, 2015). The result was non-significant at p <0.05, thus, the null hypothesis that the correlation matrix used in factor extraction contained an identity matrix was rejected and the sample was deemed adequate in line with stipulated standards, for factor rotation and extraction (see Bryman and Bell, 2015). The factor rotation and extraction was carried out using the direct oblimin and principal axis extraction methods respectively.

### **5.4.2 Communalities and Preliminary Reliability Test Results**

A total of 47 items were used to measure absorptive capacity (7), transactive memory systems (5), organisational interoperability (6), socialisation (4), externalisation (4), combination (4), internalisation (4), innovation (4), adaptation (4), and replication (5) respectively. As explained in the methodology chapter, the items used were adapted from different studies consequently, an EFA was carried out to identify problematic items, particularly items that load together on a non-theorised factor, items exhibiting large cross-loadings with other factors, and items that do not meet the threshold for significant factor loadings (<0.5). Following an unrestricted rotation and extraction of factors, an eleven-factor matrix with poor factor loadings was extracted. The item measuring REPLIC 5 (fifth measure for replication) had a very low factor loading of 0.3, and loaded together with COM4 (fourth measure for combination) as the 11th factor.

The benefit of carrying out an EFA before attempting to fit a model is that it gives the researcher the opportunity to assess the potential factor structure to identify and isolate preliminary issues that may affect the final factor solution. Two solutions are recommended in the literature for dealing with the issue encountered with the two variables mentioned above. The first option is to search for theoretically sound reasons to re-specify the hypothesised model and provide theoretical justification for an additional factor, which might have been omitted in the original theorisation. The second approach often used in cases where cross-loadings are not very significant, is to assume that there may be some measurement bias, eliminate the offending items, and retest the matrix structure for factor patterns similar to the hypothesised model. Since there is no theoretical justification to explain REPLIC5 and COM3 as a separate factor worth considering in the theoretical model, both items were eliminated. This is in keeping with the conditions of model *Identifiability explained earlier*, which stipulates that a set of data must have only one unique set of observed variables loading together for each of the latent variables in the hypothesised model (i.e. no cross-loading) (see Kline, 2015).

After eliminating the two cross-loading items (COM3 and REPLIC5), a 10 factor solution was obtained. As shown in Appendix D (1), the mean communalities for all the core items measured were sufficiently high (all above the minimum threshold of 0.5), indicating that over 50% of the variance in each latent variable extracted was explained by its underlying items, and all the items themselves are satisfactorily correlated and adequate for a factor analysis ( Hair et al., 2011; Byrne, 2013). Furthermore, Appendix D (2) shows that a 10-factor solution in the measurement model explains a combined 79% of the variance in the overall covariance matrix for all items measured, and the Kaiser-Guttman criterion of retaining components with eigenvalues greater than 1, was also satisfactory for the 10 factor solution (Hair et al., 2006). Likewise, figure 5.1 is a scree plot of the eigenvalues, and it shows that the steep line of the scree slope begins a flat-line trend after the 10th factor, which further supports the extraction of a 10 factor solution in the measurement model.



***Figure 5.1:*** *Scree plot of Eigenvalues showing a 10-Factor solution for the Measurement Model*

Chrobach’s alpha statistics were computed for all extracted factors as a preliminary test for reliability. In line with the recommended cut-off as shown in Table 4.4, the coefficients were all greater than or equal to 0.70 and thus, considered adequate (Kline, 2015). This preliminary reliability test indicated that for all the items measured, less than 30% of the variance in the observed scores can be statistically attributed to some form of random error. All items for the respective constructs were sufficiently correlated and after eliminating the cross-loading items, the retained items (45) each loaded parsimoniously on a single construct. Based on these tests, the 10 factor matrix solution was adopted to develop and test areflective confirmatory model based on the hypothesised constructs and relationships. The resulting 10-factor pattern matrix was used for the subsequent CFA and model building steps. The pattern matrix is shown in Table 5.2 below.

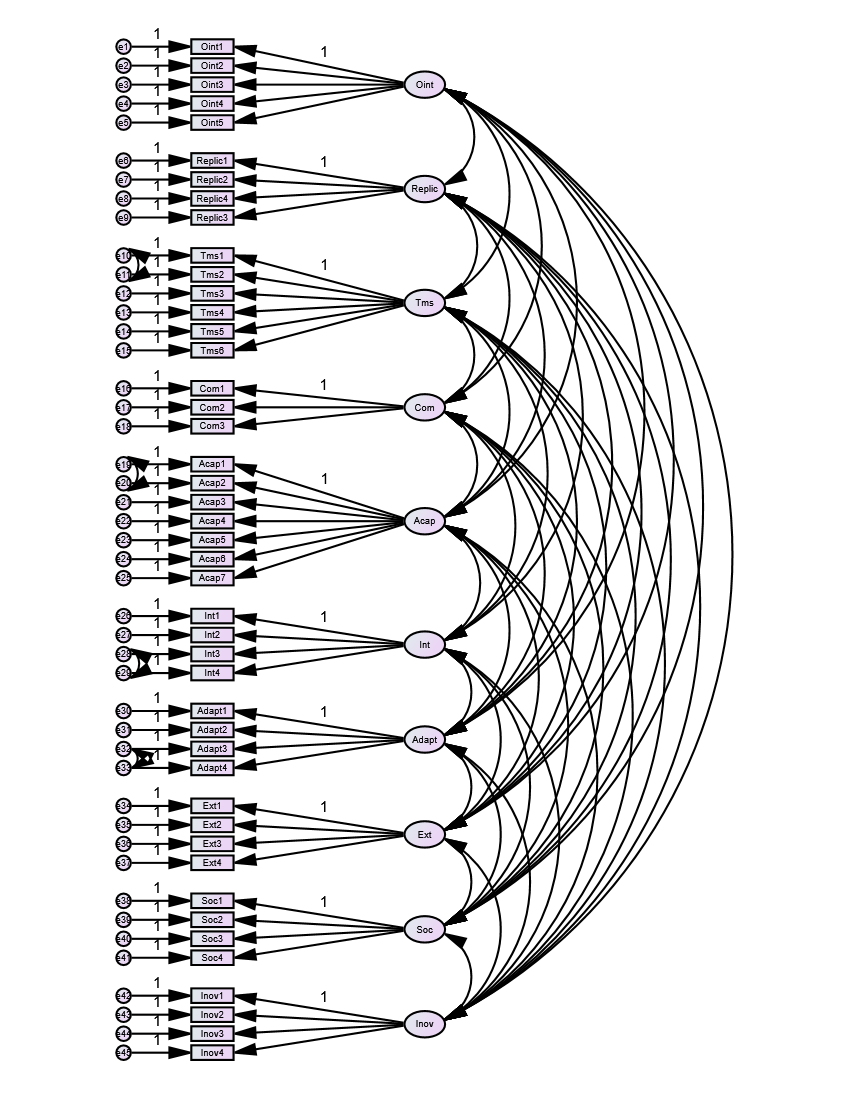
***Table 5.2****: Pattern matrix showing factor loadings for the 10 factors extracted*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Factor | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Oint1 | .861 |  |  |  |  |  |  |  |  |  |
| Oint2 | .886 |  |  |  |  |  |  |  |  |  |
| Oint3 | .809 |  |  |  |  |  |  |  |  |  |
| Oint4 | .819 |  |  |  |  |  |  |  |  |  |
| Oint5 | .814 |  |  |  |  |  |  |  |  |  |
| Replic1 |  | .579 |  |  |  |  |  |  |  |  |
| Replic2 |  | .903 |  |  |  |  |  |  |  |  |
| Replic4 |  | .929 |  |  |  |  |  |  |  |  |
| Replic3 |  | .922 |  |  |  |  |  |  |  |  |
| Tms1 |  |  | -.798 |  |  |  |  |  |  |  |
| Tms2 |  |  | -.879 |  |  |  |  |  |  |  |
| Tms3 |  |  | -.916 |  |  |  |  |  |  |  |
| Tms4 |  |  | -.905 |  |  |  |  |  |  |  |
| Tms5 |  |  | -.888 |  |  |  |  |  |  |  |
| Tms6 |  |  | -.849 |  |  |  |  |  |  |  |
| Com1 |  |  |  | .819 |  |  |  |  |  |  |
| Com2 |  |  |  | .824 |  |  |  |  |  |  |
| Com3 |  |  |  | .844 |  |  |  |  |  |  |
| Acap1 |  |  |  |  | .812 |  |  |  |  |  |
| Acap2 |  |  |  |  | .903 |  |  |  |  |  |
| Acap3 |  |  |  |  | .800 |  |  |  |  |  |
| Acap4 |  |  |  |  | 925 |  |  |  |  |  |
| Acap5 |  |  |  |  | .854 |  |  |  |  |  |
| Acap6 |  |  |  |  | .846 |  |  |  |  |  |
| Acap7 |  |  |  |  | .937 |  |  |  |  |  |
| Int1 |  |  |  |  |  | .836 |  |  |  |  |
| Int2 |  |  |  |  |  | .835 |  |  |  |  |
| Int3 |  |  |  |  |  | .872 |  |  |  |  |
| Int4 |  |  |  |  |  | .583 |  |  |  |  |
| Adapt1 |  |  |  |  |  |  | .807 |  |  |  |
| Adapt2 |  |  |  |  |  |  | .762 |  |  |  |
| Adapt3 |  |  |  |  |  |  | .771 |  |  |  |
| Adapt4 |  |  |  |  |  |  | .594 |  |  |  |
| Adapt1 |  |  |  |  |  |  | .807 | .766 |  |  |
| Ext2 |  |  |  |  |  |  |  | .850 |  |  |
| Ext3 |  |  |  |  |  |  |  | .694 |  |  |
| Ext4 |  |  |  |  |  |  |  | .671 |  |  |
| Soc1 |  |  |  |  |  |  |  |  | .840 |  |
| Soc2 |  |  |  |  |  |  |  |  | .806 |  |
| Soc3 |  |  |  |  |  |  |  |  | .839 |  |
| Soc4 |  |  |  |  |  |  |  |  | .581 |  |
| Inov1 |  |  |  |  |  |  |  |  |  | .872 |
| Inov2 |  |  |  |  |  |  |  |  |  | .671 |
| Inov3 |  |  |  |  |  |  |  |  |  | .682 |
| Inov4 |  |  |  |  |  |  |  |  |  | .762 |

## **5.5 Confirmatory Factor Analysis Results**

### **5.5.1 Model Specification and Identification Results**

Using the Analysis of Moment Structure (AMOS) software, the factor loadings were used to specify or correlate observed variables to respective latent factors, and the relationships among the latent factors were estimated freely (Kline, 2014). Specification was informed in part by the underlying theory as well as the results obtained from the EFA. After specification, the confirmatory model was identified by estimating the theorised covariance among the latent variables in the hypothesised model (Byrne, 2013). The schematic of the identified reflexive CFA model shown in Figure 5.2 below was developed on the AMOS tool and shows the 10 latent theorised constructs specified to correspond with the factor loadings from the pattern matrix (Jarvis et al., 2003). After model specification and identification, the goodness-of-fit of the initial measurement model was estimated and found to be adequate in line with the cut-off criteria itemised in the last chapter. The error terms for TMS1🡪TMS2, ACAP1🡪ACAP2, ADAPT3🡪ADAPT and INT3🡪INT4 showed high modification indices and were covaried to improve the model fit (Kline, 2015). The fit indices obtained for the measurement model after covaring the error terms as follows: Chi-square (X2)=1620.594, degrees of freedom (df) =897, chi-square goodness-of-fit (X2/df) =1.807, comparative fit index (CFI) =0.92*,* parsimony comparative fit index (PCFI) =0.84, Normed fit index (NFI) =0.85, root mean squared error of approximation (RMSEA)=0.063, Tucker-Lewis Index (TLI)=0.92, goodness-of-fit (GFI) =0.758, parsimony goodness-of-fit (PGFI) =0.657 and PCLOSE =0.12. Since the fit indices indicated sufficient fit between the hypothesised measurement model and the data, it was unnecessary to use the modification indices generated to improve the fit of the model as explained earlier.



***Figure 5.2****: Measurement model*

### **5.5.2 CFA Model Validity and Reliability Test Results**

As explained in the previous chapter, the validity and reliability of the measurement model were estimated using three statistical tests in addition to the Chronbach’s reliability estimates. The additional tests include a test for *Composite Reliability* (CR) to estimate the latent construct reliability, a test of the *Average Variance Extracted* (AVE) to estimate convergent validity, and a test of the *Average Shared Variance* (ASV) to estimate discriminant validity. Results for composite reliability (CR) obtained for all constructs as shown in Table 5.3 were above the recommended 0.8 threshold (Byrne, 2013). Likewise, for convergent validity, results showed that the AVE for all constructs were above the stipulated cut-off of 0.50, which indicates that each construct explained over 50% of the variance in its underlying measurement items and the amount of variance caused by measurement errors is minimal (below 20% for nearly all constructs). The Fornell–Larcker approach of comparing the square root of the AVE of each construct and the correlation between the constructs to test for discriminant validity, showed that on average, each construct was more closely related to its underlying measures than the measures of other constructs (see Table 5.4 for the square root of AVE and correlation matrix) (Hair et al., 2006). Likewise, the Average shared Variance (ASV) for each construct was lower than the respective AVEs, which implies that the variance in the observed variables of each latent variable are better explained by the respective latent variables. Discriminant validity is particularly important in mediation testing because as explained by Zhao et al. (2010), mediation tests are completely meaningless if it is not clearly demonstrated that the mediators are sufficiently dissimilar from the independent or the dependent variables. Where there is no clear distinction, the data may appear to provide evidence for mediation where none exists. As shown in the correlation matrix in table 5.4, the mediator variables show sufficient discriminant validity from the dependent and independent variables explored.

***Table 5.3****: Measures of Validity and Reliability*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Α | CR | AVE | MSV | MaxR(H) |
| Soc |  | 0.932 | 0.923 | 0.750 | 0.366 | 0.929 |
| Oint |  | 0.963 | 0.963 | 0.838 | 0.384 | 0.975 |
| Replic |  | 0.913 | 0.917 | 0.738 | 0.166 | 0.982 |
| Tms |  | 0.969 | 0.963 | 0.815 | 0.262 | 0.988 |
| Com |  | 0.868 | 0.872 | 0.694 | 0.033 | 0.989 |
| Acap |  | 0.970 | 0.965 | 0.799 | 0.358 | 0.992 |
| Adapt |  | 0.827 | 0.819 | 0.537 | 0.166 | 0.992 |
| Ext |  | 0.942 | 0.935 | 0.784 | 0.399 | 0.993 |
| Inov |  | 0.936 | 0.929 | 0.765 | 0.399 | 0.994 |
| Int |  | 0.940 | 0.943 | 0.807 | 0.128 | 0.994 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Soc | Oint | Replic | Tms | Com | Acap | Adapt | Ext | Inov | Int |
| **0.866** |  |  |  |  |  |  |  |  |  |
| -0.527 | **0.916** |  |  |  |  |  |  |  |  |
| -0.030 | -0.036 | **0.858785** |  | **Read Caveats and Assumptions below**,  and then click me. |  |  |  |  |  |
| -0.503 | 0.442 | -0.075 | **0.902563** |  |  |  |  |  |  |
| -0.174 | 0.183 | -0.086 | 0.042 | **0.832895** |  |  |  |  |  |
| -0.525 | 0.512 | 0.001 | 0.446 | -0.021 | **0.89359** |  |  |  |  |
| 0.054 | -0.094 | 0.408 | 0.039 | -0.149 | -0.081 | **0.733007** |  |  |  |
| 0.509 | -0.590 | -0.045 | -0.512 | -0.076 | -0.531 | 0.016 | **0.885454** |  |  |
| -0.605 | 0.620 | 0.024 | 0.504 | 0.112 | 0.598 | -0.048 | -0.632 | **0.87492** |  |
| 0.313 | 0.236 | -0.063 | -0.358 | 0.122 | -0.243 | -0.061 | 0.234 | -0.219 | **0.898244** |

***Table 5.4****: Correlation matrix of factors.*

***Note:*** *Bold figures on the diagonal are the square roots of the Average Variance Extracted (AVE)*

### **5.5.3 Common Methods Bias Test Results**

Social desirability, item ambiguity, context effect, and using a single questionnaire to collect data on the predictor and criterion variables could result in common method variance or bias. To test for common methods bias, the unmeasured latent factor approach was used (see Podsakoff et al., 2003). A ‘dummy’ common latent factor (CLF) was introduced into the model to ascertain if a reasonable amount of variance in the model is explained by the external dummy variable. A comparison of the standardized regression weights before and after the common latent factor was added showed no significant difference, indicating that there was no significant common methods bias.

