ANALYSIS OF THE DEVELOPMENT OF REGIONAL PRODUCTIVE SYSTEMS FROM A STRUCTURAL RELATIONAL APPROACH

THE CASES OF ANDALUSIA AND THE BASQUE COUNTRY

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ABSTRACT

This work analyses productive systems from a structural relational perspective. This has been done theoretically and also empirically, discussing the adoption of the network perspective and relating the structure and evolution of productive systems with development.

The benefits of adopting the network perspective as a methodological approach in economic research are shown. From this perspective, the consideration of the social character of economic actors and relationships is made possible with this methodology. Moreover, territory and history are also considered as fundamental factors when studying economic relationships.

In order to consider the whole set of economic agents and links acting in a particular geographic context different concepts are discussed. The regional productive system concept is considered the most appropriate to study economic structures from a network interdisciplinary perspective.

The structural analysis is then approached by studying the structure and evolution of regional productive systems. The method selected to study the systems from a relational view is social network analysis, although also input-output indices are used. From their application to the Spanish regions of Andalusia and the Basque Country in 1980 and 1995, two production systems have been selected in each region: an agro-food system and a metal-mechanical system. Once they have been studied and compared, institutional information is added to analyse them as regional productive systems.

The comparison allows conclusions to be obtained that are related to the existence and persistence of development interregional differences. Therefore, a set of hypotheses are tested through mechanism causality establishing relationships between productive systems and structures and differences in regional development. Hypotheses refer to the structure of production systems, the role of services in the systems and the role of social capital on development.

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1. INTRODUCTION

The objective of this research is to study productive systems and their relation with development from a structural, interdisciplinary and holistic view. In order to do that an appropriate epistemological perspective should be adopted, to consider the social nature of economic actors, the importance of historical and geographical aspects and the relational character of socio-economic institutions. Moreover, an appropriate set of methods should also be selected, in accordance with the adopted epistemological perspective. The selected methodology should consider the relational character of economic actors. Once the epistemological perspective of the research has been decided, it will be applied to study regional economic structures and their relationship with regional development.

The main aspects of the methodological view assumed in this research are: the consideration of the territory as a crucial economic factor, the concern that economic research should be holistic including diverse actors, aspects and relations, and the focus in the relational and structural character of socio-economic systems.

The consideration of the territory as a crucial economic factor leads to the selection of regions, instead of nations, as the units of analysis. Cultural and institutional conditions underlying the regional economies are some of the main causal factors that contribute to their development, having a localised character and constituting the relational specificities and abilities of economic actors. Those factors are difficult to reproduce in other regions, and therefore they constitute regional qualities that explain the economic success of some regions and therefore contribute to particular national development processes. However, economic research has traditionally focused on nations. Particularly, economic development and growth studies are concentrated in national attributes and policies, emphasising macroeconomic considerations and forgetting the substantial differences existing in economic performances across regions belonging to the same country.

To approach economic systems localised in regions, considering the area's cultural and institutional conditions generates the necessity of accepting a holistic perspective. Diverse actors and factors have to be taken into account. In that sense, formal and informal interdependencies are taking place in economic systems, among firms and other institutions. Moreover, those are purposive interdependent actors and not independent agents looking for their maximum benefit, like it is the case in mainstream economics. The social and relational character of economic actors should be considered depending on the links maintained among them, in a formal or informal sense, and being affected by the economic history and the location factor of their area.

Traditional economic research generally considers nations instead of regions, average agents instead of differentiated actors, and their attributes instead of their relationships. Moreover, usually only economic aspects are taken into account as the social, geographical and historical character of economic systems and processes are ignored.

From this research perspective, the whole set of related actors constituting diverse economic systems at regional level make particular structures. Those relational structures can be compared among regions and in time to consider their evolution. In order to do that a relational structural analysis should be followed. In line with a structural view, the elements of a set can not be defined according to their intrinsic value but attending to their relationships with the other elements in the same system. Therefore, the scientific analysis should concentrate on clarifying and explaining the composition and relations maintained in the structures.

In the particular case of economics, the main characteristics of a structural analysis should be the consideration of a global perspective, the interdependence of the analysed components, the consideration of historical and social factors and a dynamic view of the economic situation. Then, the objective of an economic structural analysis should be the study of interdependence relationships, having some permanent character, linking the main components of a comprehensive economy.

Following those ideas, this research offers two different and related contributions, one in the methodological and theoretical side, in the first part, and another empirical, in the second part. The research is structured in the form described as follows:

Chapter two is focused on the methodological approach adopted in this research: the network perspective. It offers the necessary foundations to study economic systems from a relational and structural view. Although it allows for the consideration of the social character of economic structures, it has been rarely adopted in economic research as economic agents are generally assumed as independent and therefore researchers focus on their attributes forgetting relations and structures. The objective of chapter two is to show the benefits of applying network perspective to the economic research. Social capital and embeddedness are among the main concepts favouring the use of the network methodology in economics, and allowing for the consideration of the social character of economic actors and relationships. Territory and history are also fundamental factors when studying economic relations, because economic actions and relations take place in a particular geographic and historical context and are affected by it. The network perspective has the necessary interdisciplinary character to study economic structures.

When studying economic systems, the sets of their related interdependent complex components constitute structures inside structures, considering different micro and macro levels. Therefore, the research can be focused at different stages. In chapter two different concepts that aim to consider the whole set of economic agents and links, acting in a particular geographic context are also discussed. The regional productive system term is considered the most appropriate to study economic structures from a network interdisciplinary perspective. Productive systems, made of firms, formal and informal institutions and their relationships, are embedded in the regional net made by the whole complex social relationships, constituting a basic part of the regional structure.

The structural analysis is then approached in this research by studying the structure and evolution of regional productive systems. In the economic literature, the terms structure and structural analysis have been widely applied, but usually to mean the separate study of the main factors of economic systems. One of the aspects that has been more generally studied as structural is the characterisation and evolution of the main economic sectors, according to their weight in GDP and employment. Moreover, structural studies generally use econometrics and descriptive statistics without using a specific method for their analyses. The use of a relational analysis to study the main structural factors and the dynamics of those relationships, has not received enough attention when referring to the meaning of the economic structure concept.

One of the most important structural analyses in the economic literature is the input-output study that considers that the economic structure is represented in an input-output table through exchange relations maintained among economic sectors. Those data have been widely used in empirical national studies. Usually, they have been applied to the calculation of several coefficients to classify the productive branches, to descriptive analyses of final demand, consumption, imports and employment, and through models to measure separate effects (volume of final demand, composition of final demand, technical coefficients) of changes in production. But they have not been studied from a network perspective, focused in relations, and matching perfectly with the structural character of the input-output information, and offering very enriching economic interpretations. It is remarkable that even at international level a proper structural input-output analysis has not been developed, finding only some studies applying graph theory and minimal flow analysis to study the trade relations in national input-output tables.

The methods selected in this research to study the productive systems from a relational view are explained in chapter three. The main method corresponds to social network analysis, offering a whole set of specific measures to value relationships taking place in a particular network or system. Input-output indices are also used and therefore they are explained, together with the main characteristic of the selected data, in chapter three.

Input-output data are analysed in chapter four to identify regional production systems, as sets of productive branches related by their intermediate transactions, and therefore by their productive processes. This will be the first step for the empirical study of regional productive systems as they constitute their technical side. In chapter four, the main production systems in Andalusia and the Basque Country are identified and characterised using several network measures, input-output indices, a particular algorithm, and regional historical information. Once they have been studied and compared, institutional information is added in chapter five to transform them into regional productive systems.

Regional production systems and regional productive systems are identified in the two selected Spanish regions for time and spatial comparisons. Those regions have been chosen because they are representative of the lowest and highest level of regional development in the country. Andalusia, located in the south of Spain, is considered an objective 1 region in the European Union, with a relatively large territory, low development level, and highly specialised in agriculture and in the agro-food industry. The Basque Country is an industrialised region of the north of Spain, with a high development level, relative small territorial dimension and socio-political problems. The geographical level of this study is regional, and its economic level is situated in the productive system, instead of considering the whole country and the complete set of economic relations. Regional, instead of national, and productive systems, instead of the whole exchange net have been chosen in the analysis to avoid an excessive generalisation in the study and in the conclusions, to make a more realistic research and to obtain more credible findings. There are particularities at regional level, showing the countries heterogeneity, that have great importance when trying to understand their productive structures and their differences in development and growth. The two selected regions are compared in two different years, 1980 and 1995, looking for conclusions related to the existence and persistence of development interregional differences.

Productive systems have a fundamental role in the explanation of interregional development differences, therefore regional systems are compared to test, in chapter five, a set of hypotheses establishing relationships between productive systems structures and differences in regional development. The research intends to clarify the importance of structural factors on regional development paths.

The proposed hypotheses will be tested by applying mechanism causality, because through the application of social network analysis the explanation of phenomena occurring at a macro level are found in its underlying structure, that is, in the process occurring at an inferior level, which in this analysis is the level of the firms that form productive branches making the production and productive systems.

Finally, the main conclusions that can be drawn from this work have been summarised in chapter six.

2. THE NETWORK PERSPECTIVE AND THE CONCEPT OF PRODUCTIVE SYSTEM

2.1. Introduction

The focus of this chapter is to show the main aspects of the methodological perspective adopted in this research. The main methodology applied is the *network perspective*, and therefore it seems necessary to expound first of all the basic ideas of this perspective, its foundations, and its main concepts. Complementary to this, *input-output analysis* is applied as well, but it is a perspective that is already well known in economics and does not constitute the main methodological approach.[1] Its main characteristics are explained in the third chapter which examines the method and the data.

As one the main objectives of this research is the identification of linked groups of productive sub-sectors, the explanations presented in this chapter will show the suitability of the selected network methodology to cover this objective.

The *network perspective* is considered a research methodology that offers a particular view for the study of agents of any type as social related actors. The distinctive character of this methodology is its *structuralist* nature, as the focus for analysis is the relationships maintained among the agents under study.[2] There are basic concepts brought or accepted in this perspective contributing to the development of a proper method of analysis, and therefore contributing to the acknowledgement of the perspective as a methodology or even as a paradigm. Some of those concepts are: *network*, *embeddedness*, *weak and strong ties*, *bridges*, *structural holes*, and *social capital;* all of these focus on the understanding of diverse types of groups of related social actors.

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[1] The economic literature focused in input-output analysis is very vast; some of the basic references are Leontief (1951, 1967, 1977 and 1985), Rasmussen (1956), Dorfman, Samuelson and Solow (1958) and Schultz (1977).

[2] Although information about attributes is considered in some studies applying network analysis, this is done only in a complementary form to enrich the research. The main characteristic of this approach is its relational character.

The network methodology can be applied to the analysis of groups of actors of any kind, and therefore it is applicable to the study of economic organisations acting in a social structure as related agents. When this methodology is used for economic studies, there are contributions of both economics and sociology in the analyses, and the concept of *embeddedness* allows for the co-ordination between both disciplines. Therefore, the approach and the concepts offered by *network analysis* are available for the study of economic organisations, allowing for the proposal of theories, depending on the kind of research to be done, such as the *exchange theories*. There are several empirical studies explaining the behaviour and performance of economic organisations as exchanging economic actors, each of them focused on concrete agents such as firms, groups of firms, other economic institutions, or productive sectors, and in particular relationships such as organisation charts, input-output relationships, trust or friendship (Scott, 1987; Krackhardt, 1992; Perrow, 1992 and Uzzi, 1996 among others).

More specifically, when the units of analysis are groups of exchanging firms or productive sectors, there appear in the literature a set of concepts proposed to study the behaviour of such groups, such as those of *productive systems*, *production systems* or *industrial districts* among others. These can all be considered as networks of economic organisations, and therefore can be analysed from the network view. Of all these the *productive system* is the most general concept, considering the possibility of a broad set of relations and economic agents, in addition to the exchanging firms. For this reason this is the chosen concept in the present research, for the identification of groups of related productive sub-sectors and institutions in selected geographical areas inside Spain, through the application of the *network perspective*. In addition to the identification and analysis of *regional productive systems*, the *input-output analysis* is applied through several indices, for a better explanation and characterisation of the selected systems.[3]

For a clearer exposition the following section of this chapter is dedicated to the explanation of the main characteristics of the *network perspective*, as a methodology for

[3] The input-output indices are explained, together with a brief exposition of the input-output theory, in chapter three focused on the description of the methods and the data.

analysis in several disciplines. Section 2.3 adapts the methodological foundations of the perspective to the case of economic organisations, showing a literature review in that area. The last section is even more concrete, adapting the *network perspective* for economic organisations to several concepts appearing in the economic literature to name and identify groups of firms or of productive sectors. With reference to those concepts, the *regional productive system* appears as the most relevant, and therefore it is selected for its identification and characterisation in the next chapters.

2.2. The network perspective

This section shows the basic aspects of the *network perspective* as a research methodology, considered by several authors as a paradigm,[4] according to which the analysed agents, as any group of social actors, are embedded in networks of social relations. The structure of the social nets is crucial to understand the opportunities and restrictions of actors in accordance with their positions in them. The networks and their structures are studied by analysing the relations maintained among agents, in contrast to traditional analyses focused on the attributes of the actors.

As any network is embedded in a more complex one, the establishment of limits is necessary, and therefore the researcher chooses the kind of agents and the kind of relation under analysis. Depending on this choice and on the planned objective, several theories have been proposed following the present perspective.[5] All the theories apply certain concepts that are essential for the approach, such as those of *embeddednes* and *social capital* amongst others. All those terms are necessary for the explanation of the structure and evolution of the network and the identification of actors in special positions.