### **5.5.4 Metric and Configural Invariance Test Results**

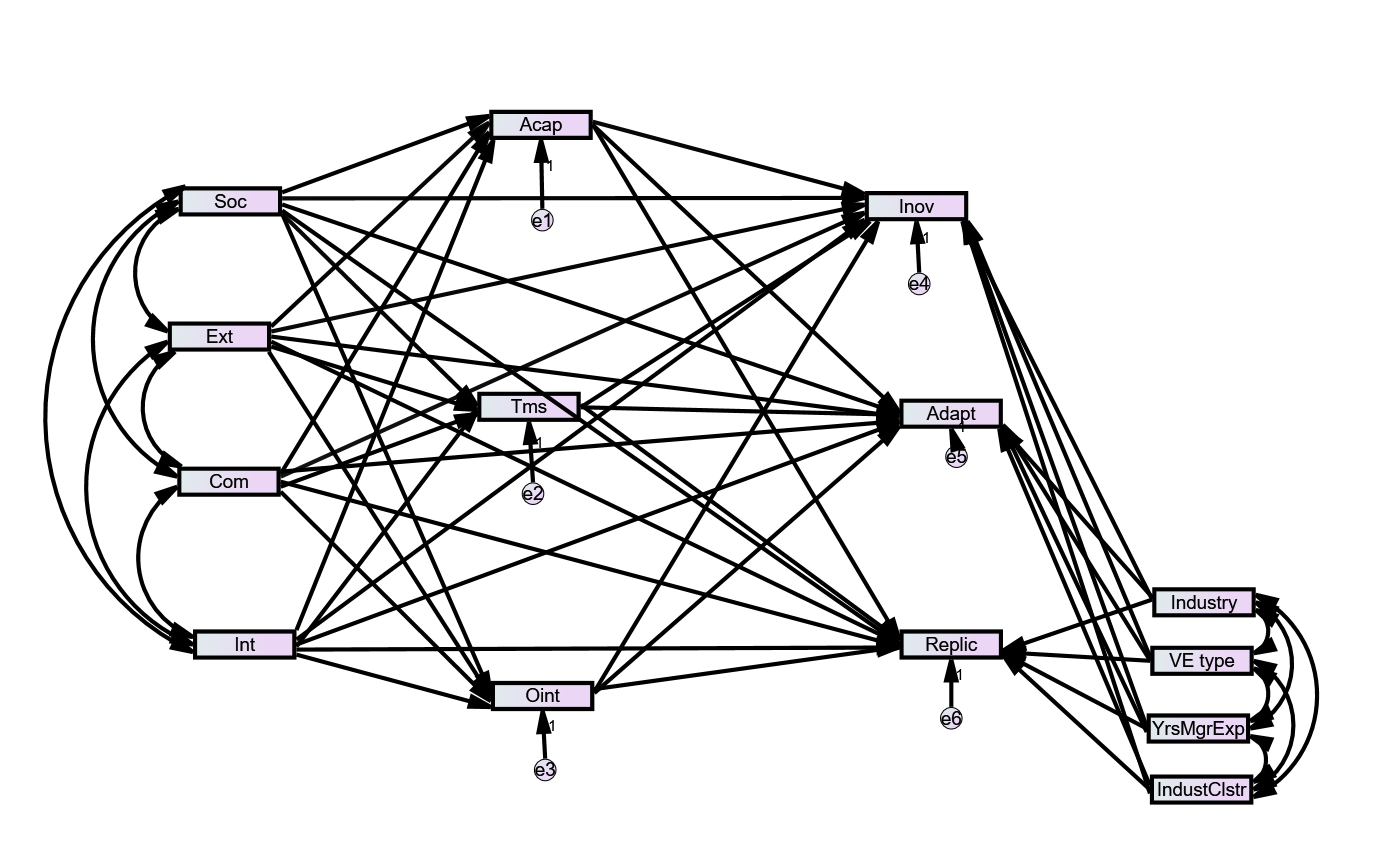
The multi-groups in the data were subjected to an invariance test to determine if the factor structure in the different groups are equivalent. The groups tested include: Hierarchical VEs vs. Holarchical VEs, industry cluster Vs no industry cluster. The results of a chi-squared difference test (see Table 5.5a and 5.5b below) for metric invariance conducted was non-significant for the unconstrained and fully constrained models across the 4 multi-groups, indicating that the factor structure is consistent across all the sub-groups in the sample. In addition, a comparison of the standardised regression weights and critical ratios of differences in regression weights yielded non-significant z scores across all sub-groups at p-value < 0.05. Furthermore, measurement models created by splitting the data into the respective sub-groups showed adequate model fit for the hierarchical vs. holarchical subgroups [fit indices: X2 =2890.167; df =1794; X2/df =1.611; CFI =0.894*;* PCFI =0.810; NFI =0.85; RMSEA =0.055; TLI=0.883; GFI =0.654; PGFI =0.567; and PCLOSE =0.011], as well as the cluster vs. no cluster subgroups [fit indices: X2 =2969.538; df =1794; X2/df =1.655; CFI =0.887*;* PCFI =0.84; NFI =0.765; RMSEA =0.057; TLI=0.875; GFI =0.652; PGFI =0.565; and PCLOSE =0.011]. These findings show that the conditions for configural invariance were met in the sampled data (Dimitrov, 2010; Milfont and Fischer, 2015).

***Table 5.5a:*** *Chi-Squared difference test results for metric invariance test for Hierarchical vs. Holarchical*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Chi-square | df | p-val | Invariant? | chi-square and df for the constrained model were obtained by constraining all the regressions of observed variables on latent factors. |
| Overall Model |  |  |  |  |
| Unconstrained | 2969.538 | 1794 |  |  |
| Fully constrained | 3005.065 | 1839 |  |  |
| Number of groups | Hierarchical vs. Holarchical | 2 |  |  |
| Difference | 35.527 | 45 | 0.843 | YES | Groups are not different at the model level, however, they may be different at the path level. |
| Chi-square Thresholds | |  |  |  |

***Table 5.5b****: Chi-Squared difference test results for metric invariance test for firms in Cluster Vs Not part of industry or regional Cluster*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Chi-square | Df | p-val | Invariant? | chi-square and df for the constrained model were obtained by constraining all the regressions of observed variables on latent factors. |
| Overall Model |  |  |  |  |
| Unconstrained | 2890.167 | 1794 |  |  |
| Fully constrained | `2934.139 | 1839 |  |  |
| Number of groups | Cluster vs. Not part of industry or regional Cluster | 2 |  |  |
| Difference | 43.972 | 45 | 0.515 | YES | Groups are not different at the model level, however, they may be different at the path level. |
| Chi-square Thresholds | |  |  |  |



***Figure 5.3:*** *Schematic of structural equation path model*

## **5.6 Results on Mediation Effect of Dynamic capabilities on the Stages and Outcomes of Knowledge Sharing**

The resulting measurement model following the CFA was deemed acceptable and sufficiently fitting for path model analysis. Prior to building the path model, the correlations within each latent variable and its underlying measures were condensed to create composite latent variables using AMOS. Figure 5.3 above shows the composite structural equation model for this study.

As shown, the independent variables - socialisation (SOC, externalisation (EXT), combination (COM), and internalisation (INT) in the multiple-mediator model were allowed to covary. Likewise, the residuals associated with the mediators, dependent, and control variables were also allowed to covary because according to Hayes and Preacher (2013), fixing these parameters to zero would imply that any observed covariance among the dynamic capabilities (ACAP, OINT, TMS) or knowledge outcomes would be entirely attributed to the effect of the SECI knowledge sharing stages without accounting for the effect of residuals (errors). Before proceeding to report the mediation findings for this study, a brief recap on the mediation procedures outlined in the methodology in line with recommendations by Zhao et al. (2010) is helpful. According to Zhao and colleagues, a variable (M) mediates the relationship between X and Y if it meets the following conditions:

1. Variations in levels of X significantly accounts for variations in M
2. Variations in M significantly accounts for variations in Y
3. When paths X🡪M and M🡪Y are controlled, the significant relationship between X🡪Y (independent and dependent) is no longer significant.
4. When Path X🡪Y is zero, it represents the strongest demonstration of mediation occurring among the variables.

The authors explained that independent-dependent variable relationships in the social sciences usually have multiple mediators, but researchers are constrained in their ability to identify all relevant mediators by their knowledge, scope, field of study, and context. Consequently, whereas in a few cases where the data may indicate “indirect only” mediation, more often than not, either the ‘competitive mediation’ or ‘complementary mediation’ are to be expected if the theorisation on mediation is sound. They further argued that the commonly reported “indirect only” results very often masks omitted-variable bias.

They further noted that in cases where it is not part of a study’s theorisation, there is no statistical requirement to hypothesize about or demonstrate that a significant zero order effect (or the effect to be mediated) exists between the independent and dependent variables before carrying out mediation tests. The authors demonstrated that such a direct effect of X🡪Y is algebraically equivalent to the *“total effect of X on Y”,* or the sum of the indirect effect of X on Y through M and the direct effect of X on Y. As such, they argued that checking for the existence of a total-effect before testing for mediation is superfluous because if the signs (+ or -) of the direct and indirect effects are opposing, then the direct effect to be mediated may not be observed even when strong mediation exists.

Accordingly, the following effects were assessed in this study to identify the possible forms of mediation of dynamic capabilities on the processes of knowledge sharing and the knowledge outcomes (innovation, adaptation and replication) (Hayes and Preacher, 2013). Using the AMOS software, the direct effects of the SECI stages on the three dynamic capabilities were estimated as well as the direct effects of the mediators (dynamic capabilities) on the outcome variables. Next, the specific indirect effects of the SECI stages of knowledge sharing through each of the mediators (i.e. ACAP, TMS and OINT) on the dependent variables (i.e. innovation, replication, and adaptation) were also estimated. Finally, the total indirect effects (the sum of the specific indirect effects), and the total effects (the sum of the direct and indirect effects) are estimated. The corresponding 95% confidence intervals for the different effects estimated were obtained using AMOS, which is capable of concurrently estimating both total and specific indirect effects using bias-corrected (BC 95%) bootstrapping (Zhang and Preacher, 2015). As explained in the previous chapter, bootstrapping is a more effective and valid approach for estimating indirect effects than the frequently applied Sobel test approach. Each bootstrap involves random sampling, replacement, and resampling. Once a specified number of bootstraps is reached, the distribution of the estimates gives an indication of the sampling distribution of the indirect effects observed. In this study, 5,000 bootstrap samples were drawn in line with recommendations by (Hayes and Preacher, 2013). Mediation is theorised to exist in cases where the lower and upper bound estimates are greater than zero, in order to infer that the mediation effect for a given relationship is not zero with 95% confidence. As noted, the possible types of mediation include:

1. *Complementary mediation* where the indirect effect and the direct effect are both significant and the product of their coefficients is positive.
2. *Competitive mediation* where the indirect effect and the direct effect are both significant and the product of their coefficients is negative.
3. *Indirect-only mediation* where the indirect effect is significant, but the direct effect is not significant.
4. *Direct-only non-mediation* where the indirect effect is not significant, but the direct effect is significant.
5. *No-effect non-mediation* where neither the direct effect nor the indirect effect is significant.

**5.6.1 Findings on the Mediating Effect of Absorptive Capacity on Knowledge Sharing and Outcomes**

Table 4 below shows the standardized regression coefficient for:

1. *The direct effects*: SECI🡪Knowledge outcomes (innovation, adaptation, and replication)
2. *The indirect effects*: SECI🡪Dynamic capabilities 🡪Knowledge outcomes
3. *The total effects*: sum of the indirect effects and the direct effects.
4. The unstandardized indirect effects were computed using AMOS for 5,000 bootstrapped samples, and the 95% confidence interval was computed by determining the indirect effects at the lower 2.5th and upper 97.5th percentiles.

To test each mediation hypothesis, bootstrapping procedures were carried out, while treating the other mediators as covariates. Bootstrapping, as explained earlier, was carried out to increase the likelihood that any mediation observed is representative of the entire population. Since only a single sample (202 responses) was collected, the alternative would have been to draw several independent samples from the population through a series of data collection processes. Bootstrapping enabled the researcher to statistically achieve this by taking out several samples from the main sample, test for the significance of the mediation and then replace each bootstrap sample before resampling (Hayes and Preacher, 2013).

The first interesting observation that can be gleaned from examining the direct impacts of the SECI stages without the mediators as captured in the first column of tables 3,4, and 5 is that with the exception of the direct paths from SOC🡪ADAPT and COM🡪ADAPT, all other direct paths show an inverse relationship between the stages of knowledge sharing and innovation, adaptation and replication in collaborative VEs. These findings appear to be contrary to some of the previous studies on intra-organisational knowledge sharing using the SECI model. Plausible explanations for these findings are provided in the discussion chapter.

Regarding the mediating role of ACAP on the ability of collaborating VE partners to achieve innovation through the SECI knowledge sharing processes, the results in Table 5.6 show that ACAP mediated the relations between the SECI stages of knowledge sharing and innovation (H1a-d). From the results of the mediation analysis, the direct paths from socialisation and externalisation processes to innovation, were significant and negative, and the indirect paths through ACAP were also significant and negative, indicating that for the hypothesised relationships H1a and H1b, the ability to achieve innovations through socialisation and externalisation in VEs is mediated by ACAP through complementary mediation. In other words, the paths from SOC🡪INOV and EXT🡪INOV are mediated by ACAP acting complementarily with other dynamic capabilities. For H1c and H1d, the findings show that ACAP mediated the processes of achieving innovations through combination and internalisation through indirect-only or full mediation, since the direct paths were non-significant. For the path from COM🡪INOV in H1c, the positive impact of combination on innovation is strengthened as firms’ increase their investments in ACAP building routines. Likewise, findings from the path analysis of H1d (INT🡪INOV) suggest that firms with high ACAP are able to reduce the negative impact of knowledge internalisation on innovation in collaborative ventures. For H2a-d on the mediating role of ACAP on adaptation in VEs, findings show that ACAP plays a mediating role in paths H2a (SOC🡪ADAPT), H2b (EXT🡪ADAPT), and H2c (INT🡪ADAPT) through indirect-only or full mediation, since the direct paths were non-significant. However, for path H2c (COM🡪ADAPT), ACAP was shown to play a partial complementary mediating role by dampening the negative impact of knowledge combination processes on the ability to achieve successful knowledge adaptations in VEs. Contrary to the hypothesised predictions for H3 a-d on the mediating role of ACAP on Replication, findings suggest that ACAP does not play a significant mediating role between the stages of knowledge sharing and the ability to replicate processes, routines and other forms of external knowledge in VEs. Possible reasons for this finding will be discussed, drawing on prior theoretical basis.

***Table 5.6****: Results on the mediating impact of Absorptive Capacity (H1-H3)*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Hypothesis | Mediator =ACAP | Direct Effect without mediator | Direct Effect with mediator | Indirect Effect  95% Bias-corrected confidence interval | Remarks |
| H1a | SOC🡪INOV | -0.384\*\*\* | -0.297\*\*\* | \*\*\* | *Complementary mediation* |
| H1b | EXT🡪INOV | -0.438\*\*\* | -0.353\*\*\* | \*\*\* | *Complementary mediation* |
| H1c | COM🡪INOV | 0.011 (NS) | 0.036 (NS) | \*\* | *Indirect-only mediation* |
| H1d | INT🡪INOV | -0.084 (NS) | -0.012 (NS) | \*\*\* | *Indirect-only mediation* |
|  |  |  |  |  |  |
| H2a | SOC🡪ADAPT | 0.056 (NS) | 0.002 (NS) | \*\* | *Indirect-only mediation* |
| H2b | EXT🡪ADAPT | -0.027 (NS) | -0.083 (NS) | \*\* | *Indirect-only mediation* |
| H2c | COM🡪ADAPT | -0.146\*\* | -0.126\*\* | \*\* | *Complementary mediation* |
| H2d | INT🡪ADAPT | -0.029  (NS) | -0.045 (NS) | \*\* | *Indirect-only mediation* |
|  |  |  |  |  |  |
| H3a | SOC🡪REPLIC | -0.022  (NS) | -0.049 (NS) | NS | *No mediation* |
| H3b | EXT🡪REPLIC | -0.046  (NS) | -0.072 (NS) | NS | *No mediation* |
| H3c | COM🡪REPLIC | -0.092  (NS) | -0.10 (NS) | NS | *No mediation* |
| H3d | INT🡪REPLIC | -0.005  (NS) | -0.012 (NS) | NS | *No mediation* |

\* p < 0.05; \*\* p < 0.01; \*\*\* p < 0.001

**5.6.2 Findings on the Mediating Effect of Transactive Memory Systems on Knowledge Sharing and Outcomes**

Findings on the mediating role of TMS on innovation in VEs confirmed the a priori stated hypothesis (H4a-d). Similar to the mediation role played by ACAP, mediation analysis results show that TMS also play a partial complementary mediating role on innovation as a knowledge outcomes of knowledge sharing through the SECI stages. As outlined in Table 5.7 below, TMS played a complementary mediating role on paths SOC🡪INOV and EXT🡪INOV and an indirect-only or full mediating role on COM🡪INOV and INT🡪INOV respectively. On the other hand, TMS was found to fully mediate the four SECI paths for SOC🡪REPLIC, EXT🡪REPLIC, COM🡪REPLIC and INT🡪REPLIC respectively. This implies that TMS is an antecedent capability for replication of knowledge in VEs. However, the counterintuitive findings for H5 (a-d) suggest that the hypothesised mediating impact of TMS on the SECI stages of knowledge sharing and adaptation were all non-significant since the bootstrapped unstandardized indirect effect through TMS at 95% confidence interval showed statistical non-significant. On the other hand, the path coefficients for H4a-d show that the paths from SOC🡪INOV and EXT🡪INOV were complementarily mediated by TMS while the paths from COM🡪INOV and INT🡪INOV were fully mediated (Indirect-only) respectively. An explanation is offered in the discussion chapter for the counterintuitive findings for H5 a-d.

***Table 5.7:*** *Results on the mediating impact of Transactive Memory Systems (H4-H6)*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Hypothesis | Mediator =TMS | Direct Effect without mediator | Direct Effect with mediator | Indirect Effect  95% Bias-corrected confidence interval | Remarks |
| H4a | SOC🡪INOV | -0.384\*\*\* | -0.346\*\*\* | \*\*\* | *Complementary mediation* |
| H4b | EXT🡪INOV | -0.438\*\*\* | -0.372\*\*\* | \*\*\* | *Complementary mediation* |
| H4c | COM🡪INOV | 0.011 (NS) | 0.013(NS) | \*\* | *Indirect-only mediation* |
| H4d | INT🡪INOV | -0.084 (NS) | -0.051 (NS) | \*\*\* | *Indirect-only mediation* |
|  |  |  |  |  |  |
| H5a | SOC🡪ADAPT | 0.056 (NS) | 0.083  (NS) | NS | *No mediation* |
| H5b | EXT🡪ADAPT | -0.027 (NS) | -0.003 (NS) | NS | *No mediation* |
| H5c | COM🡪ADAPT | -0.146\*\* | -0.144\*\* | NS | *No mediation* |
| H5d | INT🡪ADAPT | -0.029  (NS) | -0.005 (NS) | NS | *No mediation* |
|  |  |  |  |  |  |
| H6a | SOC🡪REPLIC | -0.022  (NS) | -0.082 (NS) | \*\* | *Indirect-Only mediation* |
| H6b | EXT🡪REPLIC | -0.046  (NS) | -0.112 (NS) | \*\* | *Indirect-Only mediation* |
| H6c | COM🡪REPLIC | -0.092  (NS) | -0.096 (NS) | \*\* | *Indirect-Only mediation* |
| H6d | INT🡪REPLIC | -.005  (NS) | -0.057 (NS) | \*\* | *Indirect-Only mediation* |

\* p < 0.05; \*\* p < 0.01; \*\*\* p < 0.001

**5.6.3 Findings on the Mediating Effect of Organisational Interoperability on Knowledge Sharing and Outcomes**

Similar to the other dynamic capabilities examined, the results shown in table 5.8 indicate that OINT also mediated the relations between the SECI stages of knowledge sharing and innovation for firms engaged in VEs. Mediation analysis showed that OINT also played a complementary mediating role on paths SOC🡪INOV and EXT🡪INOV and an indirect-only or full mediating role on COM🡪INOV and INT🡪INOV respectively. However, contrary to expectation, the bootstrapped unstandardized indirect paths for H8a-d and H9a-d for the paths from the SECI processes to adaptation and replication respectively through OINT at 95% confidence interval were all statistically non-significant. These findings suggest that while OINT plays a significant mediating role on the ability to achieve innovations in VEs, its impact on adaptation and replication appear non-significant. These findings shall be explored further in the discussion chapter.

Next, the findings obtained from testing H10 and H11 on the interaction effects between SOC-x-EXT representing tacit knowledge sharing; and COM-x-INT representing explicit knowledge sharing are presented.

***Table 5.8:*** *Results on the mediating impact of Organisational Interoperability (H7-H9)*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Hypothesis | Mediator =OINT | Direct Effect without mediator | Direct Effect with mediator | Indirect Effect  95% Bias-corrected confidence interval | Remarks |
| H7a | SOC🡪INOV | -0.384\*\*\* | -0.299\*\*\* | \*\*\* | *Complementary mediation* |
| H7b | EXT🡪INOV | -0.438\*\*\* | -0.327\*\*\* | \*\*\* | *Complementary mediation* |
| H7c | COM🡪INOV | 0.011 (NS) | 0.003 (NS) | \*\* | *Indirect-only mediation* |
| H7d | INT🡪INOV | -0.084 (NS) | -0.044 (NS) | \*\*\* | *Indirect-only mediation* |
|  |  |  |  |  |  |
| H8a | SOC🡪ADAPT | 0.056 (NS) | 0.025(NS) | NS | *No mediation* |
| H8b | EXT🡪ADAPT | -0.027 (NS) | -0.068 (NS) | NS | *No mediation* |
| H8c | COM🡪ADAPT | -0.146\*\* | -0.141\*\* | NS | *No mediation* |
| H8d | INT🡪ADAPT | -0.029  (NS) | -0.043 (NS) | NS | *No mediation* |
|  |  |  |  |  |  |
| H9a | SOC🡪REPLIC | -0.022  (NS) | -0.058 (NS) | NS | *No mediation* |
| H9b | EXT🡪REPLIC | -0.046  (NS) | -0.093 (NS) | NS | *No mediation* |
| H9c | COM🡪REPLIC | -0.092  (NS) | -0.086 (NS) | NS | *No mediation* |
| H9d | INT🡪REPLIC | -.005  (NS) | -0.021 (NS) | NS | *No mediation* |

\* p < 0.05; \*\* p < 0.01; \*\*\* p < 0.001

**5.6.4 Findings on the Interaction Effects between the Tacit and Explicit Stages of the SECI model.**

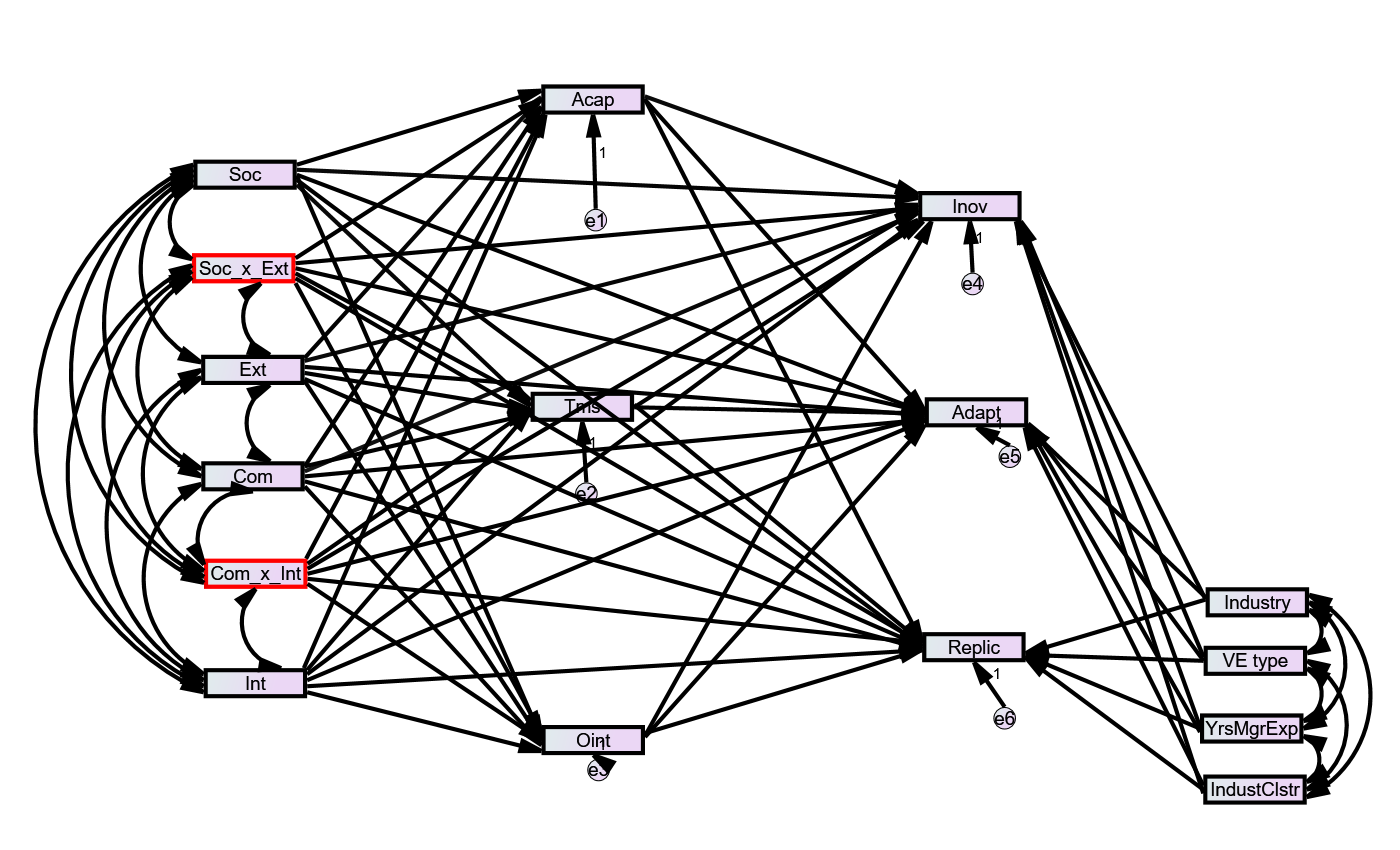
As explained in the literature review, the SECI model by Nonaka and Takeuchi (1996) was chosen to explore the mediating impact of dynamic capabilities on knowledge sharing in VEs because the model, unlike others, accounts for two important and overlapping spirals in the knowledge sharing process:

1. The *knowledge conversion spiral* of tacit🡪explicit conversions, which captures the re-contextualization and re-coding of individual knowledge into collective and retrievable organisation knowledge.
2. The *social justification spiral which embodies* four distinct and human mediated processes involved in the creation and sharing of organisational knowledge (i.e. socialisation🡪externalisation🡪combination🡪internalisation) (Von Krogh et al., 2012).

Overall, hypotheses 1-9 focused on the “main effect” of each of the SECI stages in the social justification spiral of knowledge sharing on the three knowledge outcomes through the theorised mediators (dynamic capabilities). In testing for each mediated path, the effects of other independent variables assumed to exist as independent covariates. The above findings for H 1-9 provide empirical evidence on the mediating impact of dynamics on the social justification aspect of the SECI model. These findings are largely supported by theory and previous studies (e.g. Anand et al., 2010).

As explained in the previous chapter, a statistical interaction occurs when the effect an independent variable on a dependent variable is altered or *changed* with changes in another independent variable. Based on the conceptualisation of the SECI model by Nonaka and Takeuchi (1996), socialisation and externalisation are theorised to ‘interact to produce tacit to explicit knowledge conversions, while combination and internalisation routines interact to yield explicit to tacit knowledge conversions in the knowledge creation spiral. Accordingly, hypotheses H10 (a-c) and H11 (a-c) were proposed to verify whether the effect of socialisation on the knowledge outcomes is altered by the level of development of externalisation routines for *tacit knowledge sharing*. Likewise, H11 (a-c) examine whether improved internalisation routines have an impact on the ability to achieve desired knowledge outcomes in VEs using knowledge combination routines.

To test the two-way interaction hypotheses described above for H10 and H11, the SECI independent variables were standardised and multiplied to create product variables for (SOC)x(EXT) and (COM)x(INT) representing tacit and explicit knowledge sharing routines respectively. The product terms were introduced into the hypothesized model and the goodness-of-fit of the resulting model was assessed. The resulting fit indices indicated that a satisfactory model fit was achieved for the model with the interaction terms [fit indices: X2 =103.828; df =48; X2/df =2.163; CFI =0.946*;* PCFI =0.378; NFI =0.85; RMSEA =0.076; TLI=0.883; GFI =0.942; PGFI =0.333; and PCLOSE =0.018]. Figure 5.4 below is a schematic of the hypothesised model with the interaction terms.



***Figure 5.4****: Schematic of the hypothesised model with the interaction terms.*

The interaction effect for the two standardised variables [(SOC)x(EXT) and (COM)x(INT)] were plotted by entering the standardised regression coefficients (including intercept/constant) in a worksheet for testing two-way interaction effects (from Gaskin, 2012). Findings showed that the paths linking the interaction term (SOC)x(EXT) (H9a) and (COM)x(INT) (H10a) respectively to innovation were significant while the hypothesized paths for the effect of the two interaction terms on adaptation and replication (for H9b, H9c, H10b and H10c) produced counterintuitively non-significant results. To test the interaction effect in H9a, the unstandardized regression coefficients for the two direct paths from SOC🡪INOV (-0.215 p<0.05) and EXT🡪INOV (-0.236 p<0.05), and the interaction path (SOC)x(EXT)🡪INOV (0.163 p<0.05) were plotted. Likewise, for H10a, the unstandardized regression coefficients for the direct paths from COM🡪INOV (0.005 p<0.05) and INT🡪INOV (0.041 p<0.05), and the interaction path (SOC)x(EXT)🡪INOV (0.085 p<0.05) were also plotted. The plots of these two significant interaction paths for tacit knowledge sharing [(SOC)x(EXT)] and explicit knowledge sharing [(COM)x(EXT)] are shown in figure 5.5 and 5.6 below. For H9a (Figure 5.5), findings indicate that effective knowledge externalisation routines dampen the negative impact of knowledge socialisation routines on innovation among firms engaged in episodic VEs. Similarly, figure 5.6 shows that the interaction between combination and internalisation is significant, and internalisation serves to strengthen the positive impact of knowledge combination routines on the ability for firms in VEs to innovate. In other words, the findings suggest that the interactions between the stages for tacit knowledge sharing and explicit knowledge sharing significantly impact the innovative capabilities of partners in VEs. These findings are noteworthy because they resonate with the conceptual arguments on tacit and explicit knowledge sharing processes proposed by Nonaka and colleagues, as well as the empirical findings from other studies applying the SECI model to team and organisational studies.

In the next chapter, detailed and analytical discussions are presented to further buttress the validated hypotheses and to provide a logical and probable theoretical rationale for the counterintuitive findings reported, with reference to practical examples and case studies.

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| **Figure 5.5:** *The interaction effect of Externalisation on the relationship between Socialisation and Innovation* | |  |  |  |  |  |  |  |  |
|  | |  |  |  |  |  |  |  |  |
| Variable names: | |  |  |  |  |  |  |  |  |
| Independent variable: | | Socialisation |  |  |  |  |  |  |  |
| Moderator: | | Externalisation |  |  |  |  |  |  |  |
| Dependent variable | | Innovation |  |  |  |  |  |  |  |
| Unstandardized Regression Coefficients: | |  |  |  |  |  |  |  |  |
| Independent variable: | | -0.215 |  |  |  |  |  |  |  |
| Moderator: | | -0.236 |  |  |  |  |  |  |  |
| Interaction: | | 0.163 |  |  |  |  |  |  |  |
|  | |  |  |  |  |  |  |  |  |
| Intercept / Constant: | | 2 |  |  |  |  |  |  |  |
|  | |  |  |  |  |  |  |  |  |
| The independent variable is Socialisation since it represents the first stage of explicit knowledge sharing. The moderator here is Externalisation and the interaction is the product variable (SOC)x(EXT). The intercept/constant represents the vertical position for the graph plot. | | |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| Externalisation dampens the negative relationship between Socialisation and Innovation. | | | | | | |
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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  | | |  | | --- | |  | | |  | |  | |  | |  | |  | |  | |
| **Figure 5.6:** *The interaction effect of Internalisation on the relationship between Combination and Innovation* | |  | |  | |  | |  | |  | |  | |  | |  | |
|  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Variable names: | |  | |  | |  | |  | |  | |  | |  | |  | |
| Independent variable: | | Combination | |  | |  | |  | |  | |  | |  | |  | |
| Moderator: | | Internalisation | |  | |  | |  | |  | |  | |  | |  | |
| Dependent variable | | Innovation | |  | |  | |  | |  | |  | |  | |  | |
| Unstandardized Regression Coefficients: | |  | |  | |  | |  | |  | |  | |  | |  | |
| Independent variable: | | 0.005 | |  | |  | |  | |  | |  | |  | |  | |
| Moderator: | | 0.041 | |  | |  | |  | |  | |  | |  | |  | |
| Interaction: | | 0.085 | |  | |  | |  | |  | |  | |  | |  | |
|  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Intercept / Constant: | | 2 | |  | |  | |  | |  | |  | |  | |  | |
|  | |  | |  | |  | |  | |  | |  | |  | |  | |
| The independent variable is Combination since it represents the first stage of explicit knowledge sharing. The moderator here is Internalisation and the interaction is the product variable (COM)x(INT). The intercept/constant represents the vertical position for the graph plot. | | | |  | |  | |  | |  | |  | |  | |  | |
|  | |  | |  | |  | |  | |  | |  | |
| Internalisation strengthens the positive relationship between Combination and Innovation. | | | | | | | | | | | | | |
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|  | |  | |  | | | | | | | | | | | | | |

## **5.7 Chapter Summary**

The findings reported in this chapter validated the hypothesised ACAP, TMS, and OINT mediated model of knowledge sharing for innovation, adaptation, and replication in VEs. Regarding the hypothesised mediating role of ACAP, the findings confirmed that ACAP partially mediates the processes of tacit knowledge sharing (socialisation and externalisation) but fully mediates the processes of explicit knowledge sharing (combination and internalisation) for innovation. Findings also show that ACAP fully mediates the processes of tacit knowledge sharing for knowledge adaptation, and partially mediates the processes of explicit knowledge sharing in VEs. However, the hypothesised impact on replication was non-significant. On the role of TMS, findings showed that TMS fully mediated the processes of tacit knowledge sharing and complementarily (partial) mediated the processes for explicit knowledge sharing for innovation. Results also confirmed that the TMS of collaborating firms in VEs fully mediates the tacit and explicit knowledge sharing processes for replication but showed a non-significant effect on the processes for adaptation. OINT was found to partially mediate the tacit and explicit knowledge sharing processes for innovation, but counterintuitive non-significant findings were reported for the impact of OINT on adaptation and replication. The next chapter presents pointed discussions on these findings and highlights the key contributions of the study to the theory and practice of knowledge sharing in collaborative ventures.

**CHAPTER SIX: DISCUSSION**

## **6.1 Discussion**

This study examined the impact of three dynamic capabilities –absorptive capacity (ACAP), transactive memory system (TMS), and organisational interoperability (OINT)- on the ability to innovate, adapt, or replicate knowledge through VEs. The focus was on how these dynamic capabilities impact the processes of tacit and explicit knowledge sharing; captured through the SECI process-based model of knowledge creation and sharing developed by Nonaka and Takeuchi (1996). The two objectives of the study were to:

1. Propose and test hypotheses on the mediating role of dynamic capabilities on the ability to achieve broad knowledge goals through tacit and explicit knowledge sharing in VEs.
2. Develop and validate a conceptual framework and enrich the current theoretical and practical understanding of the dynamics of knowledge sharing in VEs.

To meet the first objective, nine hypotheses were proposed after a review of previous related studies on dynamic capabilities, VEs, and knowledge sharing in teams, firms, supply chains, VEs, and other forms of collaborative networks. Two other hypotheses were proposed to test the theorised interactions among the stages for tacit knowledge sharing [(SOC)x(EXT)] and explicit knowledge sharing [(COM)x(INT)], which are theorised to occur in continuous spirals of SECI processes that expand from the individual domain, through teams and eventually to organisational and inter-organisational knowledge creation and sharing.

Based on the literature, a conceptual framework was developed to include the theorised enabling role of overarching dynamic capabilities in the SECI process framework for tacit and explicit knowledge sharing in inter-organisational collaborations. The boundary condition for the study was knowledge sharing among firms collaborating under the fluid inter-organisational structure of VEs, and the literature review covered the different strands of research highlighting the drivers and benefits of knowledge sharing in collaborative ventures. The aspects of knowledge that were of interest in this study included those dimensions that have been conceptualised and validated as economically viable (know-how, know-what, know-who, and know-why) as opposed to the philosophical dimensions like gut feeling, and intuition, which are imperative to understanding knowledge sharing but rather difficult to measure and to falsify empirically. The main driver or knowledge outcome often emphasised in the literature is innovation, and a broad scope of studies have explored how the pursuit of innovation motivates firms to source for knowledge outside their immediate boundaries. However, further reviews revealed that adaptation and replication are two other similar but conceptually distinct drivers of collaborative knowledge sharing that have been largely overlooked. These knowledge outcomes facilitate competition by eliminating or minimising the need to make a fresh start or reinvent the wheel, while also enabling firms to conform to broadly validated industry standards of competence at comparatively lower investment costs and potentially lower risk of investment failure.

Another important consideration taken in this study is the role of technological systems and knowledge artefacts or repositories. Since the study surveyed VEs, the primary knowledge artefact of interest, based on findings from the review, is organisational routines. In addition to understanding how individually justified belief and social justification interact to produce organisational knowledge sharing, the study also sought to explore the relational factors that enable firms participating in episodic, loosely coupled, and technology aided networks to share knowledge accumulated in their distinct repositories of organisational processes and routines. The relational view of strategic management and the knowledge-based view of the firm provided theoretical justification for knowledge sharing in episodic collaborations rather than the traditional routes through long-term contractual or short-term transactional relationships.

As noted in the review, most of the extant work on organisational knowledge sharing have been confined to analyses of team-work and cross-functional collaborations. The majority of such studies have shown that the tenets of social justification and supernormal profit generation through collaborative synergies apply in different social contexts. This study contributes to the body of literature on knowledge sharing by providing evidence on the impact of dynamic capabilities on the social justification processes (SECI) of knowledge sharing.

This chapter discusses the study’s main findings and contributions under four broad subheadings. First, the key findings on the social validation cycle of the SECI model (socialisation🡪externalisation🡪 combination🡪internalisation) are discussed to highlight the relevance of dynamic capabilities in the social justification processes of knowledge sharing in VEs. Next, the findings on the interaction effect for tacit knowledge sharing (socialisation🡪externalisation) and explicit knowledge sharing (combination🡪internalisation) are discussed, highlighting the practical and research implications of the SECI tacit and explicit knowledge sharing processes for VEs. Implications of tacit🡪explicit knowledge conversions for knowledge management research and practice are also highlighted. Finally, since most of the companies sampled are involved in some form of production process, a generalised discussion on the practical relevance of dynamic capabilities in mediating the knowledge sourcing strategies that drive make or buy decisions in modular product manufacturing. This is to highlight the application of the study findings and framework in future research on specific knowledge sharing challenge in VEs. Finally, the chapter concludes with a summary of the research contributions using a 2x2 matrix developed by Corley and Gioia (2011) to aid researchers in their assessment of the originality and utility of management research.

### **6.1.1 The Role of Absorptive Capacity in Inter-organisational knowledge Creation and Sharing**

From the mediation results reported in the previous chapter, ACAP partially mediates the processes of tacit knowledge sharing (socialisation and externalisation) but fully mediates the processes of explicit knowledge sharing (combination and internalisation) for innovation. Findings also show that ACAP fully mediates the processes of tacit knowledge sharing for knowledge adaptation, and partially mediates the processes of explicit knowledge sharing. The impact of ACAP on the ability to replicate organisational routines was non-significant. Referring to the implications of indirect-only/full and complementary/partial mediation, Rucker et al. (2011) noted that:

“The distinction between full and partial mediation has been influential in theory testing and the development of social psychological knowledge. In a simple mediation model with one mediator, full mediation suggests that a researcher has completely explained the process by which X Influences Y and there is no need to test for further indirect effects. In the case of partial mediation, there is a clear implication that other indirect effects could (and probably should) be examined and tested empirically. Thus, conclusions of partial and full mediation can have implications for theory building as they suggest the plausibility of additional mechanisms. Practically, partial versus full mediation might be viewed as an indication of the importance of an intermediate variable in explaining the total effect.”