In an attempt to offer a clearer exposition, this section is divided in two parts, the first one refers to the presentation of the perspective as a methodology that focuses on the relationships maintained among any kind of actor. The second part is dedicated to the

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[4] Some authors referring to it as a paradigm are Nohria (1992), Emirbayer and Goodwin (1994), Degenne and Forsé (1999) and Wasserman and Faust (1994).

[5] See Monge and Contractor (1998) for an overview of theories applying network analysis.

definition and explanation of the main theoretical concepts applied by the *network perspective*.

2.2.1.- The network perspective as a relational methodology

Social network analysis, generally known as the *network perspective* is considered a methodology, even a paradigm, applicable to several disciplines, offering a set of methods for the systematic study of social structures.

As we will be able to see through this chapter, the *network perspective* has its own concepts, methods, and what is more important, a methodological view, according to which the main aspect for analysis is the existing set of relations among the agents under study. It is therefore also considered a *structuralist perspective*, given that the structural position of individuals or groups in the set of relations they maintain explains the regularities in their behaviour, and the opportunities and restrictions of action for the actors involved.

Any kind of agent can be analysed: individuals, organisations, institutions, countries or regions. In general terms the unit of analysis is not the individual, but an entity that can consists of a collection of individuals, and the linkages among them. The agents are studied from the view that the main explanation for their behaviour and the results of such behaviours are the relationships maintained among them.

The ties or linkages among the members in the network analytic framework may be any relationship existing between units. The perspective is therefore focused on the relational structure of a group of entities, and the properties of that relational system.

According to Degenne and Forsé (1999, p. 2): "Network analysis analyses *overall relations* in an inductive attempt to identify behaviour patterns and the groups or social strata that correlate with those patterns. Then, it sorts out the pertinent groups *a posteriori* and *identifies the concrete constraints of structure on behaviour at the same time as it uncovers constraints on structure from group interactions*".

From a methodological point of view, the *network perspective* is not *reductionist*, but holistic, as opposed to individualistic, and interdisciplinary. The actors are purposeful, intentional agents, with social and economic motivations, and their actions are influenced by the net of relations in which they are *embedded*.

The *homo economicus* studied by the economic theory is compatible with the network perspective and the inclusion of social relations, as actors are considered rational and acting to achieve goals according to their personal preferences.[6] Nevertheless, there are constraints in the structure of the network interfering with individual actions and influencing the probability of achieving some goals.[7]

By giving precise formal definitions to aspects of the political, economic, or social structural environment, the *network perspective* makes it possible to answer social and behavioural research questions.

In general, the environment in which agents act is characterised by a particular structure in which they behave according to their preferences, and therefore with capacity of modifying the original structure through the effect of interactions among them. In that manner, the network in which the agents are embedded is evolving and changing.[8]

The agents and the relationships maintained among them form a *social network*, where the position of every agent is a key element shaping its general structure, implying opportunities as well as restrictions for the involved actors. The structure of the network explains the results caused by actions, moreover, the form of the network has a major impact on the process of exchange of any kind, in a way in which the structure affects the exchanges and at the same time it is the product of elementary interactions.

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[6] This bases on Granovetter (1985) and will be discussed in section 2.3.1.

[7] "The structural perspective is deductively superior to normative action since its use of network models provides a rigorous algebraic representation of system stratification from which hypotheses can be derived. It is descriptively superior to atomistic action since it explicitly takes into account the social context within which actors make evaluations", Burt (1982), in Degenne and Forsé (1999, p. 11).

[8] Deeper reaching arguments in this respect can be found in Burt (1982), Leydesdorff (1991) and Degenne and Forsé (1999).

According to Wasserman and Faust (1994), the central principles underlying the *network perspective*, in addition to the use of relational concepts, are:

- Actors and their actions are viewed as interdependent rather than independent, autonomous units.
- Relational ties, or linkages, between actors are channels to transfer or for the flow of resources, either material or nonmaterial.
- Network models focusing on individuals view the network structural environment as providing opportunities for or constraints on individual actions.
- Network models conceptualise structure (mainly social, economic and political), as lasting patterns of relations among actors.

In Emirbayer and Goodwin (1994), the underlying theoretical presuppositions and conceptual strategies of *network analysis* are the priority of relations over categories, and that relational and positional analyses are ways of representing social structure. In accordance to the first presupposition, the authors focus on what they call the *anticategorical imperative*, according to which network theories build their explanations from relations instead of attributes, from patterns of relations. Following the second aspect referring to the relational analysis it is noted that both direct and indirect connections among actors explain social networks. With respect to positional analysis the importance of the ties' nature is underlined, not from one actor to another, but to third parties.

For the application of the *network perspective* there is not only one particular theory or model recommended, as this will depend on the kind of actors and relations under study, and on the necessity to focus on some aspects to develop the research. When choosing a theory it is important to bear in mind that any structure is always embedded in a larger one which consists of all the influences that remain outside of the defined model. Therefore, it is one of the researchers' tasks to decide on the limits of the network, the level of network or sub-network, the kind of relations and the unit or entity to be studied, everything according to theoretical and practical considerations and to the subject proposed in the analysis.

As has been remarked, structural and relational information is used to study or test theories; nevertheless, information about attributes of actors can be very useful to complement the analysis.[9]

Monge and Contractor (1998) present the following theories as explicative of the emergence of networks, considering that the theoretical basis for any study can be diverse, and therefore it could be useful to use aspects from more than one theory in a particular study:

- Theories of self-interest: theory of social capital and transaction cost economic theories.
- Theories of mutual self-interest and collective action: collective action and mobilisation and collective action and the adoption of innovations.
- Exchange and dependence theories: power, leadership, trust and ethical behaviour, resource dependency theory and power in inter-organisational networks, corporate elite and interlocking groups of directors, creation, maintenance, dissolution and reconstitution of inter-firm links and network organisations.
- Contagion theories: general workplace attitudes, attitudes towards technologies, behaviour through contagion and inter-organisational contagion.
- Cognitive theories: semantic networks, network organisations as knowledge structures, cognitive social structures and cognitive consistency.
- Theories of homophily: general demographic homophily and gender homophily.
- Theories of physical and electronic proximity.
- Uncertainty reduction and contingency theories.
- Social support theories.
- Theories of network evolution.

Therefore, there is a wide set of proposed theories to apply the network perspective to different objectives, actors and relations. All the theories follow the principles of the *network approach* presented before, and all of them use the main concepts explained next.

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[9] For some authors, as for DiMaggio (1992), it is not possible to disregard the actors' attributes when studying social networks.

2.2.2. Main theoretical concepts in the network perspective

There are some network concepts that are essential in the perspective, from a theoretical and from a practical point of view. They are interrelated among themselves, as each one refers to the characteristics of the agents, the relationships, or the network as a whole.

The notion of *network* has already been mentioned in the previous section, as a concrete set of actors and the defined relation or relations connecting them. The actors can be individuals or groups, and the ties can be formal or informal. Therefore, a group of related organisations is considered a network, but at the same time the organisation itself is also considered a network. Moreover, as networks are made of agents and relationships they change according to both of them.

"Networks are constantly being socially constructed, reproduced, and altered as the result of actions of actors (...) Therefore networks are as much process as they are structure, being continually shaped and reshaped by the actions of actors who are in turn constrained by the structural positions in which they find themselves". Nohria (1992, p. 7).

As every network of agents and relations is embedded in a more complex one, social networks have no natural frontiers, and therefore it is a methodological problem, faced by the researcher, to decide the boundaries and the relations to be studied. For Tichyet *et al* (1979), and Brass and Burkhardt (1992), the basic network types are defined by the following relations: exchange of goods and services, exchange of information and ideas, and affective relationships or liking.

The relationships maintained among actors, the ties, have different intensity depending on which actors they are linking. According to Granovetter (1973) it is possible, and useful, to distinguish between *strong and weak ties*. For Granovetter, there are four factors defining the strength of a tie: amount of time, emotional intensity, intimacy, and reciprocal services.[10] But the notions of *strong and weak ties* have been applied to any

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[10] "The strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterise the ties", Granovetter (1973, p. 1310).

kind of network, even for organisations and institutions. The important thing is that *strong ties* are linking actors belonging to the same group, actors interacting with high frequency. But a *weak tie* will be the one between the member of a group and the member of a different group, that is, the agents linked by a *weak tie* do not belong to the same group, and therefore that link constitutes a *bridge*. *Weak ties*, acting as *bridges*, provide agents with access to information and resources beyond those available in their own social groups.

When there is more than one path to connect or link two agents belonging to different groups, but one of them is particularly short in relation to the others, such a *weak tie* constitutes a *local bridge*. As every group, or net, is *embedded* in a more complex one, *bridges* imply cohesion and accessibility to resources and information. *Weak ties* are especially useful in the diffusion of innovation among agents, in this case, individuals with many *weak ties* are often called *liaison persons*. That person or actor connects two network sectors and all his ties into one or both sectors are weak. For Granovetter (1973, p. 1368), this situation is particularly important when talking about the diffusion of risky innovations.

When analysing the structure of a network it could be feasible to find groups, or small networks, which are weakly connected. Then, between every two weakly tied networks there is a hole, or what Burt (1992 and 2001) names as a *structural hole*. *Structural holes* show the opportunities for some strategic agents to allow for the flow of any exchange among groups or networks. The existence of *structural holes*, and therefore *bridges* and *weak ties* implies the existence of a potential for some agents as a characteristic of the structure of the network.

At the same time, a high cohesion of the net, with many strong ties and therefore high density, implies feasible co-operation and co-ordination among the agents building the network. This is, again, a characteristic of the network structure with positive implications.

Consequently, the relational structure of the network is a resource emerging from it, available for its exploitation in the benefit of the group. This structural resource is the *social capital*, which is present in every network regardless of its size and scope, as all social relations and social structures facilitate some forms of *social capital.* However, it acts with different intensity depending on the structure because it emerges from the relations or links maintained among the actors constituting the network. Therefore the social structure is a kind of capital i.e. *social capital* that can create for certain individuals or groups, holding a certain position in the structure, advantages in pursuing their ends and therefore better connected actors enjoy higher returns. "By analogy with notions of physical capital and human capital – tools and training that enhance individual productivity – "social capital" refers to features of social organization, such as networks, norms, and trust, which facilitate coordination and cooperation for mutual benefit. Social capital enhances the benefits of investment in physical and human capital". Putnam (1993, p. 2). According to the same author, and others such as Coleman (1988), the productivity of *social capital* makes possible the achievement of certain ends that would not be attainable in its absence.

Social capital is seen at present as a vital factor for economic development at any level, helping to formulate new strategies for development:[11] relationships are a strategy for development and growth.

For Coleman (1988), the notion of *social capital* is a way of introducing social structure into the rational action paradigm, and therefore connecting sociology and economics. With rational action, and through *social capital*, each actor has control over certain resources, and interests in certain resources and events.

The relationship *between structural holes* and *social capital* is not clear at all, although it seems generally accepted that *social capital* is bigger in the case of networks with strong links inside them, with high closure, and with many *weak ties* acting as *bridges* through *structural holes* linking them with other networks (Burt, 2000).

For Burt (2001), the network mechanisms that theoretically define *social capital* are *network contagion* and *prominence*, *network closure* and *structural holes*. The first mechanism refers to the case in which the social structure facilitates the transmission of

[11] "Where you live and whom you know – the social capital you can draw on – helps to define who you are and thus to determine your fate", Putnam (1993, p. 6).

beliefs and practices among actors (people or organisations). The *Network closure* mechanism explains that in dense networks the risk of co-operation is lower and the facilities to access information are higher. For the last, s*tructural holes,* mechanism there is connection with other groups and therefore access to a higher volume of information that is in turn less redundant and attainable in less time.

According to all the above, and continuing with the main ideas presented in the previous section, the structure of a network, and the position of the actors in the net, offer essential information. The position of the agents makes it possible to obtain inferences about which agents are strategic in the network by checking if they occupy a central position or a *bridge* position. This can also be linked with the existence of power, prestige, dependency relationships, or even vulnerability.

In the case of actors in vulnerable positions, that is, positions in which they depend on one or very few other agents to maintain their relationships in the network, the existence of *social capital* through *structural holes* gives them some possibilities to reduce their vulnerability. A possible strategy is the extension of their network relations by establishing links with other actors, and another way to act is to consolidate their networks by linking the weaker vulnerable actors among them (Monge and Contractor, 1998).

One type of agent for which the situations described in this section are clearly applicable is the economic organisations, and from this point the analysis will be focused on them.

2.3. Network theories for economic organisations

This section shows the adaptation of the network methodology and concepts to the particular case in which the actors are economic organisations. In that sense, a literature review is offered together with the exposition of the link between economics and sociology through the concept of *embeddedness* proposed by Granovetter in 1985. After that, the application of the perspective as a structural analysis with its complete set of terms and concepts for economic organisations as related actors will be explained. And finally, a specific set of theories belonging to the network methodology, which are named exchange theories and which are clearly applicable to economic analysis, and some empirical studies that have already applied them will be described.

2.3.1. Economics and Sociology: the concept of embeddedness

The *embeddedness* argument, which constitutes one of the main bases in the network perspective, proposed by Granovetter (1985), offers a potential link between sociology and economics to explain business behaviour. For that author, economic interactions are embedded in a net of social and personal relationships, and explaining them by abstracting them from such a net will lead to a misunderstanding of the analysed phenomenon. A similar idea is that of Wilkinson (1983) offering an alternative methodology for the study of economics, by necessarily including the economic, social and political perspectives in every research.

What Wilkinson proposes as an alternative methodology has been always present from the classics. In the texts of Adam Smith, David Ricardo, John Stuart Mill and Karl Marx it is not possible to understand the economy without considering at the same time the ongoing political, institutional, and philosophical aspects. Nevertheless, at the time in which Wilkinson defended such alternative methodology, the leading economic paradigm was and is the neoclassical one, in which *positivism* is the prevailing theoretical perspective and it seems necessary to propose that kind of interdisciplinary methodology again.[12]

In the application of network analysis to economic studies, according to Uzzi (1996, p. 674): "Embeddedness refers to the process by which social relations shape economic action in ways that some mainstream economic schemes overlook or misspecify when they assume that social ties affect economic behaviour only minimally or, in some stringent accounts, reduce the efficiency of the price system".

The co-ordination of both perspectives, sociological and economic, embraces the concept of rational action, superimposing on it, endogenously or exogenously, social and institutional organisations. Following Granovetter, the concept of man applied in

[12] Friedman (1953) and Scott (1984) are among the most influential references discussing the concept of positivism in economics.

economic analysis is under-socialised and therefore economic researchers forget the importance of personal relations and of networks of relations, which is *embeddedness*, in generating trust, in establishing expectations, and in creating and enforcing norms.

For Coleman (1988, p. S97), the *embeddedness* is an "attempt to introduce into the analysis of economic systems, social organizations and social relations not merely as a structure that springs into place to fulfil an economic function but as a structure with history and continuity that give it an independent effect on the functioning of economic systems".

Agreeing with the notion of embedded economic networks, pre-existing social relations lead to trust and this in turn to embedded ties, trust generates subsequent commitments, which leads to reciprocated exchanges, this to concrete trust, and this again to embedded ties.

2.3.2. Structural analysis for economic organisations

A set of the network theories is focused in the analysis of organisations, considered networks and at the same time actors in bigger networks. In Nohria (1992), the basic premises underlining a network perspective of organisations are:

- All organisations are in important respects social networks and need to be addressed and analysed as such. The relationships in the whole network would be made of formal or prescribed, as organisational charts and input-output tables, as well as informal or emergent relations.
- An organisation's environment is properly seen as a network of other organisations. The most significant elements in an organisation's environment are the other organisations and the pattern of relations among them, named *interorganisational field*.[13] The organisations in that field would be suppliers, resources and product

[13]DiMaggio and Powell (1983), explain that when an organisational field is consolidated, the organisations on it start becoming more similar to one another, calling that phenomenon *isomorphism*, as a process of homogeneity. Isomorphic change can happen through coerciveness, imitation (mimetic processes), or normative pressures. According to the authors, diversity is more convenient than isomorphism, and for this reason it is necessary to know its causes for political purposes. In knowing the causes, a theory of institutional isomorphism is necessary because the theories of natural selection (invisible hand by Adam Smith), and elite control (represented by Marx), are not satisfactory to explain the changes towards homogeneity.

consumers, regulatory agencies, other organisations producing similar products or services and so on.

- The actions, attitudes and behaviour of actors in organisations can be best explained in terms of their position in networks of relationships.
- Networks constraint actions and in turn are shaped by them.
- The comparative analysis of organisations must take into account their network characteristics.

Nohria (1992) describes the importance of applying the network perspective that has been maturing as an academic discipline, to economic analysis, especially to study the emergence of new entrepreneurial firms, the formation of regional districts, the expansion of new industries, the dynamics of Asian economies and the evolution of technological developments as new information technologies.[14]

In the case of economic organisations, as for any actor in general, the structure of the network and the position of each organisation in it define the opportunities and constraints of actors forming the group. "The type of network in which an organisation is embedded defines the opportunities potentially available; its position in that structure and the types of inter-firm ties it maintains define its access to those opportunities". Uzzi (1996, p. 675).

According to the network perspective, and its application to economic organisations, a market is considered a network, constituting a group of agents and the relationships among them. In that case, the effects of maintaining concrete relations in the net can be evaluated with data on economic transactions. For market relationships, a better performance is predicted for groups with strong relations among their agents, and spanning *structural holes* allowing the access to diverse perspectives, skills, resources and technologies. Creativity and learning would be stimulated by *structural holes*, increasing in turn the competitive advantages of the actors in the group. The organisation's ability to learn would be bigger, and consequently the capacity of the firm to manage technical change. "Organizations with management and collaboration

[14] Leading to new production arrangements, new ways for internal organisation, new ways to organise ties to firms with which they transact, and therefore creating manufacturing and telecommunication networks.

networks that more often bridge structural holes in their surrounding market of technology and practice will learn faster and be more productively creative". Burt (2000, p. 24).

The analysis of *structural holes* for the study of economic organisations is particularly interesting. For Burt, the holes imply *entrepreneurial opportunities*, with organisations in *bridge* positions having access to information, resources and innovations. This situation would increase the *social capital* of actors in those positions.[15] Although cohesion or *network closure* would also increase it, a network rich in entrepreneurial opportunities is considered by Burt (2000) an *entrepreneurial network*, with actors building *bridges* and spanning *structural holes*.

Firms or organisations in general, in strategic exchange positions with other firms and institutions are key diffusers of innovation, knowledge and behaviour strategies. Such organisations are potential participants for common projects and investments, among other sharing opportunities. In that way, the profits obtained owing to their position are reinforced, allowing them to reach even better results. As a consequence, even inside their own networks, made of groups of firms exchanging goods and services, those organisations are considered very attractive firms.

In market studies the *social capital* of *network closure* and that of *structural holes* are considered complementary. There is a high performance when spanning *structural holes* beyond the group, and showing strong relations within the group mainly through communication and co-ordination.

In market relations, the economic organisation acts as a rational agent according to its preferences, and at the same time establishes relations of co-ordination and trust with the other organisations, working in embedded networks instead of in an atomistic mass of discrete firms. Nevertheless, firms can decide to maintain strictly competitive or commercial relations with some firms, and to develop informal relations with other group of firms. In the first case, there are firms needed for the productive process,

[15] S*ocial capital* is in essence social structure as it will be seen in section 2.4.

without or with a minimum of *embeddedness*, in the second case there are multiple, formal and informal, and therefore embedded relations.

At the same time, routine trade relations and embedded ties are maintained. The embedded ties exist among the firms maintaining a continued and high level of transactions, while the competitive relations are those which are specifically necessary for developing the business. Those necessary relationships maintained with a specific group of firms would be dependency relations that, according to the *dependency theory*, would imply power relations, as dependency is considered the basis of power.[16] This would be the case in which a firm decides to trade with a particular firm for economic reasons, cost decisions, scarceness of sources, or distance problems among others.

In the case of economic sectors as the unit of analysis, the main dependency reason is a technological one owing to the productive process. In most of the cases the economic sector, acting as an actor in the network, can not choose alternative sectors. Although it is convenient to consider the possibility of certain intermediate inputs that can be substituted by others, focusing on economic reasons as in the case of firms, probably in a longer period and under less flexible conditions depending on each productive process. One of the decision factors considered by a productive sector or branch, when selecting another branch for the exchanges, would be that of location. Proximity determines in an important respect the exchanging partners for cost reduction, reputation and trust search, information and innovation exchange, and other important aspects.

2.3.3. Exchange theories and empirical studies

As has been explained and underlined before, the network perspective is applied as a methodology to several researches, with different objectives, focuses, actors and relations. It is the researchers' task to decide, according to their particular study, the theory to be applied in each particular case.

[16] For Benson (1975) organisations are dependent upon their positions in the network, because the networks are mechanisms by which organisations acquire and dispense scarce resources, and therefore create and perpetuate a system of power relations. Following that idea, Pfeffer and Salancik (1978) formulate a *resource dependency theory*.

In that sense, some researchers specially interested in the study of economic relations, apply exchange theories following the network perspective, deciding the actors, relations and limits of the network to be analysed.

"We also need a distinction between the competitive market situations dear to economists, and networks of local elites or organizational actors. In an ideal free market environment, any two actors can theoretically exchange resources. In a network, more parameters are involved. In particular, actors must share mutual trust and links may be direct or indirect. In addition, each position has a specific 'value', e.g. Cutpoints have options of control and exchange not available to other nodes. All these factors must be taken into account to determine the power, prestige and influence of each actor". Degenne and Forsé (1999, p. 146).[17]

According to Markovsky *et al* (1988), following Cook *et al* (1983), an exchange network can be defined with the following characteristics:

- A set of actors, either people or corporate groups.
- A distribution of valued resources among those actors.
- For each actor a set of exchange opportunities with other actors in the network.
- A set of historically developed and utilised exchange opportunities, called exchange relations.
- A set of network connections linking exchange relations into a single network structure.

Jones *et al* (1997) provide a theory of exchange, to explain under what conditions *network governance* has comparative advantages. Following that theory, economic organisations use social mechanisms to co-ordinate, adapt and safeguard exchanges. By doing that, the *network governance* form shows advantages over both hierarchy and market solutions. "The theory says that the network form of governance is a response to exchange conditions of asset specificity, demand uncertainty, task complexity and

[17] *Node* is the technical name for an actor in the network. A *cutpoint* is a node in a network whose removal would increase the number of connected *components* in the net. A *component* is a group of *nodes* which are all interconnected among themselves and without connection with any node outside the group. The removal of a *cutpoint* divides the network in more subsets without connection.

frequency. These exchange conditions drive firms toward structurally embedding their transactions". Jones *et al* (1997).

Network governance is understood by the authors as inter-firm co-ordination, characterised by organic or informal social systems, in contrast to bureaucratic structures within firms and formal relationships among them. The theory is proposed for the case of sets of autonomous firms and non-profit agencies, engaged in creating products or services based on implicit and open-ended contracts. The set of organisations taking part in the exchanges are persistent, working repeatedly with each other over time, and structured according to exchanges that are patterned reflecting a division of labour.

For organisations working according to the above conditions, the frequency of exchanges is fundamental. Frequency facilitates transferring tacit knowledge in customised exchanges, mainly for specialised processes. According to Jones *et al* (1997), frequent interactions are what establish the conditions for relational and structural *embeddedness,* what in turn provide the foundations for social mechanisms to adapt, co-ordinate and safeguard exchanges effectively. The necessary conditions for network governance to emerge are demand uncertainty with stable supply, customised exchanges high in human asset specificity, complex tasks integrating diverse specialists, and frequent exchanges among parties comprising the network.

In the demand uncertainty with stable supply condition, it is considered that unknown and rapid shifts in consumer preferences, rapid changes in knowledge or technology, and seasonal variations, lead to demand uncertainty and outsourcing or subcontracting.

When the second condition, of customised exchanges high in human asset specificity, is included, then participant knowledge and skills, and therefore human asset specificity, are considered in the exchanges through customisation. Moreover, this participation increases the dependency among the exchanging parties, increasing the necessity for co-ordination among them. In that sense, co-operation, proximity, and repeated exchanges, are required to effectively transfer tacit knowledge among parties. Co-ordination is not enhanced by market mechanisms, but there is a tendency to dis-aggregation and therefore the necessity for co-ordination and integration. Following those circumstances, network governance enhances the rapid dissemination of tacit knowledge across firm boundaries.

According to the third condition, of complex tasks integrating diverse specialists, the fact that task complexity requires different specialised inputs to complete a product or service is taken into account. Therefore, there should be behavioural interdependence and need for co-ordinating activities. Simultaneously, time pressure provokes the necessity to reduce lead-time in rapidly changing markets or to reduce costs in highly competitive markets. Therefore, team co-ordination means that diversely skilled members are working simultaneously to produce a product or service in more efficient conditions.

Following the last condition above (frequent exchanges among parties comprising the network), frequent exchanges and human asset specificity helps the transfer of tacit knowledge among parties. Moreover, with reciprocity in frequent exchanges, *embeddedness* is being developed.

The combination of all the above conditions promotes structural *embeddedness* among exchange parties through the following social mechanisms: restricted access to exchanges in the network, *macroculture*, collective sanctions and reputation.

When there is restricted access to exchanges in the network, continued interaction may "substitute for internal socialisation process, and permit exchange partners to learn each other's systems, develop communication protocols, and establish routines for working together, all of which enhance co-ordination" Jones *et al* (1997). Restricted access generates more interactions, more knowledge about each other, less incentives for opportunism, less costs of monitoring, and higher co-ordination.

Macroculture refers to shared assumptions and values, leading to specific actions and therefore to behaviour patterns. *Macroculture* is enhanced by close geographic proximity, increasing the likelihood and ease of interaction. Network governance is expected to be found in geographically concentrated areas.

Collective sanctions involve group members punishing other members who violate group norms, values or goals, reducing behavioural uncertainty.

Reputation increases and improves information about the reliability and goodwill of others, reducing behavioural uncertainty.

The interaction of the above social mechanisms decreases co-ordination costs, enhances safeguarding customised exchanges, and increases the likelihood of emergence of network governance. “Since network governance is a select, persistent and structured set of autonomous firms, it is not enough to call an industry or region a network without examining relations among firms and how these relations complete a product or service”. Jones *et al* (1997).

Another exchange theory is proposed by Degenne and Forsé (1999) talking about a global dynamic theory of exchange, for which there could be positively and negatively connected networks. The connectivity in exchange networks would make an exchange occurring through a link to be affected by other exchanges through other links. In the case of positive connectivity, co-ordinated action and group integration depend on co-operation among network members. With negative connectivity, co-ordinated action and group interaction depend on competition. Moreover, when there is positive connectivity an exchange increases the probability of other exchanges; in the case of negative connectivity that probability falls

According to Degenne and Forsé (1999), in most real life situations there is a mix of positive and negative exchanges. Moreover, following Coleman (1973), rational behaviour of actors generates an interactive mix of self-interest and control. Usually there is collective action in those networks, and there is uncertainty affecting the links. “If no single actor can achieve the goal alone or award herself the total payoff, the system of actor is defined as a network of mutual dependencies. Each actor and her special interests are dependent on the other actors for achievement”. Degenne and Forsé (1999, p. 143).