Similar to findings from existing studies on knowledge sharing in collaborative ventures, this research demonstrates that ACAP is a prerequisite for building effective tacit and explicit knowledge sharing routines for innovation and adaptation of knowledge in VEs. The findings of this study specifically show that ACAP provides partial mediation for the process of tacit knowledge sharing for innovation in VEs, implying that at this stage, firms need complementary capabilities like TMS and OINT to capture tacit knowledge that can be applied in innovative endeavours. Once externalised, the findings further show that ACAP fully mediates the process of explicit knowledge sharing for innovation. In terms of knowledge adaptation, it was argued in the review that the desire to adapt external knowledge is often driven by the need for conformity. As such, adaptations need to conform to external requirements (market, regulatory, financial, legal etc.) but requires the ability to infuse unique features that tailor such adaptations to the collaborative needs, structure and infrastructure. Our findings support this line of thinking, as ACAP was found to fully mediate the socialisation and externalisation processes required for adaptation of external knowledge in VEs.

Organisational knowledge is a social construct whose boundaries are fixed by social actors engaged in co-production. Consequently, collaboratively generated knowledge in teams, firms, and networks is distinguishable but not entirely independent of justified true belief. While justified true belief deals with individual cognition, social justification is a much broader concept, driven by the realisation that economically viable knowledge, regardless of form (tacit and explicit) or category (know-how, know-what, know-who and know-why), has ramifications beyond the limits of expertise or individual knowing. On the other hand, defining knowledge only as an outcome of social systems diminishes the important role of knowledge tacitness of which Polanyi argued, is the livewire of sense making.

Tacitness serves as an internal regulatory and protective mechanisms for intellectual property and as a differentiator of firms’ unique offerings constitutes the primary source of value in collaborative engagements. But knowledge validation through social justification is affected by boundary related factors like experience, mutual trust, and governance mechanisms. So while firms might be able to recognise the value of external knowledge sources on the merit of their own internal competence or expertise, previous studies have established that higher order meta-routines are required to bridge the gap between different social justification processes in knowledge exchanges. As deduced from the review of previous conceptual and empirical literature, ACAP is an enabling condition for effective and timely social validation of knowledge through a firm’s knowledge sharing routines. As proposed, the mediating impact of ACAP on the socialisation processes among collaborating firms in VEs that brings about innovation and adaptation were validated in this study.

Knowledge validation is a painstaking process of reflecting, monitoring, refining, and capturing external knowledge based on a collective perception that a given source of external knowledge can potentially improve, modify or completely alter existing organisational routines. In long-term collaborations, validation is a lot easier because the parties to knowledge sharing have long-established patterns and meanings, which support such decision-making. However, for episodic collaborations, firms enter into relationships with a strategy for gleaning potential patterns and meanings based on subtle cues from their partners and from previous experience. ACAP has been shown to provide firms with the added capability for identifying, assimilating, and transforming viable external knowledge into useful organisational value creating routines.

Likewise, over time, certain aspects of economically viable knowledge may become obsolete; thus, firms require the additional capability to reconfigure and refine knowledge routines to align with existing conditions and requirements. As explained, validation of knowledge in VEs; particularly for those VEs formed by firms without previous business dealings (who do not belong to an organised industry cluster or breeding environment) occurs through sudden, intricate, and often unplanned interactions among firms with different technologies, routines, processes and people. A seemingly straightforward collaborative initiative as upgrading to a new sets of tools, technologies, or processes based on tried and tested industry benchmarks (e.g. lean, six-sigma, just-in-time) requires firms to have well developed ACAP in addition to expertise, to facilitate the exploitation/exploration, assimilation, transformation and codification of relevant external knowledge that contribute towards making such initiatives viable for innovation. Although core‐competencies are not easily copied; they nonetheless become obsolete overtime if firms are unable to quickly devise ways of aligning their capabilities with ongoing advancements in their respective industries (Nonaka and Takeuchi, 1996). For cross-industry collaborations, it may not be entirely possible to be versed in the developments that pertain to partners’ competencies. Nonetheless, studies show that partners require the capability to keep pace with industry changes by using efficient routines socialisation and externalisation routines for tacit knowledge sharing. Otherwise, the very qualities of VEs that make them a viable organisational choice for cross-regional collaborations can serve as major deterrents to the socialisation and externalisation processes for tacit knowledge sharing and the ability of VEs to produce innovations or adapt their knowledge to market, industry or regional requirements.

The literature review highlighted the key argument on tacitness popularised by Popper in the early 1960s, that the domain of concepts (theories, analogies, explicit mental models) although related, is distinct from the domain of human cognition. This assertion is relevant for understanding knowledge sharing across businesses in part, due to advances in technologies that have now facilitated the embedding of explicit organisational knowledge in different locations, artefacts, processes and technological media. These different warehouses of knowledge, unlike information; have to be tacitly understood to be applied effectively. Furthermore, firms often house multiple specialised divisions where data, information, and knowledge are processed and understood through unique conventions (e.g. the different KPIs often applied in purchasing/procurement, accounting, and finance). This can constitute a challenge for explicating knowledge for innovation and adaptation through knowledge combination and internalisation routines. VEs often involve partners with different divisional and firm-level knowledge processing conventions, which when poorly managed, results in a great deal of redundancy and task duplicity due to trapped divisional knowledge, incompatible standards and differences in the knowledge combination and internalisation routines of partnering firms. The findings of this research confirmed the role mediating of ACAP on the ability of firms to synchronise their combination and internalisation routines for effectively explicating collaborative knowledge for innovation and adaptation.

ACAP was originally viewed as a quality derived from a firm’s R&D investment, which empowers it to generate new knowledge and innovations. The typical measures included qualities such as R&D expenditure, R&D intensity (R&D expenditure/total sales), level of R&D investment, the continuity and longevity of R&D activities and the existence of fixed and permanent R&D departments/labs. However, following years of reconceptualization, researchers now acknowledge that ACAP, while closely tied to R&D, is a set of meta-routines that are developed based on a firm's intent and ability to recognise opportunities in external knowledge sources across different industries. Indeed, the ability to recognise value is predominantly expertise/individual based, however, there needs to be an organised management strategy around knowledge acquisition (exploitation and exploration), assimilation, transformation, and implementation for relational ACAP to develop in a firm. Firms often require some in-house knowledge to aid the recognition and evaluation of new knowledge but in many cases of episodic collaborations, such in-house knowledge may not be available due to the diversity of expertise involved. This study shows that ACAP enables the development of effective tacit and explicit knowledge sharing routines for acquiring, assimilating, transforming and exploiting external knowledge in VEs, implying that it provides firms with the ability to quickly scan for value and patterns of knowledge socialisation, externalisation, combination and internalisation that facilitate innovation and adaptation in short term collaborations.

Since VEs are tenured collaborations, poor recognition of value (irrespective of expertise) leads managers to over- or underestimate investments in collaborations, and as explained in the review, the ability to effectively harness innovation and adaptation capabilities from collaborations requires relation-specific investments. Thus, ACAP routine development should deliberately incentivised by management, and there must be a concerted effort by management and leadership commitment from VE partners to create an enabling environment where employees from the different collaborating firms are able to promptly and collectively identify the value in external knowledge resources. This enables them to promptly devise and instil decision rules for selecting, vetting and assimilating such knowledge routines for innovation and adaptation of knowledge within VEs and beyond.

Cohen and Levinthal (1990) stressed that ACAP is path-dependent or uniquely tied to specific collaborations. Collaborations across geographical regions are saddled with external and internal political constraints or enablers that must be understood before embarking on joint projects with international partners. On the external front, the socio-political debates affecting production operations revolve around issues of sustainability, emission reduction, resource efficiency, sourcing options (out or in sourcing), the management and appropriation of big-data in business decision making, and issues pertaining to the provision of market, infrastructural and legal structures to support cross-regional collaborative ventures (Koh et al. 2011a; Koh et al. 2011b) The inability to scan for useful knowledge around such issues in order to develop strategies to engage with them, is perhaps one of the main reasons for failed collaborations and poor knowledge sharing in VEs. These external socio-political issues place constraints on management decision making, owing to the inefficiencies of human bounded rationality. Likewise, some of these socio-political drivers cited above have now evolved to become the standard for appraising innovation, adaptation, and replication in certain regions of the world, however, in other regions, some of these initiatives are still quite contentious. Findings from this study suggest that ACAP mediates the tacit and explicit knowledge routines by providing firms with the capability to quickly recognise the value in (on in some cases, manage) such political and legal drivers of innovation and adaptation of external knowledge in VEs. Collaborating partners are often subject to different political jurisdictions with varying requirements. Results from this study point to the role of ACAP in facilitating the alignment of operational strategies/relation-specific investments to the right initiatives with the most potential to produce innovations. Likewise, ACAP diminishes the tendency to adopt band-wagon strategies for such challenges.

There is growing interest in the literature on the institutional pressures that affect knowledge sharing. In the broadest sense, the three main approaches to institutionalism are the political and economic approach (Douglas North) the sociological approach (DiMaggio and Powell), and the increasingly pervasive literature on comparative capitalism (varieties of capitalism). Each perspective is slightly different but they all tend to centre on the effect of institutions on the knowledge sharing priorities of firms belonging to different nation states and under the influence of varying supra-national mandates (e.g. trade blocs). Overall, political, economic (firms), and sociological institutions are usually partially or fully coupled and can exert a sizable effect on inter-organisational knowledge sharing. Most institutions use cohesive forces to motivate or deter aspects of knowledge sharing. Much of the arguments against cohesive forces in the literature in institutions centres on the idea that regulatory pressures in favour of a particular knowledge orientation (e.g. sustainable technologies) increases resistance to change and does not promote the effective diffusion of knowledge capabilities beyond the objective of meeting regulations. However, studies show that coercion can be a source of value, because it creates economic and social incentives for pursuing particular innovations and adaptations in some cases. With well-developed ACAP, firms are better positioned to recognise the value/or lack thereof in cohesive institutional knowledge sharing pressures, and absorb the right know-why, know-who and know-what to either innovate, or make appropriate knowledge adaptations that are both economically viable and socio-politically aligned to the given collaboration context.

Consequently, in addition to relying on the expertise and training of employees, ACAP building routines need to be considered at the initiation and recruitment stage of the VE life-cycle. Citing the case of a chemical company, Massini (2010) noted that ACAP was directly linked to the firm’s ability to make a priori judgements about the performance and competitiveness of potential investments, and an investment in a new plant that was initially considered successful turned out to be a poor decision when there was a sudden and almost unanimous change in the business model adopted by its competitors (contract manufacturing) which rendered the firms seemingly proactive investment void.

As noted, ACAP, in addition to being path-dependent is also a cumulative capability. As such, firms require ongoing investments in ACAP building strategies to improve both tacit and explicit knowledge sharing routines for innovation and adaptations. ACAP meta routines are developed through investments in explicit strategies like hiring trained employees with requisite experience in a collaborative context or geography, investment in joint R&D activities, or as a by-product of strategic knowledge sharing alliances through industry clusters and virtual breeding environments. A coarse-grained description of a system phenomenon like collaborative knowledge sharing (particularly when it involves international partners), deals with large system subcomponents of knowledge sharing pertaining to the structures and infrastructure for internal/cross functional and external knowledge sharing. A fine-grained description on the other hand considers smaller and often overlapping components, which may have several complementarities e.g. design-manufacturing integration (DMI), manufacturing-sales integration (MSI), R&D integration and so on. Fine-grained conceptualizations can thus, be embedded in one or more coarse-grained ones. For instance, VEs could focus on DMI or MSI through supplier/customer integration, or as part of an independent strategy with dedicated investments in new capacity, infrastructure and capability recruitment. Coarse-grained and fine-grained conceptualisations of inter-organisational knowledge sharing represent two distinct levels of knowledge sharing; strategic knowledge sharing and operational knowledge sharing. Previous studies have shown that firms with well-developed ACAP are better able to link their bottom-up tacit and explicit operational level knowledge sharing for sub-level tasks like DMI and MSI, to overall collaborative top-down strategies for cross-firm knowledge sharing.

The ACAP routines used to align collaborative knowledge sharing strategies to operations level knowledge requirements can be developed by investing in explicit strategies like hiring trained employees with experience in the given collaborative context or geography, investing in joint R&D activities, or as a by-product of strategic knowledge sharing alliances, industry clusters and virtual breeding environments. In this study, the role of VEs in enhancing knowledge sharing is emphasised; and this is underpinned by the relational view of strategic management, which emphasises collaborative rents as both a motivator for joint ventures and a driver of economically viable and competitive innovation, adaptation and replication. Hess and Rothamel (2011) provide a good example of how a network collaborative strategy adopted in the pharmaceutical industry is enabled by the ACAP building strategy used in the industry for knowledge exploration and exploitation. They examined two predominant strategies used by firms in the industry to absorb external knowledge, namely, recruitment and retention of star scientists (exploration), and engagement in strategic alliances (exploitation). According to them (p.898):

“It is theoretically possible that a firm sources all of its knowledge internally through combining internal exploration by star scientists with internal exploitation by staff scientists. Alternatively, it is theoretically possible that a firm sources all of its knowledge externally through combining upstream alliances with downstream alliances. Although these are theoretically possible combinations, they tend to be not probable, because the vast majority of firms, across many different industries, have moved to an open innovation system, combining internal and external R&D (Chesbrough, 2003). Specifically, in our sample of global pharmaceutical companies, 75 of the 108 (69%) of the sample firms have followed a system of open innovation by simultaneously employing at least one star scientist and one staff scientist, combined with the pursuit of at least one upstream and one downstream alliance during a single year.” (p.898)

Their study demonstrates how knowledge socialisation through industry clusters in the pharmaceutical industry fostered the development of social capital, which in turn, diminished the marginal transaction costs and risks affecting alliances formed (e.g. investments in training, intellectual property agreements etc.). By examining how knowledge complementarities impact innovation, the study exemplifies the role played by ACAP in linking strategic level knowledge sharing strategies to operational knowledge sharing processes for innovation in the industry.

Strategic VEs must however, be well timed in order to be effective. As can be gleaned from the literature review, innovative firms are able to maintain their momentum by synchronise the timing of their collaborations with the industry’s pace of development. In industries with high knowledge appropriablity, studies have shown that the odds for knowledge replication are incredibly high, because the barriers to entry, cost of acquiring product or service knowledge routines/processes, and the ease of poaching expertise are marginal in comparison to industries where knowledge is highly sticky. Although ACAP has been linked to improving the ability of firms replicate knowledge in such industries as argued in the review, findings show that it does not significantly mediate the processes of knowledge sharing for replication of knowledge in VEs. Thus, the association between knowledge appropriability and replication ma perhaps, partly explain why the findings indicate that high investments in ACAP would not necessarily affect the replication of external knowledge in VEs. ACAP is a significantly expensive capability to develop especially in long-distance collaborations. Consequently, it is conceivable that firms engaged in VEs for knowledge replication may consider sunk costs in developing relational ACAP with partners as unnecessary due to the low barriers to entry and low cost of replication in industries with high knowledge approapriablity. This finding is not exactly counterintuitive because as cited in the literature, some prior studies have demonstrated similar findings regarding the marginal role of ACAP on internal knowledge replication in firms operating in industries with high knowledge appropriability regimes. However, the hypothesis on the mediating impact of ACAP on replication was proposed because studies also show that ACAP improves the ability to replicate in industries with low appropriability. Considering the sample demographics, majority of the firms sampled were from the food processing industry where appropriability is quite high, which could also be a factor that partly explains this finding.

Overall, the findings on the role of ACAP provide sufficient evidence that knowledge sharing processes for innovation and adaptation require well-developed ACAP. The somewhat counterintuitive finding on the mediating role of ACAP on replication could be partly explained by the appropriation regimes.

### **6.1.2 The Role of Transactive memory Systems in Inter-Organisational Tacit and Explicit Knowledge Sharing in Virtual Enterprises**

The major transaction costs in collaborations are incurred during the processes of encoding, storage, and retrieval of valuable knowledge. In the literature, these bloated transaction costs are mostly ascribed to the bounded rationality of actors or structural and infrastructural mismatches, which lead to knowledge distortions, leakages or outright loss of valuable knowledge (Wegner and Wegner, 1995). Knowledge encoding is often facilitated by group socialisation and externalisation, combination, and internalisation routines. These routines, such as group discussion, cross-functional teams, and strategic management meetings usually result in new ways of interpreting or understanding the collective value of collaborative engagements. However, since collaborating firms are usually pooled from different industries, there is always the risk of attaching wrong labels to knowledge in the encoding phase. Consequently, the knowledge retrieval and translation phases may be affected by contextual interpretation, depending on where in the VE such knowledge is required. Consequently, it is quite common for collaborating groups to ‘forget’ relevant knowledge or find potentially useful knowledge without a synchronised storage mechanism to facilitate future retrievals. The finding on the mediating role of TMS on innovation and replication through tacit and explicit knowledge sharing in VEs is similar to those from previous studies on team innovation, where it has been found to increase members’ task specialization and ability to systematically find relevant knowledge when required. In team collaborations with well-functioning TMS, members’ awareness of one another’s’ expertise enables participating firms’ to align their socialisation and externalisation routines, which in turn, facilitates innovation. In addition, well established TMS facilitates the coordination and synchronisation of collaborative activities, and grants members some degree of access to combined repositories of knowledge of transaction histories, which diminishes the transaction costs associated with encoding, storage, and retrieval of valuable knowledge.

Some studies have shown that having common or shared standards for sense making or “mutual knowledge” enables collaborating firms to share and communicate knowledge more readily based on the assurance that each party knows that other parties possess similar encoding and retrieval routines (Davis et al., 2006). Others have further demonstrated that a lack of mutual knowledge in collaborative ventures can lead to poor decision quality, task-redundancy, and time wasted on managing mismatches (Cramton, 2001). However, Oakhill et al. (1996) noted that:

“it is a lack of mutual knowledge, and hence an asymmetry between speaker/writer and listener/reader, that typically prompts a linguistic interchange. Thus, both the speaker/writer’s and the hearer/reader’s knowledge (and their knowledge of each other’s knowledge) determine how individuals ought to be described, and how descriptions will be understood”

The social network theory by Granovetter (1985) could be applied here to partially explain these discrepancies on the role of mutual knowledge in cross-boundary tacit and explicit knowledge sharing. He proposed that business networks can be considered as *relationally embedded-*if the parties involved have close alliances and a history of interactions and transactions; or structurally embedded – when parties are only connected through a few secondary links. When there are overlapping structural connections between firms the network is said to have strong ties. Whereas weak ties suggest that there are only few connections or paths linking a given network to others. Since weak ties are not reinforced through indirect paths, they constitute ‘*structural holes’* – understood in this context to be the link between networks with complementary sources of knowledge. Typical structural holes in manufacturing VEs include boundary spanning suppliers and contract manufacturers.