In the research made by Perrow (1992) the network perspective is applied to the study of *small firm networks*. The firms in the network compete and interact by sharing information, equipment, and personnel among other things, with one another. In the group there are firms supplying raw materials; other group supplying equipment, energy, and so on; there are business and financial service firms.[18] The number of producers is high and there are distributors and customers together with an infrastructure surrounding them, consisting mainly in local and regional government, trade associations, and unions. Applying these characteristics, the author asserts that *industrial districts*, is another term for small firm networks. In the defined situation firms can react more quickly and fruitfully to changes in technology and markets. Firms act maximising their individual self-interest, but trust and co-operation coexist with competition, there are external economies of scale derived from networks, and this environment has positive effects for the efficiency of the region and of the industry.

One of the main conclusions obtained from the application of the network perspective to exchanging organisations is the importance of trust relations. As we are showing at this point, according to the results obtained through several studies, trust and embedded relations emerge in situations of continuous exchanges.

In the case study developed by Krackhardt (1992), the relationships of a selected firm are analysed, concluding that informal relations implying trust are the prevailing ones in situations of crisis or radical change. But, under normal conditions it is possible to know the structural positions of such organisation attending to formal network relationships.

Moreover, when there are informal relationships among economic organisations based on trust, there is a continuity of their relationships, the organisations concentrate on the exchange and reduce their search for alternative information sources. For those reasons, a relation of trust is behind an exchange relationship maintained continuously among organisations, even if the value of trust can not be seen or checked. In consequence, the existence of trust increases the *embeddedness* of the firms in such groups.

According to Gulati (1995), through ongoing interaction firms learn about each other and develop trust, and inter-firm trust is increasingly built as firms repeatedly interact. Therefore, the author proposes prior alliances between firms as a proxy to measure trust.

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[18] Supplying basically, business surveys, technical training, personnel administration, transport, research and development and so on.

Moreover, trust is more likely to be built in reduced geographic areas, as it is expected that firms trust domestic partners more than others. When distance among organisations is short, there is more and better information available about firms and the reputation consequences of opportunistic behaviour is greater in a domestic context. For the author, and following Bradach and Eccless (1989), the primary control mechanisms governing economic transactions among firms are price, authority and trust.[19]

The research done by Uzzi (1996), through the analysis of questionnaires sent to a group of firms, shows that there are embedded ties among the firms maintaining a stronger trade relationship. Following that idea, the author measures *embeddedeness* applying indices built with data on intermediate goods exchanges. The main result is that there is high *embeddedness* when firm exchanges are concentrated in trade relations maintained with a few other firms; in the opposite case, with low or non-existent *embeddedness*, there is a big number of contracted firms.[20] His conclusion is that a firm sending more than 20% to 25% of its business to an exchange partner, maintains an embedded tie, otherwise it represents a competitive tie. According to the answers in the questionnaires received, it was unlikely for a firm to have concentrated exchanges with another firm unless an embedded tie existed.

There are other studies focused on relations among economic organisations applied to particular sets of actors and relations, for example: Levine (1972, 1985 and 1987), Mintz and Schwartz (1981), Stokman and Wasseur (1985), Palmer *et al* (1986), Scott (1987) and Berkowitz (1988).

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[19] The author mentions Arrow (1974) asserting that trust is perhaps the most efficient mechanism for governing economic transactions, as it reduces costs.

[20] The authors uses two different complementary indices, a first order network coupling (1) and a second order network coupling (2), with values between 0 (no embeddedness) and 1 (embedded relations):

(1) $\sum_{j=1}^{n_m} p_{ij}^2$ where $p_{ij} = \frac{x_{ij}}{x_i}$, and x are outputs. (2) $\frac{\sum_{j=1}^{n_m} Q_j}{n_m}$, where $Q_j = \sum_{i=1}^{n_s} D_{ji}^2$, $D_{ji} = \frac{x_{ji}}{x_j}$, and x are inputs.

2.4. Relationships among firms and productive branches: the concept of regional productive system

Firms and productive branches are two types of actors complying with the conditions expressed in the previous sections.[21] For them, all the analysed aspects about methodology and concepts, as actors in general and as economic organisations in particular, are applicable. Nevertheless, when those groups have been studied in the literature, the network perspective has been rarely considered especially in the case of productive sectors and branches. Some references are Leoncini and Montresor (2000) and the articles included in Lahr and Dietzenbacher (2001).

There are several concepts appearing in the literature for the identification of groups of related firms or of productive branches, all of them can be identified and analysed by applying the network perspective. Some of those concepts have already appeared in the previous sections, as it is the case of *small firms networks* and *industrial districts*, but there are some more, depending on the actors that are considered to be the unit of analysis, but mainly depending on the selected relations for the research.

More specifically, the literature focused on the identification of linked productive branches or firms, uses one or another term depending mainly on the emphasis on social relations, if any at all, as well as on the geographical factors affecting them.

In that respect, we can find research studies trying to identify *Productive Systems* (Wilkinson, 1983; Lawson, 1999), *Production Systems* (Storper and Harrison, 1991), *Regional Business Clustering* (Lawson, 1999), *Industrial Districts* (Harrison, 1992; Feser and Bergman, 2000), *Industrial Complexes* (Streit, 1969; Roepke, Adams and Wiseman, 1974), *Technological Regimes* (Breschi, 2000), *Industrial Clusters* (Feser and Bergman, 2000), or *Regional Productive Systems* (Asheim and Dunford, 1997).

The wider concept, considering a broad range of relations, and therefore concerned with social relations and informal linkages together with market formal relations, is that of *productive systems*. A *productive system* is understood as being made by complex

[21] Branch is the name for groups of firms, or groups of parts of firms, dedicated to related productive activities and therefore leading to a more dis-aggregated classification than that of the productive sectors.

interactions of technical, economic, social and political nature taking place in historical time. For Wilkinson (1983) the concept of *productive system* is such a general one that it provides the basis for analysis at any level: firms, industrial districts, regions or even nations. The understanding of the *productive system* in an identified social context differentiates it from the more common concepts of *industrial complexes* and *production systems*.

The two mentioned concepts, *industrial complexes* and *production systems*, relate only to formal market relationships, without considering explicitly any kind of informal, social or interpersonal linkage. In Roepke *et al* (1974) an *industrial complex* is a group of industries having similar patterns of transactions and including other industries, which are major suppliers or markets for those within the group. The *industrial complex* can be understood in a spatial (Campbell, 1970; Czamanski, 1971) or aspatial context (Israd and Smolensky, 1963; Streit, 1969). A *production system* refers to a set of production units linked by their input-output structure, and as Storper and Harrison (1991) assert, it can be identified considering factors territorially.

Economic transaction is the characteristic which links firms and groups of firms in the two concepts above. Therefore, inter-related groups are identified applying the trade criterion. But, when other kinds of factors are specifically taken into account different concepts appear. This is the case of *regional business clustering*, *industrial districts*, *industrial cluster*, *regional cluster* and *socio-economic regions.* All of these are subsets of the wider *productive system*, as they include some of the following factors: un-treaded interdependencies, industrial atmosphere, local institutions, informal and formal co-operation, learning and knowledge, collective technical culture, personal interactions, trust and experience or collaboration. That is, some kind of non-economic or non-formal relation is added to the trade one, but without considering the whole social net in which such relations are embedded as would be the case for *productive systems*.

For all the terms above the location fact is determinant for the linkages among productive units, reinforcing and facilitating them. Location is shown as an important determinant of relations, as it comprises distinctive institutional, cultural and historical characteristics. Considering the importance of location factors, the concept of *productive system* would be that of *regional productive system*.

We should be aware that for the terms listed above, and considered subsets of the *productive system* concept, there is not only one accepted definition. Therefore, different authors add more or less social factors to their particular analysis in the necessary establishment of boundaries. For the case of *industrial clusters*, the focus is input-output relationships, but sometimes considering linked institutions influencing the competitiveness of the group (Redman, 1994), the synergies achieved with geographical concentration (Rosenfeld, 1995), or the effects of a specific spatial context in the more particular case of *regional clusters*.

Having in mind that *regional productive systems* (Asheim and Dunford, 1997) are viewed as *productive systems* for which the location and non-economic factors are of great importance, a characteristic form of *regional productive systems* is *industrial districts* (Harrison, 1992; Feser and Bereman, 2000).

In *industrial districts* local intra firm linkages are substantial and happening at local level. Firm boundaries are flexible and there is a co-operative competition among firms. Therefore trust is very important as there is continuous collaboration in the district. Firms belonging to the district are small and medium ones, and the relationship among them does not have to be an input-output one necessarily. They can be related through the sharing of tools, information or skilled personnel. According to Becattini (1989) the firms in a district are held together because of a complex of external economies and diseconomies of joint and associated costs and historical and cultural vestiges enveloping both inter firm and interpersonal relationships. For some authors such as Granovetter (1985) trust, which comes from experience, is a key in the emergence of informal ties that are deeper than mere contracts. And trust requires personal contacts and therefore geographical proximity. Firms inside an industrial district experience a combination of co-operation and competition among them.

When talking, in most general terms, about that kind of associational structure considered in location terms, the proper term including the whole set of relevant factors is that of *regional productive systems*. According to this, the consideration of institutions, social structures and even cultures and traditions are necessary to understand the most important links among firms. Those links are based on knowledge, learning, know-how, disembodied technology, and positive externalities coming from innovation processes. Agglomeration is of great concern for the better understanding of knowledge, learning and innovation flows. For this reason, and because of the existence of collective technical culture and institutional framework, the geographical question is fundamental to study such *regional productive systems* (Storper and Scott, 1995; Desrochers, 2001; Porter, 1996). Other very important factors are: un-traded interdependencies, tacit and codified knowledge generating learning by doing, learning by using and learning by interacting, and moreover interactive learning by co-operation among firms and also with local authorities.

For Wilkinson (1983) the parts constituting a *productive system* are labour power, means of production, methods by which production is organised, structure of ownership and control of productive activity, and the social and political framework within which the production process operates. Therefore the success of a *productive system* will depend on its comparative advantages in terms of its economic, technical, political and social organisation. In such a way it would acquire a strong competitive position.

The existence of this kind of nets or *regional productive systems* can be deeply understood when the importance of trust and co-operation are considered. Those two factors, happening in a particular institutional framework, create a structure of social relations in such a way that, in the explanation of a production process, it is not possible to talk only about physical and human capital and production process, but social capital appears as another production factor becoming essential for the firms.

Recognising the role of *social capital* in contemporary capitalism, understood as a learning economy (Morgan, 1997), know-how and tacit knowledge are the intangible and invisible key factors for the production processes of any firm. Therefore, knowledge, competence, skill, and organisational culture become very important for groups of interrelated firms located in a particular area and working as a social net.

In Morgan (1997), and following Storper (1991 and 1995), to study *productive systems* inside their regional location is so important because there are two main roots of learning playing a key role. Those roots are localised input-output relations, and un-traded interdependencies leading to co-ordination. The last one includes, mainly, labour markets, regional conventions, norms and values, and public or semi-public institutions; all of them should be explained in a localised or regional context. For the case of localised input-output relations, they form a net of firms related by trade flows, and at the same time those flows includes information and innovation flows. Therefore, assuming the importance of a learning process in production, it is important to realise that firms are most likely to learn from other firms, especially those which are customers, suppliers and competitors, which are related by input-output flows.

Three definitions and a theoretical claim have been discussed in this chapter in relation to the concept of social capital. Morgan's definition of social capital constitutes a particular application of the concept given by Putnam, which in turn can be placed within the most general definition referring to it as social structure, used by Burt (both concepts are discussed in section 2.2.2).

Burt's use of the term is the most general one as it refers to the relational structure of every network. Moreover, according to it, all social structures facilitate some form of social capital. Nevertheless, as has been explained in section 2.2.2, Burt argues that, depending on the structure of the network, the social capital factor will be more or less intense. In this sense, networks with high closure, and therefore strong links inside them and many weak ties linking them with other networks, will show the highest level of social capital.

The social structure definition includes Putnam's concept. His definition also refers to the relational structure of the networks, but it specifies the particular features that create and define this structure. Those features are mainly networks and norms. The existence of a net of interrelations (network) and of norms acting on the network structure makes co-ordination and co-operation easier for the mutual benefits of the actors in the social organisation. The concept of network in Putnam corresponds to the relational structure in Burt's definition. Moreover, network closure and weak ties in the social structure explanation correspond, in a more abstract form, to the facilitation of co-ordination and co-operation involved in Putnam's definition. From both perspectives, social capital reduces the risk of co-operation and facilitates the access to information.

The way in which Morgan makes use of the social capital concept fits perfectly with the two definitions discussed above. In Morgan's application of the concept, the emphasis is on the identification of the contemporary capitalist system as a learning economy. From this viewpoint, tacit knowledge, competence, skills and organisational culture are the key flows in the networks of interrelated firms working in a social network. Therefore, the concept of network given by Putnam and the social structure in Burt's definition correspond to the concept of social networks used by Morgan for the particular case of networks of interrelated firms. Depending on the structure of the network, in function of its closure and weak ties, co-ordination and co-operation will be easier, and therefore tacit knowledge will flow in a more efficient form. In fact, Morgan explicitly points out that un-traded interdependencies leading to co-ordination constitute a main root of learning in firms' networks. Among the un-traded interdependencies, Morgan includes norms and values, and those are also main factors in the social capital concept given by Putnam, which emerge in the relational structures of networks in the social structure definition.

Finally, it should be emphasised that the role of social capital as a means of linking the functioning of networks, when there are actors with a different vulnerable position, does not constitute a definition of social capital *per se*. It is instead a theoretical claim aimed to account for the empirical relevance of social capital in particular situations, where the process of integration is characterised by complexity, uncertainty and tacit knowledge. Traditionally, markets and hierarchies have been put forward in the literature as the two basic devices for integrating networks. All this will be discussed in chapter five, where the relevance of social capital, in the particular case of markets and economic structures, is discussed in relation to the efficiency of the socio-economic system and to development and where markets, hierarchies and networks, as analysed by Williamson (1983) and Ouchi (1980), are discussed and compared.

The wider *regional productive system* concept is the one to be studied in the present research, as it is the concept that considers a broadest set of relations, by applying mainly the network perspective and additionally input-output analysis. Clearly, it will not be possible to identify complete systems according to its stricter theoretic sense; rather it will be necessary to identify limited systems. Following the network methodology, some actors and specific relations will be selected from the broad net, depending on the quantity and quality of the available information and on the research objective.

More specifically, the data offered by regional input-output tables for a time period of fifteen years (1980-1995) is applied, and therefore formal trade relations are considered. Complementing that information, specific data about regional firms working in the branches classified by input-output tables are also used, in order to search for the existence of frequent trade interactions generating trust and *embeddedness*. Data about relevant institutions, as technology and research institutes are also included. Historical references considering the productive situation of every place under analysis, as well as other studies available for the same or comparable locations are of great help in the identification of the systems.

This set of information is used to consider dynamic and historical factors, and to provide a context for the systems identification and characterisation. Nevertheless, the characteristics of the data and the explanation of the specific methods applied in the research are the focus of the next chapter before the applied study is presented.

3. DATA CHARACTERISTICS AND METHODS EXPLANATION

3.1. Introduction

According to the previous chapter, the focus of this research is to study *regional productive systems* as networks of productive branches and other institutions, following a network perspective. The systems will be identified and characterised at regional level. They will be then compared in time and space to explain, from a relational structural perspective, different regional development processes. The adopted perspective implies an alternative epistemological view according to its basis, presented in the previous chapter, and its methods, explained in this chapter. For this purpose, a specific set of data has been collected, and the available methods have been studied.

Input-output analysis has been widely used in empirical studies looking for groups of interrelated sectors or branches, mainly through the application of indices to measure and classify every relation appearing in an input-output table. Those indices are explained in this chapter as they are used to complement the main method of analysis, *network analysis,* for a better understanding of the identified *regional productive systems*.

The *input-output analysis* characteristics generated the necessity of looking for another method for the groups' identification. Such method should be more in accordance with the adopted methodological perspective, explained in chapter two, should allow for the presentation of data and results in a more simplistic form than input-output indices do, and should allow for a structural analysis of the systems.

The needed method, focused on the structure of relational system, is therefore *network analysis*, which can be interestingly complemented with input-output indices.

Network analysis offers a wide set of measures for the identification of *productive systems* and for the analysis of their structures. The most important measures are explained in this chapter, simplifying them as most as possible. The main concepts and indicators are presented in such an elementary way to allow, in the next chapter when those measures are applied, for a deeper explanation when necessary.

Once the regional productive systems will be identified and characterised, their structures and evolution will be related to differentiated development patterns. This will be done through the proposal of a set of hypotheses that will be tested with mechanism causality. Therefore, this type of hypotheses testing method will be also expounded in this chapter.

In summary, this chapter is dedicated to explain the main characteristics of the data under analysis and the mentioned methods. For quantitative data, *regional input-output tables* will be used and therefore there is a section focused on the explanation of their characteristics. Other sources of information are also used, at firm level and for other institutions taking part in the *productive systems*, and therefore they are also briefly explained. Those data will be analysed in the next chapter applying the two selected methods, *social network* and *input-output analyses*. Then, the regional systems structure and evolution will offer some explanations to diverse regional development paths through mechanism causality testing.

3.2. Relevant characteristics of the used data

The principal quantitative data source for this research is *regional input-output flows*, originally elaborated by Leontief in 1951 at national level for the USA economy together with a model, the *Leontief model*, which allows for the study of inter-sectoral relationships.

Input-output data can be used in different ways and therefore the researcher should choose, according to the investigation, some data aspects. In this study input-output flows are considered in value terms, taking into account all their circularity direct and indirect connections, focused in inter-sectoral relationships eluding intra-sectoral links, using regional data and therefore avoiding extrapolations from the national flows, and considering domestic instead of total values.[22]

[22] Nevertheless, total values could be used at some point to complement the analysis for a better understanding of the obtained results.

Complementary data sources are also used: information at firm unit level for different regions and productive branches; data about regional technological centres, parks and other institutions; comparative studies for the same regions and others with similar characteristics; and historical bibliography to provide a context for the *productive systems* embedded in every region.

3.2.1. Sectoral relationships in input-output flows

Leontief offered his model in an attempt to combine an economic theory with empirical research. He explains the necessity to establish that kind of combination in the economic investigation, even if abstraction has to be done: "This chapter is concerned with a new effort to combine economic facts and theory, known as *interindustry* or *input-output* analysis. (…) It is true, of course, that the individual transactions, like individual atoms and molecules, are far too numerous for observation and description in detail. But it is possible, as with physical particles, to reduce them to some kind of order by classifying and aggregating them into groups. This is the procedure employed in input-output analysis in improving the grasp of economic theory upon the facts with which it is concerned in every real situation". Leontief (1951, p. 3).[23]

When Leontief proposed the elaboration of a table made of input-output flows and developed an analysis according to that information, he named it Input-Output or *interindustry analysis* (Leontief, 1951). "Input-Output analysis is a method of systematically quantifying the mutual interrelationships among the various sectors of a complex economic system". Leontief (1986, p. 19).

The information offered by those tables is a quantification of all the trading flows taking place among the productive branches of an economy. The model built by Leontief allows for the design of measurements to obtain specific information about inter and intra industry relationships. Consequently, *input-output* tables and *analysis*, together with *network analysis*, explained as a method in this chapter, are used further on in the research to identify and characterise *regional productive systems*.

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[23] Obtained from Leontief (1986, 2nd edition).

Briefly, the well known Leontief model can be expressed as follows:[24]

For each productive branch, production goes partially to intermediate sales and partially to final demand, therefore, in the case of the output of branch *i*, x_i, in a system of *n* branches the following equation is obtained:

$$x_i = \sum_{j=1}^{n} x_{ij} + FD_i \qquad (3.1)$$

In equation (3.1) *FD* is final demand and x_{ij} indicates the amount of *i* production sold to branch *j*.

Once *technical coefficients* are defined as in (3.2), equation (3.1) can be transformed into (3.3):

$$a_{ij} = \frac{x_{ij}}{x_j} \qquad (3.2)$$

$$x_i = \sum_{j=1}^{n} a_{ij} x_j + FD_i \qquad (3.3)$$

As this last equation holds for all *n* branches, it can be presented in matrix terms,

$$X = AX + FD \Rightarrow X = (I - A)^{-1} \cdot FD \Rightarrow X = B \cdot FD \qquad (3.4)$$

Where *A* is the *matrix of technical coefficients* and *B* is the *Leontief inverse matrix*.

The values of the *input-output matrix*, made of x_{ij} elements, are used as measurements of trade flows among sectors. Matrix *A* of *technical coefficients* will be used as a picture of the internal structure of the system. Matrix *B*, or *inverse Leontief matrix*, made of b_{ij} elements, considers all direct and indirect dependence relationships among the productive branches. Other two matrices can be built, one of them made of (3.5) coefficients, and therefore considering the weight of a trade relation on the intermediate

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[24]The Leontief model is presented here very briefly as it is very well known and it can be found in many references. For a deeper explanation of it see Leontief (1951), Dorfman *et al* (1958) and Leontief (1985).

sales of the selling branch, *IS*. The other, made of (3.6) coefficients, considers the importance of a relation on the intermediate purchases for the purchasing branch, *IP*.

$$\frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}} \Rightarrow \frac{x_{ij}}{IS_i} \tag{3.5}$$

$$\frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \Rightarrow \frac{x_{ij}}{IP_j} \tag{3.6}$$

The five matrices offer enough information to identify the kind and magnitude of inter and intra sectoral trade relationships, and therefore to apply *network analysis* and to build input-output indices helping for such identification and a better characterisation.[25]

Once the general model has been presented, the following sub-sections are dedicated to go deeply into some aspects of the Leontief model and data.

3.2.1.1 Value or physical terms

Input-output tables usually show trade flows in value terms. Therefore, when comparing two different tables or the coefficients obtained from them, changes in prices are included. There are arguments in favour and against the use of values and of quantities. Nevertheless, it is evident that prices themselves constitute a relevant variable offering important information. Bharadwaj (1966, p. 317) establishes that “if the value coefficients are to be the basis of an incentive mechanism working via the market, price changes, in themselves, play an important role”.

For Chenery and Watanabe (1958) value terms are preferred to physical terms. The main argument for them refers to practical reasons owing to the availability of data but also because at the same time the comparison in value terms is more meaningful when the interest is in the over all pattern of interdependence rather than in its details.

[25] The five matrices are: Input-output matrix, *A* matrix, *B* matrix, relative to *IS* matrix and relative to *IP* matrix.

The Leontief model (1951, 1985) allows obtaining the prices of all the branches in the system in the following way,

$$P = B^{t} VA_{u} \tag{3.7}$$

Where matrix *B* is transposed, and VA_u is the *value added* in terms of one unit of production. Matrix *B* and vector of *valued added* are needed in physical terms to achieve that vector of prices, which is quite unusual information from a practical point of view.[26]

For the identification of *productive systems* through input-output flows, the value of the transaction is of great importance when looking for the most important linkages. Value terms could be more helpful even in the comparison among regions.[27] This is because the relations maintained among sectors are tradable ones and therefore they are done in value and their changes are due to variations in bought quantities and also in price terms. Consequently, to identify a *productive system* in a place and moment current values are preferred, although to compare years values in constant and current prices could be used for comparison and to identify the characteristics of the changes.

3.2.1.2.- Direct and indirect effects

In the literature using input-output tables and model, the terms *direct* and *indirect effects* and *linkages* are widely used, but the meaning of those terms is not clear as there are two different interpretations depending on the author doing the investigation. It is necessary to clarify both perspectives to determine which will be used in this research.

For some authors the distinction between both terms refers to the last step in the relation between two branches, without intermediary branches.[28] That is, one refers to the straight flow between two sectors without going through intermediary branches (*direct*)

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[26] Nevertheless, the input-output system can be used at current and constant prices after deciding a year taken as a base.

[27] Although for time comparisons both kinds of analyses could be more useful, that is, first in current value terms and then translating them to constant price values.

[28] Some references maintaining that approach are Bharadwaj (1966), Jones (1976) and Lahr and Dietzenbacher (2001).

and the other considers all the flows in which a sector has participated to build a particular product through its sales to other intermediate sales (*indirect*).[29] Therefore, *direct linkages* can be measured with the *input-output matrix* of flows and with the technical coefficients of matrix *A*, while *total* (*direct* and *indirect*) linkages will be measured with the inverse matrix *B*.

But there is an alternative use of both terms *direct* and *indirect*. According to Rasmussen (1956), Dorfman *et al* (1958) and Hewings (1982), the *direct effect* is identified with the amount of product *i* going directly to *final demand* and not with the amount of *j* sold to *i* as the final step in elaboration of product *i*. In that case *B* can be used to identify *total* (*direct* and *indirect*) *linkages,* while to measure only *indirect effects* (*total inter-sectoral relationships* without considering the last flows going to *final demand*) the calculation should be done with the coefficients of $(B - I)$.[30]

Coefficients in matrix *A* and in the *input-output matrix* of intersectoral relations, measure the last indirect relation in the production process according to that terminology.

We shall call *inter-sectoral linkages* the ones using the coefficients of *A* and the flows of the *input-output matrix*, and *total linkages* the ones using the coefficients of *B*.

3.2.1.3.- Inter and intra sectoral relationships

Another discussion in the use of the input-output information is whether *intra-sectoral* flows and linkages should be considered.

Rasmussen (1956) suggested the use of $(B - \hat{b})$ to identify key sectors, where $\hat{b}$ is a diagonal matrix representing the *intra-sectoral* links. The remaining coefficients will consider only *inter-sectoral* relationships.[31] For the author, the inclusion of the diagonal

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[29] As an example when branch *i* sells to branches *j* and *k*, and branch j then sells to branch *k*, branches *j* and *k* have a direct relationship, but branches *i* and *k* have a direct and an indirect relationship through *j*.

[30] The coefficients in the main diagonal of matrix *B* include a 1, added to other technical coefficients, referred to the flows going to final demand. As an example, in the case of a system made of only two branches: $b_{11} = 1 + a_{11} + a_{11}^2 + a_{11}a_{21} + a_{11}^3 + a_{11}a_{12}a_{21} + ...$

[31] They are also *indirect*, according to the approach followed by the author.

in *B* would tend to equalise the indices, because of the dominating effects of *intra-sectoral* relationships. Therefore, the highest values of indices would be obtained when applying $(B-\hat{b})$ instead of $(B-I)$, and this in turn will show higher coefficients than when applying *B*.

It seems quite reasonable to operate only with *inter-sectoral* relations for the identification of *productive systems*. However, the level of sectoral dis-aggregation should be taken into account in the following way. If the sector classification is detailed enough (high dis-aggregation and therefore high number of branches), eliminating the relations that branches have with themselves will allow for a better picture of the *productive system*, following the idea of Rasmussen.[32] But if the level of aggregation is too big (low number of branches representing the whole *productive system*), the inclusion of *intra-sectoral* relations should be taken into account to include the characteristics of the region under analysis. In that last situation it could be the case of a particular sector, too aggregated, with high participation in the economy under study, including within itself a *productive system* identifiable at a lower level of aggregation.