In high-tech, cross-industry collaborative ventures, boundary spanners are invaluable in their role as translators of the different knowledge coding schemes from the different fields of expertise working together on a project. Without them, firms often struggle to assimilate explicit knowledge or share the tacit knowledge required for innovation or replication. Foxconn, is the world’s largest contract manufacturer, with facilities in Asia, Europe, Mexico and Brazil assembling over 40 percent of electronics produced by the most innovative companies in the industry. In such highly innovative industries, such boundary spanning suppliers may not be able to simultaneously keep pace with the technological advances in different industries, however, their experience makes them key repositories of knowledge, which is too often locked away and in some cases, lost.

In VEs, the level of network embeddedness may be relational if VEs are formed from clusters, or completely structural in cases where partners are pooled from the market. Findings from this study suggest that irrespective of VE type, TMS positively mediates tacit and explicit knowledge sharing for innovation and replication by supporting the processes of knowledge sharing with systematic ways of retrieving, storing, and encoding explicit knowledge. For such VEs, boundary spanning supplier become critical knowledge repositories with which to update and improve their TMS for future collaborations. Specifically, this study’s findings revealed that TMS only partially mediated the processes of tacit knowledge sharing for innovation in VEs (Socialisation and externalisation) implying that for tacit knowledge sharing in innovative processes, TMS functions in conjunction with other dynamic capabilities like ACAP for absorbing external knowledge and OINT for interfacing effectively with collaborating partners. Once tacit knowledge is codified, the findings show that TMS fully mediated the process of externalising knowledge to produce innovation and knowledge replication in VEs.

TMS also aids in knowledge retrieval in collaborative ventures, which is the process of gathering valuable knowledge from the right department, firms’ knowledge repositories like IT enabled platforms and domain expert(s), or external repositories in a timely fashion. As the findings of this study indicate, firms with well-developed TMS metaroutines activate the tacit and explicit knowledge sharing processes for innovation through the enabled access to diverse repositories. Similar to team work, knowing who knows what in VEs improves performance, however with a systematic TMS for readily retrieving such knowledge, firms are better able to locate the knowledge required for replication, and assign responsibilities to parties in a manner that best maximises the potential for innovation based on knowledge of relational and transactional histories. Organisational studies researchers view the attributes of team-level TMS as similar to the attributes at organisational and inter-organisational levels. However, only a few studies have examined the TMS at organisational level and there is a dearth of studies looking at inter-organisational structures; particularly in IT-enabled and episodic collaborative structures like VEs.

Interfirm collaborations in the high-tech industry often always requires joint knowledge work by NPD teams from different firms. Since VEs are episodic, it is conceivable that at inception, NPD teams drawn from different industries, expertise, and functional backgrounds would require well-developed TMS to be able to synchronise their knowledge domains. An old assumption was that mechanistic memory in the form of databases, files, and records were sufficient to provide relevant transactive memory for performing effectively in such collaborative projects. However, in industries such as construction, VE requirements change quite rapidly with trends, customer demands, and changing capabilities. As such, even in cases where long-term relationships are maintained through industry clusters, construction projects are very rarely ever carried out by a similar consortia of firms as previous projects. In other highly uncertain industries such as Oil and Gas, and Banking, firms usually participate in multiple concurrent VEs for risk, finance, and capability pooling. For such industries, mechanistic memory; particularly relating to know-what, know-who and know-why is obsoleted quite rapidly. In addition, it is difficult to capture mechanistic memory in a manner that it covers the different knowledge repositories with a stipulated mechanism for adding and retrieving tacit knowledge. Without the informal human connections established through the SECI processes for socially validating knowledge, the codified aspects of information warehoused in databases is lost. Cross et al.(2003) observed that in high –tech projects, engineers, scientists, and technicians were found to be five times more likely to search and retrieve know-what, know-why, know-who or know-how from people from their relational or collective TMS than via databases, noting that “a significant component of a person’s information environment consists of the relationships he or she can tap for various informational needs” (p. 27) However, mere information is devoid of the tacit aspects of knowing attached to practice, and this can only be teased out through socialisation and externalisation, combination, and internalisation routines. For instance, the tacitness associated to the practical knowledge and experience in policy requirements, mechanical processes or chemical experiments cannot be captured in databases.

According to Lewis (2003, p. 602), “It is clear that specialization without regard to how one member’s knowledge combines with or complements others’ knowledge will only create ‘islands of expertise’” However, in cases where prior interaction has established implicit and dedicated knowledge coding, retrieval and coordination routines such as is expected in virtual breeding environments it is comparatively easier to establish credibility (Lewis, 2003; Peltokorpi et al., 2014). Consequently, for VEs where members are less acquainted, aligning TMS (particularly the technological infrastructure and the coding and retrieval structures) is expected to be comparatively more tasking. Nonetheless, contrary studies have also shown that in some instances, firms with well-developed TMS from different backgrounds may struggle with knowledge sharing for innovation because conflicting TMS along with other factors such as poor leadership and differences in organisational collaborative culture could diminish the decision-making capability to arrive at prompt choices. Surprisingly, the findings on the impact of TMS on adaptation was non-significant contrary to expectation based on the literature on dynamic capabilities. Although there are no previous studies that have attempted to test this relationship, Regarding the impact of TMS on innovation in scientific teams, Peltokorpi et al. (2014) found an inverse U-shaped relationship, arguing that:

“While scholars have advocated the positive effects of TMS in knowledge-intensive teams, the present findings suggest that research teams with moderate levels of TMS are the most effective in terms of patents received. To enhance team innovation, team leaders need to ensure that processes and climate that enhance TMS formation and functioning prevail in their teams. Team leaders can also make interventions to develop and maintain supportive climate for TMS processes. At the same time, the findings suggest that teams with well-refined differentiated TMS may have negative effects on their innovative performance. Thus, managers are advised to keep in mind the drawbacks accompanied with highly differentiated TMS.”

Although one cannot eliminate the possibility that perhaps other confounding factors associated to the collaborative context may account for the non-significant finding in relation to adaptation, speculating beyond the data based on prior research on stickiness in knowledge adaptation and replication, the ability to adapt knowledge, unlike innovations and replication with strong economic incentives, is often driven by external pressures to confirm or adapt to industry standards. It is therefore possible that factors similar to those cited could explain this finding however, as with the counterintuitive finding on the impact of ACAP on replication, in-depth ethnographic studies may be useful in providing a clearer picture of the dynamics at play between tacit and explicit knowledge sharing, TMS and adaptation.

### **6.1.3 The Role of Organisational Interoperability in Inter-Organisational Tacit and Explicit Knowledge Sharing in Virtual Enterprises**

Virtualisation has made it possible for operational and administrative practices to be coordinated seamlessly across barriers of space, time, and context/structure, with the aid of ICT. Indeed, most supply chains use IT-enabled communication and information sharing infrastructure to improve end-to-end visibility and facilitate seamless information and data exchange. However, studies have shown that in most firms, especially public sector agencies and big multi-nationals, back-office systems are hard to interface or change altogether because they link-up processes that are difficult to overhaul or expensive to change. The findings from this study showed that OINT mediates firms’ ability to utilise infrastructural, structural, cultural, and cognitive readiness or preparedness to facilitate tacit and explicit knowledge sharing for innovation in VEs. Scholl and Klischewski (2007) noted that interoperability and interoperation are slightly different because while the former refers to the capability for interoperation, the latter is the practical application of developed OINT routines.

In principle, multilateral data exchange using platforms like ERP and ERP2 for Electronic Data Interphase helps to standardize the exchange of information across partnering firms and facilitates interoperation, however, intermediaries like local suppliers that hold critical knowledge are left out. Consequently, full standardisation at the point of collaboration can be technically difficult to achieve without the soft relational qualities that enable interoperation. Even for firms with well-developed TMS, integrating and interpreting knowledge from different sources in a timely manner is difficult to say the least, and in certain industries even impossible without the right level of standardisation. Thus, for majority of collaborations (whether short-term or long-term), standardisation is a very expensive strategy to adopt without the guarantee of continued business relations. in long-term collaborations, standardisation of routines can lead to costly reconfigurations. Previous studies have shown that well-developed OINT or routines instil the culture, ethos, leadership style and infrastructural training for collaboration-readiness in organisations, and provide the benefit of timely standardisation along with the flexibility for reconfiguration when needed (Kubicek and Cimander, 2009)

Often, the slow pace of adjusting to new ‘work‐styles’ has been implicated as one of the main causes of failed collaborations or delays in assimilating and co-opting new knowledge. Studies on VEs in the construction industry provide ample support for this assertion (see Lavikka et al., 2015; Nikas et al., 2007; Soibelman et al., 2010). Furthermore, as explained in the review, ACAP exists in two fluid states (potential and realised). For collaborations across wide geographies, OINT aids in the activation of firms’ ACAP to exploit external knowledge resource by facilitating swift organisational restructuring, particularly in terms of command and control. Where command and control or leadership styles encourage interoperability, ACAP and TMS are also facilitated (Rauffet et al., 2009)

Organisational capabilities, as this study vividly demonstrates, are a cumulative function of organisational experience, coordination, interaction, and learning process. They are often path-dependent skills and abilities developed over time within a firm through practice, and are usually tailored to the unique requirements of specific firms. Since they are path dependent, they can only be enhanced by indirect paths linking to other progressive ways of learning, managing resources, designing routines and making decisions (Kingston et al., 2005). Indirect paths such as OINT allows firms participating in collaborative ventures to efficiently combine and recombine knowledge resources from different sources towards achieving specific objectives. As such, firms that have developed clear interoperability roadmaps or network design patterns that can be used to aggregate best practices from within the collaboration in pursuit of innovations. OINT provides the leadership, cultural, infrastructural, and structural readiness to maximise the potential accruable from VEs. According to Rauffet et al. (2009):

“Good practices are collected on operational ground, and good solutions are proposed by functional experts of organizations. - From this collection, roadmaps are modelled, providing “interoperability design patterns” for organizations. - Finally, the management method and the tool supporting it give some rules to diffuse, implement, measure and improve these interoperability patterns, as a kind of “design principles”.

Good/best practices are tried and tested strategic, operational, technical or managerial approaches that have been tried, tested, and implemented in industries while good solutions on the other hand, are developed through R&D or expert technical or managerial experience, which have yet to be implemented. Thus, OINT roadmap for specific VEs have to be developed and implemented by strategic managers, who use the resources available from TMS and the ACAP of their employees to identify the interoperability issues that may arise in a VE collaboration be solved. - These roadmaps can then be operationalised by cross-functional teams of managers who have the TMS and ACAP to organise the ordinary capabilities or best practices of partners using OINT roadmaps (Kingston et al., 2005). This study argues that the following process is a prerequisite for inter-organisational knowledge sharing in VEs as findings show that OINT partially mediated tacit and explicit knowledge sharing for innovation. As the findings show, the tacit knowledge sharing processes (socialisation and externalisation) are partially mediated, implying that they require other mediators to be present (TMS and ACAP) in order to be facilitated by OINT. Once tacit knowledge is captured as roadmaps, the findings show that OINT fully mediates the explicit knowledge sharing processes of knowledge combination and knowledge internalisation.

Contrary to expectation, OINT had an insignificant impact on adaptation and replication in VEs. Although the literature on interoperability focuses disproportionately on technical interoperability, this study departs from previous studies by conceptualising OINT. Other forms of interoperability discussed in the literature review are more or less ordinary capabilities because they are linked to organisational resources, expertise, and technical capabilities. OINT on the other hand is dynamic because it represents the managerial the intent, ethos, culture that link the finer aspects of technical, semantic, semiotic, data, and syntactic interoperability and transform them into practical interoperation. These findings on the mediating role of OINT on the processes of tacit and explicit knowledge sharing for innovation are thus, a novel addition to the literature on knowledge sharing for innovation in collaborative ventures. Since a structural model was used in the analysis, the other mediators remained present in the model as covariates, suggesting that in cases of partial mediation, other mediators (ACAP, and TMS) exert some influence on the path observed. Consequently, for the partial mediating roles of ACAP and TMS on tacit and explicit knowledge sharing for innovation (ACAP and TMS) and adaptation (in the case of ACAP).

While it is logical to infer that technical interoperability of systems and infrastructure may be achievable in VEs formed from breeding environments or clusters, the same may not true for those episodic collaborations where partners are pooled from the market because the political, legal, and structural contingencies are conceivably higher in such collaborations. Considering the cost of implementing any form of interoperability in such VEs, it is logical to speculate that perhaps, even in cases where OINT is high, if the management interoperability roadmaps designed based on an assessment of best practices and potential strategic, operational, technical or managerial solutions from collaborations emphasise a need for adaptation and replication of knowledge, heavy OINT investments may be insignificant in the actual knowledge sharing processes, since the transaction cost of knowledge adaptation and replications are comparatively lower.

Uncertainty in most industries and the increasingly dynamic nature of collaborations have made the approach of post-hoc assessment of ordinary interoperability capabilities such as data, systems and semantic interoperability somewhat redundant. This is partly because the various dimensions that need to be interoperable for seamless collaborations and knowledge sharing for innovation are often prone to rapid and disproportionate changes with time (e.g. changes in technical capabilities in highly innovative industries). Since it may not be feasible to assess all possible future strategic, and operational interactions in order to pre-empt the direction of interoperability investments, OINT enables firms to position themselves in readiness for changes where required. The cultural, ethos, leadership and structural aspects of OINT provide the much needed readiness, which gives such firms and their partners a strategic advantage over competitors in fast moving industries where second movers on innovative ideas require only a short lead time to adapt or replicate innovations.

**6.1.4 Interaction Effect between the Processes for Tacit and Explicit Knowledge Sharing**

Although few studies like Anand et al. (2010) have examined the SECI model for knowledge sharing to validate the links among the different stages, Anand and colleagues and other studies that have attempted to validate the Tacit🡪Explicit conversion spirals captured in the SECI model have confined their studies to cross-functional and team-level knowledge sharing. In their study examining how knowledge sharing practices affect process improvement projects in the context of Six Sigma black belt projects from a cross-section of industries, they provided evidence that tacit (externalisation🡪internalisation) and explicit (combination🡪internalisation) processes interact to produce process improvements in the sampled firms. They however noted in the conclusion of their work that:

“Our main finding is that practices used in team projects to extract team-member knowledge can be quite valuable for process improvement project success. This contributes to theoretical understanding in Operations Management and Organizational Behavior disciplines. Exploration of additional nuances of relationships between knowledge-creation approaches and process improvements requires further research”.

Like previous studies, findings from this study also confirmed a significant interaction effect between the processes for tacit and explicit knowledge sharing respectively on the ability to innovate in VEs. However, as a departure from previous studies, this study confirms the interaction effect in an inter-organisational knowledge sharing context, which leads further evidence for the applicability of the model to collaborative knowledge sharing. Regarding the nuances alluded to by Anand and colleagues, the second objective of this study was to explore ways of operationalising a dynamic model for knowledge sharing in VEs. A major criticism of the SECI model is that although it purports to capture the dynamic interactions among the stages, the original operationalisation of the SECI model renders it more or less static in its representation of the tacit and explicit knowledge sharing processes. According to Nonaka and colleagues, certain enabling conditions must be present to provide the dynamism required to restart the cycle of socialisation🡪externalisation🡪combination🡪internalisation, following each iteration of knowledge sharing from individual 🡪 team 🡪 organisation🡪 inter-organisational🡪 and back to the individual dimension. While the literature on dynamic capabilities and knowledge sharing have both evolved almost in isolation, it was deduced from the literature review that for a dynamic model for knowledge sharing in collaborative ventures, the research on dynamic capabilities must be considered in tandem with research on knowledge sharing.

Accordingly, the core theses of this study is that the explored dynamic capabilities acting complementarily are necessary for converting the independent cycles of sharing at individual, team, and organisational levels into a dynamic spiral for knowledge sharing that is continuous and self-regenerating. As such this study offers the following modifications to the conceptualisation of the SECI process by including the three dynamic capabilities explored with the following justifications from theory and validated with the empirical evidence presented:

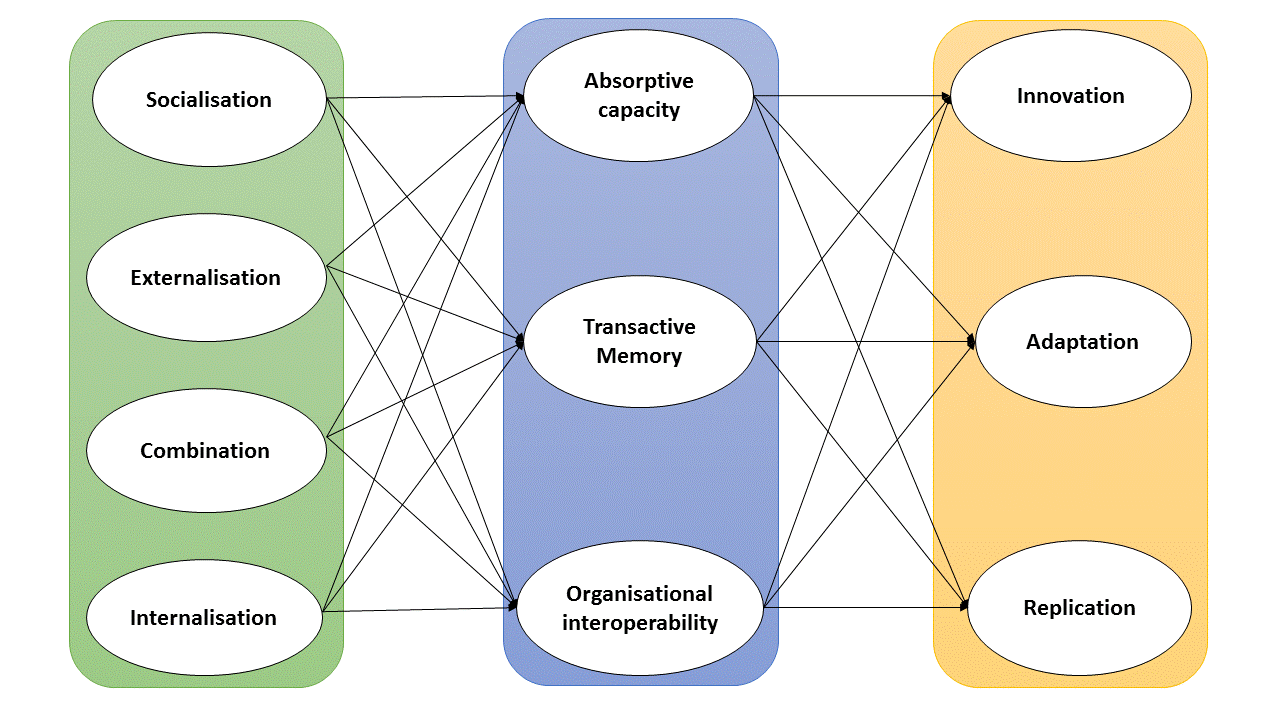
1. For efficient inter-organisational knowledge sharing, collaborating firms must continually assess, invest in, and update requisite meta-routines or dynamic capabilities, in addition to improving their ordinary or substantive skills.
2. Based on a review and assessments of the primary dynamic capabilities that have been linked to knowledge sharing in collaborations, it is proposed that the following capabilities are required for effective knowledge sharing in VEs:
3. The meta-routines for absorbing new knowledge (ACAP).
4. The meta-routines that aid the capture, storage, sorting, comparison, interpretation, and updating of knowledge gathered from prior and on-going collaborations (TMSs), and
5. The meta-routines for acquiring or developing suitable technology, organisational structure, culture and ethos for future interoperation with alliance partners (OINT).
6. These capabilities affect the sharing of both tacit and explicit knowledge relating to know-how, know-why, know-who, and know-what.