For this reason it is of great importance to characterise *productive systems* according to the particular context of the region in which it is identified, and therefore to include other sources of information. A key sector could be acting in a region inside a system in a hardly perceivable way if the level of aggregation does not allow distinguishing particular branches that are relevant for the region.[33]

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[32] The relation that a branch has with itself is known as *reflexive link*.

[33] This could be the case of services, as the statistical information for such branches is particularly weak, moreover knowing that for some authors services cannot have the role of key sectors: “Linkages are not confined to industrial sectors, but service sectors have low linkages and would not qualify as key sectors”, McGilvray (1977, p. 32, note 2). Leontief (1951, p.13), saying that technical coefficients are largely fixed by technology, asserts, “Others in the complete matrix of the economy, especially in the trade, services, and household sectors, are established by custom and other institutional factors”. Vivarelli (1997, p. 118) affirms that the dynamics of services do not have any relationship with technological progress, “In fact, the expansion in services is often completely unrelated to technological progress”.

3.2.1.4. Extrapolation of national data to other countries and to regions

It is a certain common practice, when using input-output information, to adapt in some way the national trade flows to the country regions or even to other nations.[34] Sometimes there is no adaptation at all, but it is assumed that technical coefficients are the same across regions or countries.[35]

To carry out that kind of extrapolation, it is necessary to assume that there are not differences among the productive processes of goods and services among countries or regions. This is considered mainly true for the case of developing countries among themselves, under-developed countries among them, or regions belonging to the same country.[36]

When that homogeneity is assumed, the effect of a different location and the characteristics of different regions for transportation, available technology, productive specialisation, culture, institutions, history or tastes, are not considered significant factors. However, those are key elements to be included for the *productive systems* under identification, not only when comparing countries but even when comparing regions inside the same country. For such reasons it is greatly important to find input-output tables at regional level to identify, not national, but *regional productive systems*. Once such identification is done, development strategies could be designed according to the specific characteristics of the area.

Moreover, it should be reminded, when geographical differences affecting sectoral relationships in different places are ignored, that each productive branch is not made of a unique product but of products from many other sub-branches, depending on the

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[34] Some references in this respect are McCann and Dewhurst (1998), Harris and Liu (1998) and Flegg and Webber (2000).

[35] Yotopoulos and Nugent (1973), distinguishing between developing and under-developing countries, calculate indices for eleven countries, and then extrapolate them to thirty-two countries. "Our extrapolation was based on the useful observation of Chenery and Watanabe that the structure of production as reflected in the four linkage indices was remarkably similar for one country to another". (Yotopoulos and Nugent, 1973, p. 337). The Chenery and Watanabe linkage indices will be explained further on in this chapter.

[36] "One is not surprised to find that the production of a given commodity requires relatively the same intermediate inputs in the same proportion in one country as it does in another. One would, however, be surprised to learn that the proportion of each input imported or produced domestically is the same across countries", Riedel (1976, p. 320).

aggregation level. And some sub-branches have a higher weight in some regions (or nations) than in others, therefore technical relations should be different and extrapolation has no sense. Even if extrapolation is done being aware of that fact, it is not possible to establish straight conclusions and affirmations when comparing two different places, at national or at regional level.

Some examples discussing the opportunity of extrapolations are Hirschman (1959), Bharadwaj (1966) and McGilvray (1977). A more specific reference is Harrigan *et al* (1980) trying to establish whether it is possible to use national data to study the region of Scotland, obtaining a negative conclusion.

3.2.1.5.- The meaning of backward and forward effects

Looking, in general, at the information offered by an *input-output matrix*, we could see that most of the inter branch relationships are circular. Therefore, most of the branches are buyers and sellers for other branches at the same time. When considering the effect of a branch as an intermediate buyer to obtain its product we are looking at the *backward effects*. Looking at the other side, that is, the effect of a branch as an intermediate seller for other branches to obtain their products, *forward effects* are considered.

According to the Leontief model, *backward effects* are defined as the effects of the *final demand* of one sector in the production of several sectors, as intermediate sellers. In the same way, *forward effects* are defined as the effect of several *final demands* on the production of a sector, as an intermediate seller. Both effects are calculated using the *inverse Leontief matrix*.

Several authors have asserted that the significant effects in selecting key sectors, or key relations, are the *backward* and not the *forward effects*.[37] A key sector, identified as one with high *backward effects* and then stimulated to generate growth, will encourage and pull the production of the sectors that sell it intermediate goods. However, a key sector identified as one with high *forward effects* has an uncertain effect of its perturbation on growth. In that case, once the branch has been invigorated, its production is affected by

[37] See Hirschman (1959), Bharadwaj (1966) and McGilvray (1977).

the *final demands* of the branches that are buyers for it. With the stimulation its production is increased but there is not a clear effect on the other branches. Its impulse can promote investment in other sectors buying its intermediate goods, but this cannot be something taken for granted. *Backward effects* are more powerful in that sense and therefore they can be used as a basis for investment decisions.

The same situation applies when *linkage effects* are understood in the sense of *agglomeration industries* as in Hirschman (1959).[38] In that case, the *forward effect* is not an independent inducement mechanism, but a powerful reinforcement to *backward effects*.

The discussion about the importance of *backward* and *forward effects*, when identifying key sectors or key inter-sectoral relationships, can go further. Following Jones (1976), when both effects are calculated applying the Leontief model, the *backward effect* will measure the effect of final demand of branch *i* in the production of all the branches selling to it. The *forward effect* will be measuring the effect of all *final demands* on the production of branch *i*. Therefore, in both cases the effects are measured from increases in final demands and looking at the effect, *backward*, in the production needed to allow for such *final demands*. For Jones both of them are *backward relations*. The author suggests calculating forward effects in a different way, explained further on.

Nevertheless, when calculating *forward effects* with *B* coefficients, through the sum of the rows in that matrix, the value obtained is the amount of *i* needed in the elaboration of one unit of all the goods being produced in the system, and this is generally understood as a *forward effect* of branch *i*. To obtain *backward effects* the sum of the columns of *B* matrix is calculated and the amount obtained means the quantity of every product needed to get one unit of good *i*, and this is generally understood as a *backward effect*.

[38] Although it will be explained in another section of this chapter, it can be said at this stage that Hirschman idea of *linkage effects* is in the sense of the capacity of a firm to attract other firms to the same location.

3.2.1.6. Total or inside values

Usually, input-output tables offer information about trade flows between branches for *inside* and for *total* values, and therefore considering also imports. In the case of regional tables, we find three values measuring the same flow between two branches. The first is the *inside*, corresponding to the trade happening inside the region. The second is the *national*, which corresponds to the inside plus the imports from the rest of the country and last is the *total*, that is, the national plus the imports from the rest of the world.

Therefore, a prior question to solve before using input-output data is which of them is the most relevant for the analysis. In the case of this research data are applied to identify *regional productive systems* and therefore *inside* values should be the ones under consideration. Nevertheless, the other two values offer useful complementary information for the characterisation of the identified *productive systems*.

In the search for *regional productive systems* the target is to identify groups of related sectors and firms, to explain the kind of relation they maintain and to understand their characteristics and evolution. Then, *national* or *total* values do not allow the acquisition of that kind of necessary information, as other firms, not working inside the region, will be included. Considering *national*, or more clearly *total*, values *regional productive systems* cannot be found and even less explained. With *total* values the agro-food, or the steel, or the automobile, *productive system* would be basically the same in every region and in every country because the required inputs for the whole process are similar in every place. In that sense, it is worthy to remember the distinction offered in chapter two between *production systems*, considering only trade relations, and *productive systems*, taking into account other economic, social and historical factors.

3.2.1.7. Data classification and homogeneity

The input-output data used consist of two tables for each region (Andalusia and the Basque Country), one for the year 1980 and another for 1995. According to those tables methodology, either CNAE-74 or CNAE-93 (*Clasificación Nacional de Actividades Económicas*, National Classification of Economic Activities) have been the used classification. However, every table shows a different number of productive branches and therefore they have a dissimilar aggregation level. This situation is justified in the methodological notes as an attempt to adapt each classification to the productive characteristics of the region.

The unification of all those tables involves a great difficulty and the appearance of unavoidable incongruities, therefore the decision for this research has been to homogenise branches in time inside each region but not in space. That is, the research is done with the same number of branches for 1980 and 1995 inside each region, but every region having a somehow different classification. This decision does not impede the comparison of results among regions but avoids incurring in too many biases that necessarily appear when a data homogenisation is done.

3.2.2.- Regional qualitative and quantitative information

The application of *network* and *input-output analyses* to the productive branches of the selected input-output tables will allow for the identification of *regional production systems*. Thereafter, other information is used to go from production to *productive systems*. Both type of systems will be explained and characterised.

3.2.2.1. Directorate of firms and technology institutions

Since each branch is made of firms, regional firms belonging to the branches constituting the selected *production networks* or *systems* have been selected and interviewed. Also structured questionnaires were sent to a group of firms.[39] Other complementary sources refer to regional institutions like technology parks, innovation and training centres and associations. The structure of the productive networks will be explained including those data, checking whether firms are related to the regional institutions and studying what type of relation they maintain. Through those relations there are diverse flows, like for information, technology or workers, and it is necessary to be aware of this to study *regional productive systems*. Substantial conclusions can be obtained as the existence of those links allows for a better performance of the regional firms and for the regional development process. All those data will be better understood when complemented with the information obtained from comparative references for locations with similar characteristics.

[39] Detailed information about interviews and questionnaires will be expounded in chapter five, where this information is used.

3.2.2.2. Regional economic history

Regional historical information is highly important for the identification of the *productive systems* and for their selection and characterisation. Several authors, like García Delgado and Carrera Troyano (2001), Bernal and Parejo (2001) and Fernández de Pinedo and Fernández (2001), emphasize the importance of history to understand the regional economic behaviour in Spain, and in particular in Andalusia and the Basque Country.

The historical specialisation of every region allows for deductions referred to *regional productive systems*, because the past productive structure determines the present one, and this is obvious for the selected regions in this analysis. According to its economic history, for the Basque Country a system integrating the iron, steel and machinery industries should be studied. In Andalusia the agro-food industry and mining sectors should be necessarily analysed.

The historical specialisation of every region, their comparative advantages, their workers skills, their trade and traditions offer a strong argument in support of the necessity of considering the mentioned systems in the selected cases. Therefore this type of information is included in the processes of selection and characterisation of *regional productive systems*.

3.3.- Main methods applied in this research

The two main methods applied to the data described above to study regional productive systems are *social network analysis* and measures obtained from *input-output analysis*.

This section explains the main concepts belonging to both techniques and the measures used in the next chapter to the kind of data discussed in the previous section. In order to identify and characterise regional production systems in the next chapter, the main measures to value input-output relations are explained first following the input-output model appearing at the beginning of section 3.2.1. After that, there is a section focused on the concepts and measures proposed by *network analysis*, some of them will be explained more deeply when applied in the next chapter.

The last section is dedicated to mechanism causality, because this is the hypotheses testing method selected to analyse the relationship between regional productive systems and regional development processes.

3.3.1. Measures to value input-output relations

Input-Output analysis has been widely used to develop measurements to value relationships among productive branches. Those measures are very useful for a general understanding of the production systems working in a region, for the characterisation of such systems once they have been selected using *social network analysis* and for the identification of key sectors.

In that sense, two of the most important applications of Input-Output analysis were made by Rasmussen in 1956 and by Chenery and Watanabe in 1958. Those authors showed ways to quantify and classify the relationships maintained among productive sectors. Their proposals have been widely used in economic analysis to identify key economic sectors, to plan development strategies and to identify clusters of inter-related firms, among other things. In Hirschman (1959) the use of both proposals is suggested to measure *linkage effects* (*backward* and *forward*), understood as the effects exerted by one or more firms to attract other firms to the same location, since they have some kind of supply or demand relationship.

The measures proposed by both authors, as well as the one of Streit (1969), not so generally used, are explained below. Moreover, some comments will be done referring to several works applying those techniques and for some suggestions in their use.

3.3.1.1. Rasmussen indices

The measurements proposed by Rasmussen (1956) are the following *indices of power* and *sensitivity of dispersion* in a system of *n* productive branches.

The i*ndex of power of dispersion* for *j* is:

$$U_{\cdot j} = \frac{\frac{1}{n} b_{\cdot j}}{\frac{1}{n^2} \sum_{j=1}^{n} b_{\cdot j}} \quad \text{where } b_{\cdot j} = \sum_{i=1}^{n} b_{ij} \tag{3.8}$$

The *index of sensitivity of dispersion for i* is:

$$U_{i\cdot} = \frac{\frac{1}{n} b_{i\cdot}}{\frac{1}{n^2}\sum_{i=1}^{n} b_{i\cdot}} \quad \text{where } b_{i\cdot} = \sum_{j=1}^{n} b_{ij} \tag{3.9}$$

The above indices are averages of the *backward* and *forward total linkages* of a productive branch, normalised by the overall average to allow for inter-industry comparisons.[40]

There are several versions of those indices, as they have been quite oftenly used in applied research works. The most general form is the named *absorption* and *diffusion effects*, calculated as the sum by rows and by columns of *b* coefficients.[41] Moreover, Jones (1976) proposes to calculate *forward effects* using a different *A* matrix to obtain a new *B*, the new A^* should be made of a^*_{ij} as in (3.10).

$$a^*_{ij} = \frac{x_{ij}}{x_i} \tag{3.10}$$

The new matrix is named in de Mesnard (2001) and in Lantner (2001) *matrix of allocation coefficients*.