Figure 6.1 below shows the modified/optimised dynamic framework for knowledge sharing in inter-organisational collaborations, drawing on insights from the SECI model, but optimised by including the above dynamic capabilities as antecedent metaroutines mediating the SECI processes of coding and sharing tacit and explicit organisational knowledge in VEs. The framework contributes to theory building by bridging the research on knowledge sharing in strategic management (dynamic capabilities), knowledge management (SECI model) and organisational studies/ supply chain management (Collaborative ventures) literature. Consequently, it holds prospects for future studies examining knowledge sharing for innovation, adaptation, and replication in other collaborative contexts.

**SECI Knowledge Sharing Proceeses**

**Gestalt of Dynamic Capabilities**

**Knowledge Sharing Outcomes**



**Figure 6.1*:*** *Optimised Dynamic Model of Knowledge Sharing highlighting the Mediating Role of Dynamic capabilities.*

# CHAPTER SEVEN: RESEARCH IMPACT AND CONCLUSION

**7.1 Conclusion**

This study set out to examine the dynamic nature of knowledge sharing for innovation, adaptation and replication in VEs. As an emergent and increasingly pervasive organisational configuration, the study of VEs provided a theoretically and practically compelling case for exploring how dynamic capabilities affect both tacit and explicit knowledge sharing for innovation, adaptation and replication in collaborative ventures. The study incorporated three dynamic capabilities, namely, ACAP, TMS and OINT; as mediators of the social justification spiral, and tacit🡪explicit knowledge conversion spiral in the SECI process-model of organisational learning developed by Nonaka and Takuchi. Following a review of extant studies, two broad research objectives were developed.

RO1: To propose and test hypotheses on the mediating role of dynamic capabilities (absorptive capacity, transactive memory systems and organisational interoperability) on the ability to achieve broad knowledge outcomes (innovation, adaptation, and replication) through tacit and explicit knowledge sharing (SECI processes) in VEs.

RO2: To develop and validate a dynamic conceptual framework based on the above hypotheses to enrich the current theoretical and practical understanding of knowledge sharing in VEs.

To meet the first objective, nine hypotheses were proposed to examine the mediation relationships of dynamic capabilities (ACAP, TMS and OINT) on the relationship among each knowledge sharing stage of the SECI model and three meso-level knowledge outcomes -innovation, adaptation and replication in VEs. To validate the integrity of the two distinct spirals inherent in the SECI model, further hypotheses were proposed to test the theorised interactions among the stages for tacit knowledge sharing [(SOC)x(EXT)] and explicit knowledge sharing [(COM)x(INT)]. The study sampled 202 firms from a cross-section of industries including Aeronautics and Aerospace, Automobile, Construction, Electronics, Metal-mechanics, Oil and Gas, Food processing, Telecommunications, Banking, Consulting, and Logistics and transport industries. The measures for the SECI processes, dynamic capabilities, and knowledge outcomes were adapted from previous studies on collaborative ventures and virtual work among teams. A web-based survey research design was used to maximize the potential of sampling a cross-section of industries where VEs are predominant. For the statistical tests and analyses on the dynamic capability-mediated SECI framework, the SME approach was adopted to build a correlation-based causal dynamic capability mediated SECI model of knowledge sharing. The hypothesized dynamic capability-mediated model was statistically estimated using the Analysis of Moment Structures (AMOS) program, drawing on a number of statistical techniques to such as causal modeling with latent variables, ANOVA, and multiple linear regressions. SEM was selected for the analyses in this research because of the capacity it provides to model and test ‘statistical causality’ among subjective variables.

* 1. **Theoretical and Practical Contributions**

The findings from this study make the following distinct contributions to the theory of knowledge sharing:

1. It advances a clear conceptualization of a dynamic model of knowledge sharing for collaborative ventures, based on validated and well explored constructs. Such a model is relevant to future studies examining collaborative ventures, and is particularly important for understanding collaborations across virtual organisational boundaries.
2. The study provides empirical evidence on the antecedent impact of dynamic capabilities on the processes for tacit and explicit knowledge sharing in VEs for innovation, adaptation, and replication. This provides further validation on the integrity of the conceptualized social justification processes of the model, augmented through the mediation of dynamic capabilities to account for the dynamic nature of knowledge sharing.
3. Since adaptation and replication are critical knowledge outcomes that have rarely been studied in relation to collaborations, the study provides evidence on how these outcomes are impacted by firms’ dynamic capabilities, through knowledge sharing processes.
4. In establishing a link between socialisation and externalisation for tacit knowledge sharing, and combination and Internalisation for explicit knowledge sharing, the study lends further evidence to the mechanism of the knowledge conversion spirals, while accounting for the dynamic requirements for knowledge sharing through the dynamic capabilities included in the conceptual model.
5. In terms of the theories applied, the study further confirms the theorized impact of knowledge as a critical resource for innovation adaptation and replication as articulated in the knowledge based view, but provides additional insights on the relevance of relational rents as the sources of collaborative advantage for VEs as proposed by the relational view of strategic management. Findings would thus suggest that a strictly resource based approach to appraising firm capabilities may be insufficient in collaborative ventures without due consideration to the potential value of relational rents.
6. The research on knowledge sharing is currently quite fragmented, different streams progressing concurrently in the fields of knowledge and information management, strategic management, organisational studies, and operations and supply chain management. This study contributes towards bridging the fragmented research in the field by condensing different insights and developing a framework based on research on knowledge sharing from the extant literature in (1) operations and supply chain management (studies on innovation in collaborative networks), (2) strategic management (studies on dynamic capabilities and studies highlighting the strategic role of adaptation and replication of knowledge in collaborations), organisational studies (studies on knowledge sharing in teams) and (4) studies on learning and knowledge sharing from the fields of knowledge management and cognitive studies (education, psychology and philosophy on knowledge and learning).

By way of practical contributions this thesis makes the following:

1. Since dynamic capabilities are conceptualized as being path-dependent, by identifying a gestalt of dynamic capabilities or organisational metaroutines that are mutually reinforcing and fit together in a dynamic model for knowledge sharing, companies engaged in VEs can make targeted investments in developing the requisite capabilities for collaborations in different industries depending on the desired knowledge outcome.
2. Likewise, since dynamic capabilities are also conceptualized as cumulative and experience based, in addition to appraising partners based on expertise, and resource- or location-specific economies or competencies, companies engaging in VEs can build profiles on potential partners to assess and select partners with highly developed dynamic capabilities that either complement or augment those of other partners in VEs for innovation, adaptation and replication.

Corley and Gioia (2011) proposed that management researcher adopt 2x2 matrix of the dimensions of *originality* and *utility* to map the contributions of a study to science or practice (see Corley and Gioia, 2011). They argued that contributions are original if they help to advance the current understanding incrementally, or provide some form of revelation (radical or subtle). In terms of utility, contributions could either be practically useful or scientifically useful. The Figure 7.1 below is an adaptation of Corley and Gioia’s matrix used here to summarise the contributions of this study.

Scientific

Incremental

Originality

Revelatory

Practical

Utility

***Figure 7.1:*** *Research contributions classified based on originality and utility.*

* 1. **Research Limitations and Future Studies**

Although this study makes very clear and important contributions to theory building owing to its theoretical generalisability, its main limitation like most quantitative empirical studies, is the potential to directly apply its findings in a practical intervention. As noted in the review, the approach prescribed by Engeström in the Theory of Expansive Learning would have had the advantage of providing specifics on the mechanisms through which each of the dynamic capabilities impact the processes for tacit and explicit knowledge sharing in specific VEs or in targeted industires. Although the processes operationalised by Engeström are more or less similar to those proposed in Nonaka and colleague’s SECI model, Engeström’s theory of expansive learning makes an important advancement by providing a methodology to account for the impact of culture (national and organisational) and industry on knowledge sharing, which could prove valuable in the development of effective dynamic capability metaroutines in targeted VEs. As explained in the review, Engeström’s approach includes an intervention technique called the “change laboratory” where work teams are given a series of guidelines for developing case-specific metaroutines to improve their expected knowledge outcomes from collaborations. However, applying such an approach would probably require more than one trained ethnographic researcher to observe, record, compare, and analyse the changes occuring in work teams following such interventions. Consequently, the major deterrent to this approach in relation to this study was the lack of time and resources required for experiments and ethnographic research. Furthermore, although the approach applies a generalizable sequence in the operationalisation of the stages of knowledge sharing, its non-heuristic nature would have made it impossible to arrive at a generalizable theory/framework on the role of dynamic capabilities in tacit and explicit knowledge sharing, in line with the objectives of this study. As such, the theoretical generalisability and the cross-industry scope applied in developing the dynamic-capability enhanced SECI model of knowledge sharing in this study serves as a fomidable backdrop upon which to erect a more context specific study to overcome this limitation.

Although the measures of the dynamic capabilities explored accounted for important contingencies like trust, culture, and ethos, the contingent role played by power in knowledge sharing was not directly explored. When a true power asymmetry exists in a collaborative relationship, the ACAP of the weaker party to exploit knowledge may be hampered, unless such a weaker party has developed requisite complementary capabilities. As noted in the review, although power is a relatively nuanced concept, the predominant view is that the bargaining power of parties in a collaborative venture stems from soft qualities like perceived legitimacy, market position, and reputation. The ability to assess these features in practice depends largely on a firm’s TMS. This is perharps, an interesting area of investigation for future studies on the dynamics of knowledge sharing in collaborative ventures.

Furthermore, while innovation, adaptation and replication are critical knowledge sharing outcomes, they do not necessarily represent the final *performance goals/targets* that companies seek when they decide to engage in VEs or other forms of collaborative ventures. For most companies, collaborative ventures are used to attain preset organisational targets, such as financial targets, patents/new product development targets, competence building targets and resource pooling targets. These performance targets are usually context specific and evaluated in line with the strategic dictates of stakeholders (customers, shareholders), the market, available resources/competencies and specific industry dynamics. Hence, management interventions - such as the dynamic-capability enhanced knowledge sharing model proposed in this study – can be used to reset or completely change a firm’s performance targets. In other words, the knowledge outcomes pursued by firms engaged in VEs (innovation, adaptation and replication) only serve as a means to an end (e.g improved finances or accelerated new product/patent development) and can hardly be viewed as an end in themselves. Although this study captures some direct measures of performance in its operationalisation of innovation, adaptation, and replication, there is nonetheless, room for future studies to extend the present model to examine the impact of these knowledge outcomes on specific performance attibutes of firms.

Finally, in the three years that it took to conduct this study, the researcher encountered and overcame a number of challenges, however, most of the challenges were those typically associated with data collection, the research methodology and the writing-up phase of the thesis. The next paragraph is a reflection on some of the learning points from the researcher’s experience, with emphasis on areas of personal development.

Time management is often identified as a major challenge facing doctoral researchers and during the course of this study, time and resource management were definitely points of major consideration. Although the literature review for the study commenced quite early (soon after the confirmation review process was concluded), the strategy adopted was to prepare detailed notes on the different concepts reviewed, with a view to updating them as new materials became available. While there is no universal strategy for developing the literature for a PhD thesis, most of the time management courses I attended suggested that this approach was progressive because it enables researchers to update their study without altering the course or progress of other phases of the research. Nonetheless, in retrospect, it might have been useful to commence the actual literature review and to update the drafts produced as the study progressed because it became rather challenging and time consuming to manage all the tentative notes generated as a result of this approach. To overcome this challenge, I decided to assign specific deadlines to the different sections of the literature review, and to write each section as chapters of a book or independent articles for journal publications. This enabled me to produce comprehensive reviews of each of the broad variables examined in this study, with the added advantage of being in a format that could easily be edited for future publications. Furthermore, the data collection phase also presented enormous challenges because I had to wait for a number of months to receive feedback from the respondents. In conjunction with my supervisors, we explored different ways to hasten the process and increase the response rate, including sending follow-up emails, attending academic and professional conferences where potential respondents might be in attendance and employing the services of a data mining company as reported in the methodology section to ensure that the right calibre of respondents were sampled for the study. This approach proved helpful, as I was able to increase the sample size for the study. Finally, while there were potential opportunities to establish a research relationship with some of the study respondents that indicated interest in future studies, the time required to analyse, interpret and produce the thesis made it virtually impossible to keep track of all the potential prospects. To manage this challenge, I decided to send follow-up emails to those respondents who initially indicated interest in follow up studies (via a specific question in the questionnaire) when the thesis was near completion, while maintaining close consultations with my supervisors. This produced an opportunity to extend the research and the details of the prospective study that emerged from this opportunity are presented in a subsequent subsection.

**7.4. Application of Research Findings to a Specific Industry Related Problem**

Following the data collection phase of this study, the researcher was contacted by one questionnaire respondent- a modular component contract manufacturer that specialises in fabricating assemblies for the wiring of modular electrical components. The company indicated interest in a potential future study on the application of the dynamic-capability enhanced knowledge sharing framework developed in this research to improve its tacit knowledge sharing capabilities with its partners and collaborators. In this regard, the company is specifically looking to develop targeted dynamic capability routines that can enhance its knowledge sourcing strategies for innovation. The current business strategy of the company is to collaborate with selected partners in the fabrication of hardware that can enable the seamless fitting of electronics into construction and refurbishment layouts (e.g. custom-configured accessory shelves, custom-configured multi-outlet power strips). Through its virtual enterprise organisational model, the company in collaboration with its existing and potential suppliers (mostly electrical/electronics manufacturers in China) designs and/or manufactures modular hardware for wired assemblies for its customers. In addition to being a hardware fabricator, the company provides flexible and vertically integrated manufacturing solutions for its clients by drawing on the combined expertise of its engineering R&D teams and those of its partners in the fabrication of these modular component fittings, which are either built from scratch or reengineered to fit its customer’s existing infrastructure. The next subsection of this thesis presents a literature review on modular product manufacturing, to highlight the role of dynamic capabilities in tacit knowledge sharing for firms engaged in such endeavours. Emphasis is placed on the relevance of the findings of the present study to a real-life managerial problem to highlight the potential practical impact of this study. Subsequently, a subsection is dedicated to reflecting on a plausible research methodology and strategy that can be applied to provide workable solutions for the company. A concise discussion is later presented on the merits and challenges of applying a participatory action research strategy in a longitudinal study to test the application of the intervention developed in this research (dynamic capability enhanced knowledge sharing routines) in addressing the managerial issues associated with delivering innovative solutions for the company through effective tacit knowledge sharing.

## **7.4.1 Examining the Impact of Dynamic Capabilities on Knowledge Sharing in Modular Product Manufacturing**

Due to unpredictable demand patterns and expanding global markets, manufacturers continually strive to broaden their product variety to retain market shares and improve their competitiveness (Fisher, 1997; Schuh et al., 2015). It is estimated that new product development (NPD) constitutes about 70% of product lifecycle costs, and up to 55% of manufacturers’ total revenue (Antonio et al., 2007). Consequently some manufacturers adopt product modularity as a design strategy to manage the trade-off between increasing their product variety and the cost of new product design (Pil and Cohen, 2006). By definition, product modularity is a design strategy in which loosely coupled and interchangeable components are used to create a variety of end product configurations (Pashaei and Olhager, 2015; Schilling and Steensma, 2001). Since only a few unique components are required to achieve an assortment of products, modular product architecture makes manufacturers more adaptable to changes in market requirements, and better able to customize end products to suit their consumers (Salvador and Villena, 2013). As an optimization strategy, modularity facilitates lean and agile resource management by reducing the inventory costs associated with maintaining a wide product assortment (Caridi et al., 2012). According to (Salvador et al., 2002), modularity is an efficient design strategy because it encourages a high degree of functional independence throughout a product’s life-cycle, from production and assembly, to servicing and recycling. Product modularity has been applied successfully in the aerospace industry, where companies like Boeing and Airbus design airframes to accommodate engines produced by General Electric, Pratt and Whitney, or Rolls Royce (Schilling, 2000). Computer manufacturers Hewlett Packard, apply this strategy to postpone the differentiation of inkjet printers to keep up with consumer choices and demand patterns.

Nonetheless, Lau et al. (2007) argued that most of the studies on the impact of product modularity have been carried out using “best practice” cases. Therefore, they attempted to verify the benefits of modularity in a large-scale empirical study to examine its impact on enhancing multiple competitive capabilities across different industries. Their findings showed that product modularity correlated significantly with capabilities such as delivery, flexibility and customer service, but showed no significant impact other capabilities like low price performance and product quality. This is perhaps because the ability to maintain and improve modular product architecture is contingent on other factors identified in more recent studies such as proximity, capacity, and the knowledge capability of modular component suppliers (Pashaei and Olhager, 2015). A recent study by Caridi et al. (2012) showed that proactive knowledge sourcing for the right technical and market knowledge was essential to improving the impact of modularity on operational performance, as well as product manufacturer’s design capability and product functionality over time. However, in some cases, manufacturers find themselves ‘locked in’ with long-term component suppliers. Although there are some relational benefits to maintaining a dedicated supplier base, there are also potentially adverse consequences, such as expertise or capacity mismatches in the long-run, or opportunism between manufacturers and suppliers (Schilling, 2000). According to Hoetker (2006):

“Modularity is a more multifaceted concept than previously recognized. In particular, increased product modularity enhances reconfigurability of organizations more quickly than it allows firms to move activities out of hierarchy.”

Traditionally, NPD was sequential and involved four logical steps. First, acceptable and feasible product concepts were developed through iterated and controlled steps of feedback and feed forward between the R&D department, marketing, and the engineering team (Schuh et al., 2015). After the development and formal description of feasible product concepts, the design team would then produce a prototype for manufacturing. At the manufacturing phase, critical make or buy decisions involving expertise from various departments such as purchasing, finance, and production planning are made (Wagner et al., 2015). The final stage usually involved staff training, factory/plant configuration, production/assembly scheduling and the actual manufacturing process. Today, with the evolution of information technology, big data resources, and modern manufacturing techniques such as 3-D printing for digital design (Marion et al., 2015), NPD is carried out through a process of ‘concurrent engineering’, which enables the research and development, design, and prototyping phases to run synchronously (Sobek et al., 1999; Terwiesch et al., 2002). This requires more dynamic make or buy decision making than the case of sequential product development. Since modular product suppliers are usually selected during this phase of NPD, it is critical for manufacturers to be able to choose the right suppliers using sourcing strategies associated with the traditional ‘buy decision’(Morschett et al., 2015; Pashaei and Olhager, 2015). The new institutional economic categorization of sourcing strategies adopts two broader terms; internalization and externalization, which represent to knowledge capturing phases of the SECI process. The predominant externalization strategies used by manufacturers to source for new knowledge include (a) Buying technology, components or know-how from suppliers with the required capability (b) Cooperation with component suppliers (c) Scanning the industry and other sources for the required knowledge/expertise to build required capabilities internally (Morschett et al., 2015).

Studies have established a positive relationship between these knowledge sourcing strategies and the performance of modular product manufacturers in terms of improved product design, functionality, cost performance, and marketing capabilities (Forza et al., 2005; Salvador et al., 2002; Salvador and Villena, 2013). However, in order to select the right knowledge sourcing strategy, the findings from this research suggest that such inter-organisational knowledge sharing would require dynamic capabilities for innovation. In a recent study on the effect of product modularity on launch speed, Vickery et al. (2015) noted that:

“In contrast to earlier work, the findings show modularity alone is an insufficient condition for the timely and frequent introduction of new products. Rather, launch speed is engendered by a ‘gestalt’ of dynamic capabilities. Thus, a more holistic picture of competitive advantage from launch speed is revealed: the advantage is derived from the deployment of a set of dynamic capabilities where one capability facilitates the development of another. The simultaneous effects (whether indirect or direct) of both product modularity and product platforms on manufacturing flexibility and launch show that the relationship between product modularity and innovation (of which launch is an important dimension) is more nuanced than extant literature indicates”

It is also noteworthy that most modular product supply networks are collaborative networks where autonomous firms pool together virtually dispersed capabilities (spatial, structural, and time dimensions) towards a common objective, which may be episodic. Findings from this study provide some empirical evidence on the mediating role of dynamic capabilities for knowledge sharing in such VEs, which can be applied as an intervention to address the problems of the modular product manufacturer described in the preceding subsection. Next, a reflection on a possible research strategy to extend the present study is presented.

**7.4.2 Potential Future Research Strategy.**

Most production and operations management (POM) research is carried out using advanced quantitative (statistical and optimisation) techniques and the resulting models have found very useful applications in certain areas of management (e.g. cost saving, performance management, quality management etc.). However, some have questioned the broader significance of such models to management problem solving, which often involves ‘soft’, context specific and highly nuanced concepts. Indeed, most of the well-known practical developments and interventions in operations and supply chain management such as lean management, just-in-time and total quality management have been developed by consultants working closely with managers; hardly any of these interventions have emerged from the standard POM research approaches (Baskerville and Wood-Harper 2016, Westbrook, 1995). Since most of the issues affecting management practice are unstructured and nuanced, solutions that are developed through prescriptive methods can at best, help us to understand well-defined problems or create generalised schema for categorising or grouping multi-faceted management issues. While such endeavours may prove incredibly useful in the testing of established theory (as demonstrated by the findings of this study and other similar ones) their contribution to social science research aimed at theory building is rather marginal (Coughlan and Coghlan 2002). This is because most statistical studies in the social sciences depend on perceptual measures obtained from a representative sample of a given population. Although such statistical studies can be spot-on in their representation of reality owing to the rigorous mathematical tests of validity and reliability, they lack the vital input that sense observation provides – that is, the crucial link between concept and context, which lies at the core of scientific theory building (Meehan et al., 2016).

The primary objective of change management is to map, optimise and streamline organisational processes using real-time feedback to develop standardized and repeatable best practices. For change management research like the prospective study involving the modular product manufacturer described earlier, observation and actual human experience is crucial since the concepts under investigation (innovation, knowledge sharing) are physical processes with physical expressions/implications. Much like the physical sciences, any theory building or intervention process involving physical concepts must account directly for human experience in the exact context of the problem being investigated. As explained quite vividly by theoretical physicists Einstein et al., (1935):

“Any serious consideration of a physical theory must take into account the distinction between the objective reality, which is independent of any theory, and the physical concepts with which the theory operates. These concepts are intended to correspond with the objective reality, and by means of these concepts we picture this reality to ourselves. In attempting to judge the success of a physical theory, we may ask ourselves two questions: (1) "Is the theory correct?" and (2) "Is the description given by the theory complete?" It is only in the case in which positive answers may be given to both of these questions, that the concepts of the theory may be said to be satisfactory. The correctness of the theory is judged by the degree of agreement between the conclusions of the theory and human experience……. Whatever the meaning assigned to the term complete, the following requirement for a complete theory seems to be a necessary one: every element of the physical reality must have a counterpart in the physical theory.” (p.777)

Consequently, for this prospective study, it is important to choose a research strategy that can produce practical solutions for the firm’s management. Since the knowledge sharing problems that firms deal with are unstructured, the objective of an intervention study of this nature is to arrive at an applicable and evidence based social scientific compromise and not to prescribe an optimized mathematical solution. As such, the traditional POM research techniques (simulation and mathematical modelling) would be inadequate in this instance. Some POM studies by consultants that are published in journals like the American and British Production and Inventory Control Societies (APICS/BPICS) address similar management problems, but in many cases, they tend to focus on testing established interventions in different settings (Eltantawy et al., 2015, Westbrook, 1995).

There are three main categories of observational non-experimental field research strategies that could be adopted for this prospective study, but they each differ in the extent to which the researcher intrudes upon or controls the research environment. The first approach involves controlled or *structured observations* and is quite prevalent in psychology research. Here, the researcher adopts a quasi-laboratory approach in which the location and frequency of observations are decided a priori. The participants and circumstances to be observed are carefully selected and a standardised observational procedure is applied (Singer-Dudek et al., 2013). Instead of capturing all observed behaviour, the researcher uses an agreed-upon scale or behaviour schedule to code and systematically classify observations into predetermined categories. This approach has the advantage of replicability, speed and the generation of data that is easy to analyse. Nonetheless, controlled observations can induce a bias known as the *Hawthorne effect, where* participants act differently than they would in their natural environment because they are aware and constantly reminded (by the induced observation routine) that they are being researched (Baskerville and Wood-Harper, 2016, Coughlan and Coghlan 2002, Meehan et al., 2016).

The second type of observational research is called *naturalistic or unstructured observation* and it involves studying the behaviour of participants as they occur spontaneously in their natural environment. This approach is predominantly used in case studies and is often heralded for its high ecological validity (extent to which research findings are generalizable to real-life settings) and ability to generate new ideas.  The limitations however include (1) the lack of a representative sample, (2) the inability to manipulate variables or examine cause and effect relationships since the researcher is removed from the study and (3) the need for training in relevant aspects of the phenomena observed as well as the research context to be able to identify changes or trends.

The third category known as *participant observation* is variant of natural observation where the researcher becomes overtly or covertly part of the studied subjects in order to gain deeper insights into the nature of a problem, or to understand the practical impact of an applied intervention in real-time and in context. The main downside to this approach is the possibility for selective reporting and the difficulty in translating the data collected into theoretically viable information. However, for studies focused on applying interventions or solving problems identified by management, the approach constitutes a viable research strategy. Participant observation is often used in some case studies, ethnographic studies and action-research studies. Reflecting on the focus of the prospective research described earlier, a participatory action research approach appears to be potentially suitable (Singer-Dudek et al., 2013, Canterino et al., 2016, Kaplan, 1998).

Action research refers to a form of inquiry in which the researcher is immersed in the context of a given research problem or intervention, alongside the study participants. It is a form of *learning by doing* where after having identified a problem, the researcher- along with the study participants - tries to resolve the problem by applying an intervention, monitoring its success or failure and examining the lessons learned to arrive at a solution that meets the participants’ requirements/demands. Action research is also known by other names such as participatory research, collaborative inquiry, action learning, and emancipatory research. It differs markedly from professional practices and consulting in its emphasis on theory building, where the interventions applied are underpinned by theoretical considerations. Put simply, O'Brien (2001) noted that:

“Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to further the goals of social science simultaneously.  Thus, there is a dual commitment in action research to study a system and concurrently to collaborate with members of the system in changing it in what is together regarded as a desirable direction.  Accomplishing this twin goal requires the active collaboration of researcher and client, and thus it stresses the importance of co-learning as a primary aspect of the research process.”

The underlying philosophy of action research is that by involving research participants/beneficiaries and conducting research in the real social environment, learning (by both management and the research team) is enhanced and management becomes more willingly apply any interventions explored because they are present to witness its implementation from the scratch. Although action research is driven by practice related problems, it is characteristically different from consultancy assignments. Consultants often share a common goal with the company (i.e. the application of an intervention and/or the enactment of change). The action researcher on the other hand shares the company’s goals but has a broader primary objective to discover new knowledge and to advance theory. As such, while a consultant may be able to specify details on the type of end result to be expected from the commencement of the research endeavour, the action researcher needs to leave the options open because the challenges encountered in the pursuit of an end result may just be as important to theory development as the outcome itself. According to Argyris and Schön, (1989: 85) “From the action researcher’s perspective, the challenge is to define and meet standards of appropriate rigour without sacrificing relevance”.

Some of the key merits of action research were highlighted by Winter (1989) in a comprehensive overview of the main principles of the approach. First, it presents the opportunity for r*eflexive critique*, which ensures that all interpretations, biases, assumptions and concerns that may impact the final research outcome are made explicit. Action research also allows for d*ialectical critique*, which ensures that there is a shared understanding between the researcher and the participants on the relationships that exist among the phenomena explored (knowledge sharing, dynamic capabilities and innovation) and the context of the study to ensure that any changes occurring in the course of the intervention are accurately documented. Thirdly, action research ensures that the resources used are c*ollaboratively generated* and understood by all parties to the study. In this sense, all the ideas put forward by the parties to the research are given equal significance and the interpretive categories used in the analysis of the effectiveness or otherwise of the intervention applied are duly negotiated among the research parties.  Since organisational change can be potentially threatening to the *modus oparandi* or *status quo* of the firm, all the *risks* associated with the interpretation of the potential research findings can be clearly negotiated among the research parties (participants and researchers). Furthermore, since action research embodies a diversity of views, it creates a *pluralistic pattern of inquiry* where all the commentaries, notes, records and critiques generated from the study can be collaboratively assessed, so that contradictions are open to debate before the research findings are effected or published.

 Lastly, action research enables a two-way flow of ideas, which allows theory to inform practice and vice versa. This process entails continuous iterations of feedback and feedforward. Consequently, in addition to its potential for practical problem solving, it holds great prospect for theory building, particularly in the current case, where certain theoretical premises emanating from the dynamic-capability SECI model of knowledge sharing developed in this research may be introduced from the onset to address the practical problems identified in the knowledge sharing practices of the modular product manufacturing firm (Singer-Dudek et al., 2013).

The final point of reflection on the research strategy for this prospective study is that in order to fully understand the scope of the problem of knowledge sharing and innovation and to establish plausible correlations between the changes occurring and the intervention applied (the development of targeted dynamic capability routines), a longitudinal study approach might be required. Longitudinal studies are a variant of correlational studies in which the evolution of a set of study variables is observed and studied over a protracted period of time. The amount of time required (or agreed upon by the researcher and participants) usually varies depending on the nature of the variables explored and the resources available. After the research problem is defined and the study boundary conditions set, the longitudinal study process usually commences with data collection at the outset of the study. Data collection is repeated over the course of the study to keep track of changes in the study variable(s) and to enable the researcher to make plausible correlations between the changes observed and the intervention applied over time. Taking this approach would enable the researcher to assess the impact of dynamic capabilities on specific performance outcomes (e.g. financial, new product development) resulting from improved innovativeness based on agreed parameters with the research participants. This would serve to address one of the limitations of this study highlighted earlier by extending the scope beyond the role of dynamic capabilities in achieving desired knowledge sharing outcomes to demonstrate the impact on specific firm performance targets.

Overall, applying the action research approach to this prospective study would enable the researcher make useful contributions to practice and theory, and to demonstrate the impact of the current study’s findings on the mediating role of dynamic capabilities in tacit and explicit knowledge sharing for innovation in solving a practical problem.

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**Appendix A: Questionnaire**

Informed Consent

Title of research: Exploring the Impact of Dynamic capabilities on inter-organisational knowledge sharing in virtual enterprises.

You are kindly invited to complete a questionnaire for a PhD research funded by the University of Sheffield titled “*Exploring the Impact of Dynamic capabilities on inter-organisational knowledge sharing in virtual enterprises*”. Please take time to carefully read the information provided about the purpose of this study and what it would involve. Do not hesitate to contact us for any clarification you may require, and do take time to decide whether or not you wish to take part in this survey.

Thank you for reading this.

Purpose of study: Often times, organizations form alliances with others to meet new market demands, and position themselves to compete for scarce business opportunities. These alliances are called virtual enterprises because they sometimes rely on technology to connect potential partners from different parts of the world.  Virtual enterprise projects usually have specified durations, and the partners may be competitors or geographically dispersed. This study attempts to understand how the learning abilities of individual organistions may affect the way they share knowledge when they are engaged in virtual enterprises.

Selection and participation: You have been selected for possible inclusion in this survey using certain predefined sampling criteria including:

1. Your organization is part of an industry cluster, professional community or virtual breeding environment or your organization is considered knowledgeable in virtual enterprises and project-based alliances.
2. You have the relevant managerial expertise to provide useful inputs to this study.

Ethical consideration

While your input will be useful and appreciated, participation in this study is entirely voluntary and you may decide to withdraw from the survey at any point if you wish to. If you do decide to take part, you will be given this information sheet to keep (and be asked to sign a consent form) and you can still withdraw at any time without having to give a reason.  Furthermore, the ethical considerations in this study have been reviewed in line with the ethical guidelines of the Sheffield University Management School. This implies that the information provided in this survey is anonymous and will be kept strictly confidential. We shall not request for, or publish any information that identifies you or your organization as such information is not relevant to our study findings.

Type of information required for this study

The study will include organizations from different industries and countries that have been involved in project-based and profit driven virtual enterprises. The target sample size is approximately 300 respondents. You will be kindly required to complete a Likert scale questionnaire, which will take approximately 25-30 minutes.

If you are happy with the information provided and wish to continue with this survey, please check the box provided at the end of this information sheet. We appreciate that you have taken the time to read this information sheet and many thanks for your cooperation.

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I have read, understood, and printed a copy of, the above consent form and desire of my own free will to participate in this study.

* Yes
* No

**Section A: Background.**

Kindly provide the following background information about yourself and your organization

Q3 What industry best describes the operations in your organization?

* Aeronautics and Aerospace Industry
* Automobile Industry
* Construction Industry
* Electronics Industry
* Metal-mechanics Industry
* Oil and gas Industry
* Food processing Industry
* Telecommunications Industry
* Banking
* Consulting
* Logistics and transport
* Others please specify \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q4 What is the size of your organization in terms of number of employees?

* 50 to 100
* 101 to 300
* 301 to 500
* Above 500

Q5 What position do you occupy in your organization?

* C level manager e.g. Chief Engineering officer
* Mid corporate level manager
* Operations or project level manager
* Others please specify \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q6 How many years have you worked with your organization?

* 1 to 5 years
* 6 to 10 years
* 11 to 15 years
* 16 to 20 years
* Above 20 years

Q7 How many years of managerial experience do you have?

* 1 to 5 years
* 6 to 10 years
* 11 to 15 years
* 16 to 20 years
* Above 20 years

Q8 Has your organization taken part in a joint production/manufacturing/ innovation/development collaboration with international or local companies in the last 5 years?

* Yes
* No

Q9 Have you participated in any managerial or technical capacity on a major joint project or collaboration with other organizations?

* Yes
* No

Q10 Is your organization an active member of a regional or global industry cluster which aids in locating opportunities for collaborations and joint project execution?

* Yes
* No

**Section B: Organizational experiences and approach to managing virtual enterprise joint projects.**

Virtual enterprises are joint collaborative projects involving companies with complementary or similar expertise connected to each other via technology to deliver a specific project. Partner companies are often in different geographical locations. Based on this definition, to what extent do the following questions characterize your organizations experience with virtual enterprises?

Q11 We and our virtual enterprise partners share similar preferences for contractors and secondary suppliers for the virtual enterprise.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q14 We usually enter into virtual enterprises with partners that have similar organizational structures and business strategies.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q15 Where necessary, the departments or units in our organization can share ideas freely with departments in our virtual enterprise partner firms, to improve the overall project performance.

* Never
* Rarely
* Sometimes
* Often
* All of the Time

Q16 Our organization is willing to accept and apply changes prescribed by our virtual enterprise partners that will improve their operations with us.

* Never
* Rarely
* Sometimes
* Often
* All of the Time

Q17 All our virtual enterprise partners are willing and technically capable of learning and adopting practices/procedures from out independent company operations through joint research and development.

* Never
* Rarely
* Sometimes
* Often
* All of the Time

Q18 We organize joint training programmes with our virtual enterprise partners for all employees working on joint projects.

* Never
* Rarely
* Sometimes
* Often
* All of the Time

Q19 All our virtual partners collaborate to improve the individual performance of each partner and the joint performance of the virtual enterprise project for the duration of our collaboration and beyond.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q20 We and our virtual enterprise partners focus on developing our individual expertise to tackle different aspects and challenges in our shared project (virtual division of labour)

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q21 We are confident relying on the expertise of our virtual partners to tackle challenges that may have implications for the entire virtual enterprise performance.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q22 When faced with challenges, we work harmoniously in a well-coordinated fashion with our virtual enterprise partners to solve them irrespective of the location of our partners.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q23 When we receive information from our virtual partners about processes or challenges in their expert area, we always double-check for accuracy.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q24 We trust that our virtual partners’ knowledge on critical issues about our shared project is credible.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q25 We consider it an integral part of the organizational and cultural guideline for running virtual enterprises, to share operational challenges and solutions with our virtual project partners.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q26 We have appropriate technology and technical systems in place that synchronize our operations with our virtual partners in various locations for ease in communication.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q27 Leadership and management of the virtual enterprise is viewed as a shared responsibility irrespective of the size, capability and geographical location of all virtual enterprise partners.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q28 We have management and specialized monitoring systems and processes in place to ensure the synchronization of values and goals of all virtual enterprise partners for the duration of specific projects.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q29 Our organizations technology, operating processes, employee training and culture is designed to accommodate the formation of collaborative projects with virtual partners from different parts of the world

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q30 The rules and guidelines that govern our virtual enterprise projects are similar to our own rules and guidelines and those of our virtual enterprise partners.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

**Section C:  The dynamics of knowledge sharing among virtual enterprise partners**

**The following questions examine the dynamics of managerial and technical knowledge sharing among virtual enterprise partner organizations, during the course of a joint project.**

Q31 Technical and management teams/departments organize frequent face-to-face or technology aided meetings/conference calls (skype etc.) with all virtual partners to brainstorm on ideas.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q32 We always establish cross-functional teams comprising of members from all our virtual partner organizations for project related research and development initiatives.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q33 As part of our routine, we encourage joint idea generation and meeting facilitation strategies at management and technical levels, before key joint project decisions are taken

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q34 As part of our routine, we encourage the rotation of skilled managers and employees across our virtual partner organizations to share skills and experiences with virtual partners and vice-versa.

* Never
* Rarely
* Sometimes
* Often
* All of the Time

Q35 We use management planning tools to jointly organize ideas and data generated from all the partners before adopting ideas for our joint project (e.g. Affinity diagrams, tree diagrams, prioritization matrix, process decision program charts, and activity network diagrams).