With the sum by rows of the new inverse, according to Jones (1976), the starting point is at the beginning of the production process, with an increase in primary inputs and tracing the effect forward through the system. The argument of de Mesnard (2001) and Lantner (2001) is that technical coefficients, *a*, measure the absolute direct influence of

[40] Therefore the *index of power of dispersion* measures the *backward linkages* of branch *j* in average, respect to all the branches selling it intermediate goods in the numerator, and normalised by the denominator. In the same way the *index of sensitivity of dispersion* measures the *forward linkages* of branch *i* in average respect to all the branches buying it intermediate goods in the numerator, and that average is normalised by the denominator.

[41] Some Spanish examples of such applications are Segura and Restoy (1986) and López (1995).

a sector over other sector, while allocation coefficients, $a*$, measure the relative direct influence of a sector over other sector and therefore it is an elasticity.[42]

Both Rasmussen indices can be modified, by including a system of weights, to consider the importance of the measured branch in the whole economic system. The author proposed Final Demand for the weights, to obtain *weighted indices of power and sensitivity of dispersion* ($U_{.j}^{w}$ and $U_{i.}^{w}$). Rasmussen *indices of power* and *sensitivity of dispersion* are known in a sector of the literature as *absorption* and *diffusion effects*, or even as *Hirschman indices*.[43]

Rasmussen was aware that the above indices might not tell the whole story about branches inter-relations as they are average measures. For this reason, he proposed to calculate, at the same time, measures of variability using the coefficients of variation of power and sensitivity of dispersion ($V_{.j}$ and $V_{i.}$). Both variability measures can also be re-calculated with weights, as for the indices of *power* and *sensitivity of dispersion*. The author established that a branch could be distinguished as *key industry* when it has a high $U_{.j}$ and small $V_{.j}$. This would mean that such a branch has high *backward linkages*, and those linkages are maintained with a relative high number of other branches.

3.3.1.2. Chenery and Watanabe measures

Another important proposal was made in Chenery and Watanabe (1958) presenting two measures of interdependence, as expressed in (3.11) and (3.12), where *IP* is intermediate purchases, *IS* means intermediate sales and *TD* total demand. The indices consider the importance of every branch intermediate purchases and sales for its production and demand, and both can be calculated in relative terms, with respect to the value of the index for the whole system.

[42] According to that explanation: $a_{ij}^{*} = \frac{\Delta x_{ij}}{\Delta x_j}\frac{x_j}{x_i} = a_{ij}\frac{x_j}{x_i} = \frac{x_{ij}}{x_j}\frac{x_j}{x_i} = \frac{x_{ij}}{x_i}$.

[43] See Hazari (1970) and Jones (1976).

Indirect use of factors for *j*:

$$u_j = \frac{IP_j}{x_j} \text{ with } IP_j = \sum_{i=1}^{n} x_{ij} \tag{3.11}$$

Indirect demand for *i*:

$$w_i = \frac{IS_i}{TD_i} \text{ with } IS_i = \sum_{j=1}^{n} x_{ij} \tag{3.12}$$

Chenery and Watanabe established a two-way classification, based on whether each sector values are above or below the mean values. In that form, interdependence among sectors is understood as their relation on both, demand and supply, sides. According to that classification there are four kinds of productive branches:

I) *Intermediate primary production*. Branches with low *u* and high *w*.

II) *Intermediate manufacture*. Branches with high *u* and *w*. This group is made of very dependent sectors.

III) *Final manufacture*. Branches with high *u* and low *w*.

IV) *Final primary production*. Branches with low *u* and *w*. This group is made of relatively independent sectors.

According to the indirect use of factors, *u*, branches can be classified as *primary* or *manufacture*. When the value of *u* is relatively low the branch is named *primary*, as most of its purchases are coming from primary factors (labour and capital) instead of from intermediate commodities. For values of *u* relatively high the branch is classified as *manufacture*, because most of its purchases are coming from intermediate goods instead of from primary factors.

For the indirect demand, *w*, sectors are classified as *intermediate* or *final*. When that value is relatively low, most of the branch sales are going to final demand (*final*). For a high *w* instead, most of the branch sales go to intermediate trade for other branches (*intermediate*).

These indices are generally known in the literature as *backward* and *forward linkages*, and most of the times both of them are calculated in terms of production, and not of total demand as Chenery and Watanabe did for the *indirect demand index*.

The main difference between Rasmussen and Chenery and Watanabe proposals is that the first defines the indices with the elements of the *B* matrix, and therefore considering direct and indirect effects of the production of one branch in the final demand of another. However, in Chenery and Watanabe indices the elements of the input-output matrix are used and therefore only inter-sectoral relations are considered. Consequently, both techniques should be considered complementary.

3.3.1.3 Streit coefficients

Streit coefficients are measurements of the economic linkages taking place between two branches, proposed in 1969 in the following way:

$$ST_{ij} = ST_{ji} = \frac{1}{4}\left(\frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}} + \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} + \frac{x_{ji}}{\sum_{i=1}^{n} x_{ji}} + \frac{x_{ji}}{\sum_{j=1}^{n} x_{ji}}\right) = \frac{1}{4}\left(\frac{x_{ij}}{IS_i} + \frac{x_{ij}}{IP_j} + \frac{x_{ji}}{IS_j} + \frac{x_{ji}}{IP_i}\right) \quad (3.13)$$

Once the coefficients have been obtained for every couple of branches, a unique index for each branch can be calculated as in (3.14).

$$ST_j = \sum_{i=1}^{n} ST_{ij} \quad (3.14)$$

The ST_{ij} coefficient shows all inter-sectoral relations maintained for every couple of branches, as sellers and buyers, in average. In the case of ST_j coefficients that information is summarised, showing all kind of inter-sectoral relations taking place for each branch with all the others linked to it. In this last case it is not possible to know with which branches the relations are established, as it is a condensed index, such information is obtained from the first of the two indices, (3.13).

3.3.1.4. Calculation and comparison of coefficients of variation

As it has already been mentioned before, the *coefficient of variation* is considered, by several authors, another important measure to be included in the analysis of input-output relations. According to most of the researchers, key sectors would show low *coefficients of variation* for their relations with all the productive branches. The *variation coefficients* can be applied to *B* and *A* coefficients. A high *coefficient of variation* will show that the analysed branch relates to a small number of other branches, even just with one. A low *coefficient of variation* will indicate that the studied branch relates with most of the branches in the system, even with all of them. Key branches, with low *coefficients of variation*, are disseminating in the system. In that sense those coefficients can be calculated as complementary measures to *backward* and *forward* indices.

But *variation coefficients* can be also applied for a better understanding of the *productive systems*. The development trajectory of the *productive system* can be observed by checking their evolution, complementarily to *backward* and *forward indices*. It could be the case that the *coefficients of variation* have gone down in general terms, situation that could be identified with diversified economies. But it could be observed the case of a change, where some sectors show an increase in the coefficients while others have had a decrease. In such case the first group of sectors could be identified as less integrated, and the second as more dynamics.

3.3.1.5. Application of the input-output measurements

All the above commented indices, mainly the Rasmussen ones, have been widely used, sometimes in the terms proposed by their authors and some others with variations. Even, in some cases, the indices are used but without giving recognition to their authors, which has happened especially in the case of Rasmussen.

Publications using the commented indices to identify economic key sectors are Bharadwaj (1966), Hazari (1970), Yotopoulos and Nugent (1973), McGilvray (1977) and Schultz (1977), among others. Some of those works are discussed below, because they apply the proposed measurements for specific purposes after including some variation. Therefore, this short bibliographical discussion can serve to know the type of context where the measures have been applied and in which terms.

In most of the cases, authors look for key sectors applying Rasmussen, and in some case Chenery and Watanabe, measures. More concretely, Schultz (1977) calculates the two Chenery and Watanabe indices with respect to production. Moreover, he modifies them by considering imports, including weights, and eliminating intra-sectoral relations. The *power of dispersion* of Rasmussen is also applied to check its effect on some economic aggregates. For Bharadwaj (1966) key sectors have high *power of dispersion* and low *coefficient of variation*. Therefore he applies Rasmussen together with Chenery and Watanabe indices naming them *backward* and *forward linkages*.[44] In the case of McGilvray (1977) key sectors are identified to propose an industrial development programme. He calculates Rasmussen indices but names them *backward* and *forward linkages*.[45] Hazari (1970) applies Rasmussen indices and *coefficients of variation*, and the key sectors are identified with *power* and *sensitivity of dispersion* higher than one and with relatively low *coefficients of variation*. He names the Rasmussen weighted indices using relative final demand *backward* and *forward effects*.

A different perspective is offered in Yotopoulos and Nugent (1973) when trying to check the relationship between linkages and growth in developing and under-developing countries.[46] In order to do that, they define *total linkage* as the Rasmussen *power of dispersion index* without the averages.

Other research studies applying the measurements from a theoretical perspective are Jones (1976), calculating the Chenery and Watanabe indices in relation to production and Cuello and Mansouri (1992), applying Rasmussen indices and *coefficients of variation* modified with a likelihood function and considering elasticities.

Finally, there are some studies for Spain like the following: In Dominguez Hidalgo (1999) and Prado Valle (1999) Chenery and Watanabe, Rasmussen and Streit coefficients are applied to identify *productive systems* inside the Basque Country;[47] in

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[44] There are some modifications, like *forward linkages* measured in relation to production plus net changes in inventories plus imports.

[45] The author includes some modifications by weighting them with relative production and considering the minimum economic operative capacity in the supplier sector.

[46] This article of Yotopoulos and Nugent received numerous critiques like the ones of Jones (1976), Riedel (1976) and Boucher (1976).

[47] Rasmussen coefficients are calculated without means or weights.

Santamaria Martinez, *et al* (1999) Chenery and Watanabe indices are used to characterise the agro-food *productive system* in the Basque Country; in Prado Valle and González Gómez (2001) Chenery and Watanabe and Streit indices are calculated to analyse strategic economic sectors.

3.3.2.- Social network analysis

Social network analysis uses *graph theory* and *matrix analysis* for its empirical application. Actors are considered nodes and links among them are lines or arrows, depending if relationships between actors follow a direction or are undirected. Proceeding with those two techniques, mathematical calculations should be done to obtain particular measures, like *size* and *density* among others, to identify *social networks* and to study their structure. In the application of the measures, the first step is to know the kind of group to be identified, as there are several possibilities from a conceptual and practical point of view.

Depending on the characteristics of the available data, and on the restrictions imposed to them according to the current research, there are several kinds of groups that *network analysis* can study. Once the data have been collected, and the relationships identified, there could be a *group* made by the collection of all actors on which ties are to be measured and of all kinds of relations linking them. A set of those actors can be selected, identifying *subgroups*.[48]

A less restrictive definition than the *group* is *social network*, defined in Iacobucci (1994) and in Wasserman and Faust (1994) as a finite set of actors and the relations or relation that relate to them. It is less restrictive because only a selected set of relations is considered and not all of them.[49] A particular kind of *social network* is the *component*, understood in Borgatti (1994) and Iacobucci (1994) as a *social network* with ties between all pairs of actors or nodes, and there is no one link with actors outside the network. This is a very strict term, considered a *strong alliance*, which can be relaxed

[48] Depending on the level of the research the *subgroup* can be a *dyad* (two actors), *triad* (three actors), or bigger *subgroups*, the biggest one is the *group*. When the link has a value associated to it, *cohesive subgroups* can be identified for ties with high values according to an imposed threshold.

[49] It can be identified at the same levels as *subgroups*, that is, for *dyads*, *triads*, bigger *subgroups* or *groups* when all actors are considered.

by some authors in their application. A strongly connected component is known as a *cluster*, like in Degenne and Forsé (1999) and Aroche-Reyes (2001), where the term is applied to the case of Mexican input-output tables for the year 1980 after applying several thresholds or filters.[50]

The type of g*roup* in which each actor is directly and strongly linked to most but not necessarily all others,[51] is the *social circle*. It is also labelled *social cluster*, as in Emirbayer and Goodwin (1994).

For the current research, *network analysis* is applied to input-output relations among branches, and therefore data will show the structure of a *social network*. To this type of group, the *social network*, the measures and techniques explained in the next sections will be applied. The objective is to know what its structure is and the structure of smaller groups inside it with specific characteristics.

3.3.2.1. Data representation and identification of groups inside the social network

The available data, presented in matrix terms, are analysed at first for the study of its most general characteristics, and for the identification of specific groups inside the whole network. Those data can be dichotomous (binary) or valued, and they can be with or without considering the direction of the relation (directed). When data are valued they can be transformed into binary through the application of a threshold value, based on the strength of ties in the original valued relation.[52]

3.3.2.1.1. Representing groups and social networks with graphs

The available sets of nodes and links can be expressed graphically with the broad network concepts turning into graph definitions. Generally speaking, a *graph* is considered a finite set of nodes plus the set of arrows connecting them. They can acquire several characteristics and names, depending on the specific characteristics of

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[50] There is *strong connectivity* (strongly linked actors) when there is a *path* from every node to every other. A *path* is a sequence of ties, as lines or arrows, in which all nodes and lines are distinct, that is, they are passed through only once.

[51] A generally accepted limit is 80% (Emirbayer and Goodwin, 1994).

[52] De Mesnard (2001) is focused on clarifying *Boolean topological methods*, that is, to the binary transformation of valued matrices. The author explains the pros and contras of this type of transformation for input-output data.

the group under study and the characteristics of the data, expressed in matrix terms. The main distinction appears among graphs (binary data without considering the direction of the relation), valued graphs (cardinal data) and directed graphs (data including the direction of the relation).[53]

Although there are several more specific terms, depending on the restrictions considered in the analysis,[54] when only one type of relation is included, and therefore *social networks* are analysed, the correct term is *graph*.[55] In this research *graphs* are analysed, as they are applied to *social networks*.