* Never
* Rarely
* Sometimes
* Often
* All of the Time

Q36 There are forums and incentives for suggestions and corrections from any of our virtual enterprise partners irrespective of their role and position in the virtual enterprise project.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q37 All partner organizations in our virtual enterprises are trained and empowered with the skills to capture their ideas clearly using management and planning tools.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q38 Updates, modifications or changes to project routines, are made available on shared platforms that can be accessed and modified where necessary, by any of our key virtual partners.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q39 We always use project report databases with search capabilities to enable all virtual partners to access the virtual enterprises guidelines, operations procedures, routines, project time lines etc.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q40 All our virtual enterprise partners have access to a common process improvement technology or software for managing information and processes throughout the duration of a project (e.g. Enterprise Resource Planning software like SAP, HeliumV, Adaxa suite, etc.)

* Never
* Rarely
* Sometimes
* Often
* All of the Time

Q41 We keep records and databases on best practices, project challenges, and performance measurements metrics, which can be accessed and updated by all our virtual enterprise partners.

* Never
* Rarely
* Sometimes
* Often
* All of the Time

Q42 We always use tools and technology to systematically collate all post-project reports, reviews of the experiences, lessons learned and progress made by all virtual enterprise partners.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q43 Manuals, training, simulations or on-line guides are used for sharing new and unique individual or collaborative knowledge and experience gained by partners on virtual enterprise projects.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q44 Virtual enterprise partners are encouraged and allowed to apply new knowledge acquired on joint projects in their independent operations without undue restrictions.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q45 Project-related knowledge resources and repositories, accumulated by virtual enterprise partners during the course of a project are made available to all the partners during and after the duration of a project.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Section D: Exploring the various knowledge sharing outcomes from virtual enterprise projects

The following questions explore the different performance outcomes resulting from sharing individual and routine knowledge by partners in virtual enterprises. These outcomes include: the ability to be innovative, the ability to replicate knowledge and the ability to adapt knowledge from different sources to suit specific organizational demands at the termination of virtual enterprise projects.

Q46 We jointly create and share entirely new patents, trademarks and designs with our virtual enterprise partners.

* Never
* Rarely
* Sometimes
* Often
* All of the Time

Q47 Our experience with virtual enterprises enables us to create new and more effective operational, organizational and managerial processes.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q48 Our organizations performance in terms of new product/ process development is greatly influenced by the knowledge and expertise we acquire from collaborative projects:

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q49 The best practices (management and technical) acquired from virtual enterprise projects are modified to make them unique and suitable for our individual businesses.

* Never
* Rarely
* Sometimes
* Often
* All of the Time

Q50 We and our partners usually adapt carefully selected technical know-how or management practices from previous joint projects to create unique practices for new virtual enterprise projects.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q51 Virtual enterprise partners jointly modify individual technical know-how or management practices, and combine them to create new competitive routines on joint projects.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q52 New knowledge acquired on current or previous virtual enterprise projects have often led us and our partners to revisit and update our individual expert knowledge.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q53 Working on joint projects with virtual enterprise partners provides us with proven methods and procedures for achieving operational excellence.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q54 Working on joint projects with virtual enterprise partners updates us on industry best practices and enables us to replicate these practices in our firms and future virtual enterprises.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q55 Partners are able to improve their individual productivity by carefully applying the management and operational strategies jointly developed on virtual enterprise projects.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q56 We apply the best-practice technical and management know-how acquired from previous virtual enterprises directly to our current and future virtual enterprises operations.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

Q57 We replicate the best practices and procedures from our joint projects into our operations as they have been applied in our joint project operations.

* Strongly disagree
* Disagree
* Neither Agree nor Disagree
* Agree
* Strongly Agree

**Appendix B: Data Background**

*Demographic Distribution of Data*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Industry | | | | | |
|  | | Frequency | Percent | Valid Percent | Cumulative Percent |
|  | Aeronautics and Aerospace | 6 | 3.0 | 3.0 | 3.0 |
| Automobile | 14 | 6.9 | 6.9 | 9.9 |
| Construction | 23 | 11.4 | 11.4 | 21.3 |
| Electronics | 19 | 9.4 | 9.4 | 30.7 |
| Metal-mechanics | 16 | 7.9 | 7.9 | 38.6 |
| Oil and Gas | 30 | 14.9 | 14.9 | 53.5 |
| Food processing | 31 | 15.3 | 15.3 | 68.8 |
| Telecommunications | 19 | 9.4 | 9.4 | 78.2 |
| Banking | 16 | 7.9 | 7.9 | 86.1 |
| Consulting services | 13 | 6.4 | 6.4 | 92.6 |
| Logistics and transport | 15 | 7.4 | 7.4 | 100.0 |
| Total | 202 | 100.0 | 100.0 |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Organisation size | | | | | |
|  | | Frequency | Percent | Valid Percent | Cumulative Percent |
|  | 5 to 100 | 19 | 9.4 | 9.4 | 9.4 |
| 101 to 300 | 41 | 20.3 | 20.3 | 29.7 |
| 301 to 500 | 55 | 27.2 | 27.2 | 56.9 |
| Above 500 | 87 | 43.1 | 43.1 | 100.0 |
| Total | 202 | 100.0 | 100.0 |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Job title | | | | | |
|  | | Frequency | Percent | Valid Percent | Cumulative Percent |
|  | C level manager | 26 | 12.9 | 12.9 | 12.9 |
| Mid corporate level manager | 52 | 25.7 | 25.7 | 38.6 |
| Project manager | 71 | 35.1 | 35.1 | 73.8 |
| Operations level manager | 53 | 26.2 | 26.2 | 100.0 |
| Total | 202 | 100.0 | 100.0 |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Part of a regional or global industry cluster | | | | | |
|  | | Frequency | Percent | Valid Percent | Cumulative Percent |
|  | No | 109 | 54.0 | 54.0 | 54.0 |
| Yes | 93 | 46.0 | 46.0 | 100.0 |
| Total | 202 | 100.0 | 100.0 |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Years of experience working in firm | | | | | |
|  | | Frequency | Percent | Valid Percent | Cumulative Percent |
|  | 1-5 years | 46 | 22.8 | 22.8 | 22.8 |
| 6-10 years | 38 | 18.8 | 18.8 | 41.6 |
| 11-15 years | 51 | 25.2 | 25.2 | 66.8 |
| 16-20 years | 38 | 18.8 | 18.8 | 85.6 |
| Above 20 years | 29 | 14.4 | 14.4 | 100.0 |
| Total | 202 | 100.0 | 100.0 |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Years of overall management experience | | | | | |
|  | | Frequency | Percent | Valid Percent | Cumulative Percent |
|  | 1-5 years | 35 | 17.3 | 17.3 | 17.3 |
| 6-10 years | 47 | 23.3 | 23.3 | 40.6 |
| 11-15 years | 17 | 8.4 | 8.4 | 49.0 |
| 16-20 years | 70 | 34.7 | 34.7 | 83.7 |
| Above 20 years | 33 | 16.3 | 16.3 | 100.0 |
| Total | 202 | 100.0 | 100.0 |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| VE experience | | | | | |
|  | | Frequency | Percent | Valid Percent | Cumulative Percent |
|  | Holarchical VEs | 76 | 37.6 | 37.6 | 37.6 |
| Hierarchical VEs | 126 | 62.4 | 62.4 | 100.0 |
| Total | 202 | 100.0 | 100.0 |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Region | | | | | |
|  | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | Europe | 30 | 14.9 | 14.9 | 14.9 |
| North America | 39 | 19.3 | 19.3 | 34.2 |
| South America | 22 | 10.9 | 10.9 | 45.0 |
| Africa | 33 | 16.3 | 16.3 | 61.4 |
| Middle East | 47 | 23.3 | 23.3 | 84.7 |
| Asia | 31 | 15.3 | 15.3 | 100.0 |
| Total | 202 | 100.0 | 100.0 |  |

**Appendix C: Multicollinearity Findings**

1. *Test Showing Tolerance and variance inflation factors (VIF) for all the predictor variables on the dependent variables*

|  |  |  |  |
| --- | --- | --- | --- |
| Coefficientsa | | | |
| Model | | Collinearity Statistics | |
| Tolerance | VIF |
| 1 | Soc | .410 | 2.440 |
| Ext | .420 | 2.384 |
| Int | .544 | 1.839 |
| Com | .913 | 1.095 |
| Tms | .488 | 2.049 |
| Acap | .483 | 2.069 |
| Oint | .379 | 2.641 |
| a. Dependent Variable: Inov | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| Coefficientsa | | | |
| Model | | Collinearity Statistics | |
| Tolerance | VIF |
| 1 | Soc | .410 | 2.440 |
| Ext | .420 | 2.384 |
| Int | .544 | 1.839 |
| Com | .913 | 1.095 |
| Tms | .488 | 2.049 |
| Acap | .483 | 2.069 |
| Oint | .379 | 2.641 |
| a. Dependent Variable: Adapt | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| Coefficientsa | | | |
| Model | | Collinearity Statistics | |
| Tolerance | VIF |
| 1 | Soc | .410 | 2.440 |
| Ext | .420 | 2.384 |
| Int | .544 | 1.839 |
| Com | .913 | 1.095 |
| Tms | .488 | 2.049 |
| Acap | .483 | 2.069 |
| Oint | .379 | 2.641 |
| a. Dependent Variable: Replication | | | |
|  | | | |

1. *Test Showing Tolerance and variance inflation factors (VIF) for all the independent predictors on the mediating variables*

|  |  |  |  |
| --- | --- | --- | --- |
| Coefficientsa | | | |
| Model | | Collinearity Statistics | |
| Tolerance | VIF |
| 1 | Soc | .515 | 1.943 |
| Ext | .574 | 1.743 |
| Int | .597 | 1.674 |
| Com | .946 | 1.057 |
| a. Dependent Variable: Organisational Interoperability | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| Coefficientsa | | | |
| Model | | Collinearity Statistics | |
| Tolerance | VIF |
| 1 | Soc | .515 | 1.943 |
| Ext | .574 | 1.743 |
| Int | .597 | 1.674 |
| Com | .946 | 1.057 |
| a. Dependent Variable: Transactive Memory System | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| Coefficientsa | | | |
| Model | | Collinearity Statistics | |
| Tolerance | VIF |
| 1 | Soc | .515 | 1.943 |
| Ext | .574 | 1.743 |
| Int | .597 | 1.674 |
| Com | .946 | 1.057 |
| a. Dependent Variable: Absorptive Capacity | | | |

**Appendix D: Exploratory factor Analysis**

*Analysis of factor Communalities*

|  |  |  |
| --- | --- | --- |
| Communalities | | |
|  | Initial | Extraction |
| Com1 | .648 | .684 |
| Com2 | .670 | .727 |
| Com3 | .669 | .732 |
| Soc1 | .848 | .860 |
| Soc2 | .813 | .803 |
| Soc3 | .834 | .815 |
| Soc4 | .793 | .749 |
| Ext1 | .855 | .874 |
| Ext2 | .852 | .884 |
| Ext3 | .815 | .754 |
| Ext4 | .824 | .772 |
| Int1 | .837 | .833 |
| Int2 | .857 | .875 |
| Int3 | .824 | .829 |
| Int4 | .808 | .754 |
| Acap1 | .877 | .824 |
| Acap2 | .857 | .820 |
| Acap3 | .855 | .842 |
| Acap4 | .855 | .838 |
| Acap5 | .870 | .841 |
| Acap6 | .834 | .793 |
| Acap7 | .884 | .864 |
| Tms1 | .880 | .838 |
| Tms2 | .890 | .865 |
| Tms3 | .855 | .851 |
| Tms4 | .868 | .847 |
| Tms5 | .869 | .852 |
| Tms6 | .873 | .854 |
| Oint1 | .913 | .894 |
| Oint2 | .892 | .861 |
| Oint3 | .843 | .837 |
| Oint4 | .862 | .838 |
| Oint5 | .843 | .825 |
| Inov1 | .842 | .888 |
| Inov2 | .755 | .717 |
| Inov3 | .830 | .825 |
| Inov4 | .826 | .782 |
| Replic1 | .638 | .587 |
| Replic2 | .794 | .798 |
| Replic4 | .841 | .879 |
| Replic3 | .828 | .817 |
| Adapt1 | .660 | .654 |
| Adapt2 | .682 | .661 |
| Adapt3 | .630 | .636 |
| Adapt4 | .476 | .428 |

*Total Variance Explained and Eigenvalues for the 10 Factor Solution*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Factor | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadingsa |
| Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total |
| 1 | 18.588 | 41.306 | 41.306 | 18.417 | 40.926 | 40.926 | 12.467 |
| 2 | 4.235 | 9.411 | 50.717 | 3.948 | 8.773 | 49.699 | 3.417 |
| 3 | 2.943 | 6.540 | 57.257 | 2.770 | 6.155 | 55.853 | 11.735 |
| 4 | 2.663 | 5.918 | 63.175 | 2.423 | 5.384 | 61.237 | 2.328 |
| 5 | 2.027 | 4.504 | 67.679 | 1.832 | 4.071 | 65.308 | 12.612 |
| 6 | 1.814 | 4.030 | 71.709 | 1.624 | 3.609 | 68.917 | 7.938 |
| 7 | 1.645 | 3.656 | 75.365 | 1.381 | 3.069 | 71.986 | 2.977 |
| 8 | 1.395 | 3.100 | 78.465 | 1.208 | 2.684 | 74.670 | 9.052 |
| 9 | 1.370 | 3.044 | 81.509 | 1.199 | 2.664 | 77.334 | 10.160 |
| 10 | 1.198 | 2.663 | 84.172 | 1.001 | 2.224 | 79.558 | 10.746 |
| 11 | .621 | 1.381 | 85.553 |  |  |  |  |
| 12 | .499 | 1.109 | 86.662 |  |  |  |  |
| 13 | .436 | .969 | 87.631 |  |  |  |  |
| 14 | .397 | .882 | 88.513 |  |  |  |  |
| 15 | .356 | .792 | 89.305 |  |  |  |  |
| 16 | .340 | .755 | 90.060 |  |  |  |  |
| 17 | .315 | .699 | 90.759 |  |  |  |  |
| 18 | .298 | .662 | 91.421 |  |  |  |  |
| 19 | .285 | .633 | 92.053 |  |  |  |  |
| 20 | .258 | .574 | 92.627 |  |  |  |  |
| 21 | .253 | .562 | 93.189 |  |  |  |  |
| 22 | .232 | .515 | 93.704 |  |  |  |  |
| 23 | .221 | .490 | 94.195 |  |  |  |  |
| 24 | .213 | .474 | 94.668 |  |  |  |  |
| 25 | .201 | .446 | 95.115 |  |  |  |  |
| 26 | .192 | .426 | 95.541 |  |  |  |  |
| 27 | .179 | .397 | 95.938 |  |  |  |  |
| 28 | .177 | .393 | 96.331 |  |  |  |  |
| 29 | .166 | .368 | 96.700 |  |  |  |  |
| 30 | .153 | .340 | 97.040 |  |  |  |  |
| 31 | .129 | .287 | 97.327 |  |  |  |  |
| 32 | .126 | .279 | 97.606 |  |  |  |  |
| 33 | .123 | .272 | 97.878 |  |  |  |  |
| 34 | .108 | .240 | 98.119 |  |  |  |  |
| 35 | .107 | .238 | 98.356 |  |  |  |  |
| 36 | .101 | .224 | 98.581 |  |  |  |  |
| 37 | .095 | .212 | 98.792 |  |  |  |  |
| 38 | .089 | .197 | 98.990 |  |  |  |  |
| 39 | .085 | .188 | 99.178 |  |  |  |  |
| 40 | .081 | .180 | 99.358 |  |  |  |  |
| 41 | .069 | .154 | 99.512 |  |  |  |  |
| 42 | .065 | .144 | 99.656 |  |  |  |  |
| 43 | .061 | .135 | 99.791 |  |  |  |  |
| 44 | .053 | .117 | 99.908 |  |  |  |  |
| 45 | .041 | .092 | 100.000 |  |  |  |  |

Extraction Method: Principal Axis Factoring.



Downloaded: 23/07/2016

Approved: 16/01/2015

Raymond Obayi

Registration number: 130122368

Management School

Programme: PhD

Dear Raymond

**PROJECT TITLE:** The Mediating Role of Organisations’ Dynamic Capabilities on Tacit and Explicit Knowledge Sharing in Virtual Enterprises

**APPLICATION:** Reference Number 002062

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 16/01/2015 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

University research ethics application form 002062 (dated 24/10/2014).



Participant consent form 003184 version 1 (24/10/2014).



Participant consent form 003175 version 1 (24/10/2014).



The following optional amendments were suggested:

Some changes should be carried out as follows: 1. Information sheet: more information about data usage and storage (who has access to the data, how the information will be used - you mentioned in the form that it will be used "for other related studies" but it is not in the information sheet). A sample questionnaire should also be included. 2. Consent form: need to be tailored to this project, there are still irrelevant information, for e.g. use of audio recording. Please adjust the form to reflect what the participants consent to what you are actually going to do in the study.

If during the course of the project you need to [deviate significantly from the above-approved documentation](https://www.shef.ac.uk/ris/other/gov-ethics/ethicspolicy/approval-procedure/review-procedure/changes-made-after-approval) please inform me since written approval will be required.



Yours sincerely

Harriet Godfrey-Holmes

Ethics Administrator

Information School

**Appendix F: Conference papers, publications and papers-in-progress**

**Conference Papers**

1. The Role of Knowledge Sharing in Determining the Span and Intensity of Integration in Supply Networks (EUROMA Conference 13 April 2014)
2. Towards a Conceptualisation of Supply Chain Integration Beyond the Dyad: A Systematic Review (EUROMA Conference 13 April 2014)
3. Knowledge Sourcing in Modular Product Manufacturing: The Role of Transactive Memory Systems and Absorptive Capacity (EUROMA Conference 20 June 2015)
4. Retail Supply Chain Flexibility: A Transaction Cost perspective of the Mediating Role of interorganizational learning (IPSERA Conference 31 October 2015)
5. Retail Supply Chain Flexibility: The Mediating Role of interorganizational learning Drivers (Academy of Management Conference 7 August 2015)
6. Risk Identification, Assessment, and Management in Oil and Gas Projects (POMS conference, 2016)

**Recent Publications and Papers under Review**

1. Improving Retail Supply Flexibility using Buyer-Supplier Relational Capabilities –Accepted for publication 2016: International Journal of Operations and Production Management (IJOPM)- Manuscript ID IJOPM-12-2015-0775
2. Conceptualising a Circular Framework of Supply Chain Resource Sustainability (Accepted with Minor Corrections for publication 2016: IJOPM)
3. Integrated Resource Efficiency: Measurement and Management – Accepted 2016: International Journal of Operations and Production Management (IJOPM) - Manuscript ID IJOPM-05-2015-0266 ((Accepted for publication 2016: IJOPM)

**Work-in-Progress**

1. Sustaining Organisational Learning Using Adaptive, Innovative, and Replicative Specialized Communities of Practice (in progress 2016)
2. Knowledge Sourcing in Modular Product Manufacturing: The Mediating Role of Dynamic Capabilities (in Progress 2016)
3. Towards a Conceptualisation of Supply Chain Integration Beyond the Dyad: A Systematic Review (in progress 2016)