The name of the graph can also reflect the *social network* connectivity or cohesiveness. When this is the case, the term *connected graph* is used when there is a path from every node to every other node, and *cohesive graph* when there are many short *geodesics* and small *diameters* relative to its size.[56]

Graphs of networks with directed links are labelled as *digraphs*, as shown in Iacobucci (1994) among others, although the general term of *graph* is usually applied to both situations, directed and undirected relationships. A *strongly connected graph* is a connected digraph and a *unilaterally connected digraph* is a digraph connected in one direction (Borgatti, 1994).[57]

Graphs can be used to show characteristics of the network that can not be seen in a simple way. In that sense, there are *reduced graphs* when *clusters*, instead of actors, are

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[53] All those terms are compared and explained in Wasserman and Faust (1994).

[54] The simplest graph concepts refer to *trivial graph*, containing only one node*, empty graph*, with a finite set of nodes and no lines and *simple graph*, made of undirected relations, without loops, and containing no more than one line between a pair of nodes. When more interesting situations appear, a *complete graph* can be identified if for any pair of nodes there is at least one arrow. A graph is said to be *reflexive* when reflexive links are allowed.

[55] When more than one relation is considered for the same set of actors, and therefore *groups* or *subgroups* are analysed, the chosen term is *multigraph.* A *multigraph* is made of one set of nodes, and more than one set of lines. A *complex graph* is a *multigraph* containing *loops* or reflexive links.

[56] *Geodesic* is the shortest path between two nodes. *Diameter* is the length of the longest geodesic between any pair of nodes. Measures of *size* are explained in the next section.

[57] When, for simplicity reasons, the arrows are taken out from the digraph leaving just lines, the proper term is *underlying graph*, in this case an underlying connected graph is a *weakly connected graph*. In Degenne and Forsé (1999) a *P-graph* is the graph in which the maximum number of arrows directed in one way from one node to another is *P*.

linked, the new nodes are the *clusters* and inside each *cluster* there are strongly connected components.[58]

When the relations have a value, and therefore data are weighted, each arrow carries a number in the *valued graph*. In that case, values can be reverted to binary according to certain threshold or filter, as shown in Iacobucci (1994) and Degenne and Forsé (1999).[59]

3.3.2.1.2. Identification of specific groups inside the social network

Once the appropriate graph is chosen to represent *groups*, *subgroups* or *social networks*, *cliques* can be identified and their properties studied. A *clique* is defined as a maximal complete subgraph of three or more nodes, all of which are inter-linked. It implies a very strict definition of cohesive subgroups and there are other less restrictive terms emerging from it and more interesting for their identification. Those terms are *cliques at level c* for valued data, *n-cliques* for maximal subgraphs, *n-clan*, *n-club*, *k-plex*, *k-core*, *LS-set* and *lambda set*.[60]

Some references explaining in detail the differences among those terms are Degenne and Forsé (1999) and Wasserman and Faust (1994), this last one referring to Hubbell (1965) as an example applying those concepts to ties in input-output tables. The concept of *component*, mentioned in section 3.3.2 as a particular type of *social network*, can also be applied for their identification as regions inside the network.

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[58] Moreover, the relations can be established among a set of actors and a subset of those actors in the case of *hypergraphs* (Iacobucci, 1994). Another specific case appears when there is a set of actors competing in some events, and a relation indicating superior performance in the competition, this in graphical terms receives the name of *tournament*.

[59] Values can be 0, 1 and –1 showing positive and hostile relations in *signed graphs*. Other technical term is the *block*, a sub-graph without cutpoints. A *cutpoint* is defined as a node whose removal would disconnect the graph (Degenne and Forsé, 1999).

[60] As an example, a *clique at level c* is a subgraph with ties between all pairs of actors having values higher or equal to a threshold *c*; another condition is that there is no other actor outside the clique with ties of strength equal or greater than *c*. A complete definition of all those terms can be found in Wasserman and Faust (1994).

3.3.2.2. Measuring the general characteristics of social networks and their groups

All the terms described in this section can be used to measure, in network terms, the general characteristics of a *social network* and of the groups that can be identified within it.

3.3.2.2.1. Size, density and distance

Measuring the network *size*, *density* and *distance* permits the most general and basic study of its structure and distinguishing nodes which occupy important positions on it. As can be deduced from Degenne and Forsé (1999) among others, the application of this group of measures is usually the first step in the structural analysis of a network.

A *network size* measures the number of contacts in the network. This simple calculation gives an initial idea about the importance and complexity of the network under study. Although that is the standard size measure, the *order* of the network can be also used as a size measure calculating the number of nodes in a graph.[61]

There are other size measures, that can not be considered to be so general as the above, which should be applied in more specific cases, as the *effective size of a node* proposed in Borgatti (1997), measuring the node directed relations minus its redundancy. Redundancy exists to the extent that the contacts of a node are connected among them. Then, redundancy does not exist if the actors related to the node under study are not inter-connected.[62] A low node redundancy can be identified with actors in strategic positions, because it would have access to diverse resources that could not be available for the other actors.

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[61] For a detailed explanation of this measure see Borgatti (1994), Wasserman and Faust (1994) and Degenne and Forsé (1999).

[62] The effective size of node *i* can be measured as $\sum_j \left[1 - \sum_q p_{iq} m_{jq}\right]$, $q \neq i, j$; where $p_{iq} = \frac{\left(x_{iq} + x_{qi}\right)}{\sum_j \left(x_{ij} + x_{ji}\right)}$, $i \neq j$ and $m_{jq} = \frac{\left(x_{jq} + x_{qj}\right)}{\max_k \left(x_{jk} + x_{kj}\right)}$, $j \neq k$. In non-valued, undirected graphs: $p_{iq} = \frac{x_{iq}}{\sum_j x_{ij}}$, $i \neq j$ and $m_{jq} = \frac{x_{jq}}{\max_k \left(x_{jk}\right)} \Rightarrow m_{jq} = x_{jq}$

Density, as a network measure, is the ratio between the number of arrows in a graph and the arrows in a complete graph with the same number of nodes.[63] It is, therefore, the number of effective connections related to the total number of possible connections. With L as the number of arrows and g the number of nodes, density is:

$$\Delta = \frac{L}{g(g-1)},\ 0 \leq \Delta \leq 1 \tag{3.15}$$

In the case of directed relations, the *degree* of the network can be calculated as for *density* measure, as established in Burt (2000), distinguishing between *indegree* and *outdegree*. The *indegree* of a node is the number of arrows converging to a given node, and therefore the number of nodes adjacent to the measured node.[64] The *outdegree* of a node is its number of outbound arrows and therefore the number of nodes adjacent from the measured node. In that case, the *degree* of a node is the *indegree* plus *outdegree*.

A *social network* with high density would show a complex structure with many relationships allowing diverse flows.

Distances between nodes can be measured in several forms to get information about the structure of the network.[65] The most general measure of distance between nodes is the *walk*, defined as any sequence of steps of any length, without considering direction, for any group of nodes in the net, and nodes and lines can appear more than once. The length of the *walk* is the number of its lines, and it is the most general kind of sequence of adjacent nodes. In a *directed walk* there is a sequence of alternating nodes and

[63] Some references explaining it are Borgatti (1994), Iacobucci (1994), Wasserman and Faust (1994) and Degenne and Forsé (1999).

[64] Two nodes are adjacent when there is a line linking them.

[65] Iacobucci (1994) and Degenne and Forsé (1999) offer detailed information about the several measures of distance.

arrows, all arrows are pointing in the same direction, and its length is the number of instances of arrows in it.[66]

Other common measures of distance, together with *walk*, are *path* and *cycle*, both of them offering several variants. Those are the most useful measures of distance, although there are others that can be used additionally.[67]

Although already defined in this chapter, a *path* is a *walk* in which all nodes and lines are distinct and its length is the number of its lines. A *directed path* is a *directed walk* in which no node and no arrow is included more than once, all arrows point in the same direction and its length is the number of arrows.[68] *Path length* is understood as the distance between two nodes, that is, the number of arrows connecting the two nodes.[69]

A *cycle* is a *closed walk*, or *directed walk* for directed links, of at least three nodes in which all lines are distinct and all nodes, except the beginning an ending, are also different.

The two following graphs, taken from Wasserman and Faust (1994, pp. 106 and 131) are examples of the defined concepts.

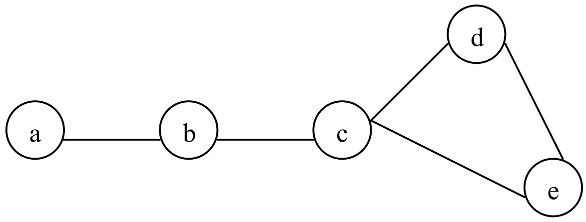
[66] Other terms derived from walk and more specific than it are *closed walk*, when the walk begins and ends at the same node, *semiwalk*, when the direction of the arrow is irrelevant and its length is the number of instances. A *trail* is a *walk* in which all lines are distinct and the nodes may be included more than once; a *directed trail* is a *directed walk* in which no arrow is included more than once. A *tour* is a *closed walk* where each line is used at least once.

[67] This is the case of *eccentricity*, defined as the largest geodesic distance between the node and any other, summarising how far a node is from the node most distant in the graph. Another is *interaction distance*, defined as the number of steps needed to connect two nodes.

[68] The notation is not unanimous, in Degenne and Forsé (1994) the definition of *path* is given to the concept of *chain*, and our chosen definition of *directed path* is given to *path*. Therefore, not distinguishing between *path* and *directed path* but between *chain* and *path*.

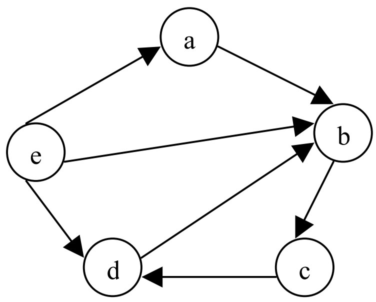
[69] A *semipath* is a path in which the direction of the arrow is irrelevant. Its length is the number of arrows. A *semicycle* is a closed directed semiwalk where all nodes, except the first and the last, are distinct.

Figure 3.1: Undirected social network



In figure 3.1 there are *paths* such as {b, c, d}, *walks* like {b, c, d, c} and the *cycle* {d, e, c, d} can also be found.

Figure 3.2: Directed social network



In figure 3.2 a *directed path* is {e, d, b, c}, a *directed walk*, {e, a, b, c, d, b, c} and a *cycle* is {b, c, d, b}.

In the case of *regional productive systems*, those calculations offer information about the complexity of the productive relations net. The obtained information can be dynamically analysed, to test the relationship between a more complex and dense structure of relations and the regional development level. Moreover, conclusions about technical changes in productive relations can be deduced from an increase or reduction in the size of the network and the reachability of branches through other branches. Therefore the existence and change of dependency productive relations can also be analysed.

3.3.2.2.2. Position and restriction

The concepts and measures shown in the previous section are those which are most generally used in the structural study of a network, as they make it possible to obtain a wide view of its structure. However, there are more concrete measurements which help to give a deeper analysis of network structures. This is the case of *position*, studied for the identification of groups of individuals similarly embedded in networks of relations. Such individuals do not need to be in direct or indirect contact, as explained in Wasserman and Faust (1994) where there are some references of works applying those measures to study international trade and the world economic system.[70] When two actors occupy the same *position* in the network, they are said to have *redundant contacts* and therefore they are in a situation of *structural equivalence*.

Following Emirbayer and Goodwin (1994), among others, positional analysis studies the actor's ties to third parties applying *structural equivalence* and *blockmodelling*. In a strict sense, two actors are *structurally equivalent* if they have identical ties to and from all other actors in the network. The collection of equivalent or approximately equivalent actors allows for the identification of equivalence classes and therefore positions.

By applying *blockmodelling* the original matrix of relations is permuted to put together the structurally equivalent actors, obtaining a new matrix (*image matrix*) with blocks of equivalent actors. The *image matrix* describes the ties between positions and it can be represented in a *reduced graph* in a way that if there is a link between two blocks, then there is a link among any component of the two blocks. For the representation in an *image matrix* and *reduced graph* of *equivalent blocks*, it is necessary to have a criterion to separate the blocks, as *perfect structural equivalence* is very difficult to find.[71]

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[70] Some references are Snyder and Kick (1979), Breiger (1981), Nolan (1983, 1987 and 1988), Lenski and Nolan (1984) and Nemeth and Smith (1985).

[71] Possible criteria are: a minimum *density* within a block, the zero block criterion (the block is zero if all the ties on it are zero), the one block criterion (the block is one if all their binary ties are ones), the alfa density for an alfa threshold density value, or through comparison (assigning a value for density to each of the three criteria: zeroblock, alfa density and one block, therefore with a continuum of cutoff values).

Two possible measures of *structural equivalence* are *euclidean distance* and *correlation*.[72] Burkhardt (1994) proposes the application of the measure of *structural equivalence* (3.16) appearing in MacEvoy and Freeman (1987) by considering the aggregate dissimilarity or distance between *i*'s and *j*'s relations in a network. Once the index is calculated, and therefore a dissimilarity matrix is obtained, Burkhardt measures the correlation between that matrix and a structural equivalent matrix.

$$d_{ij} = \frac{\sqrt{\sum_{k=1}^{N} \left(x_{ik} - x_{jk}\right)^2}}{N} \tag{3.16}$$

Moreover, the position of actors in a network can be affected by the restrictions on it, that is, by the limited access that some agents have to other agents. To consider that question an *index of constraint* can be calculated, describing the extent to which a network is concentrated in redundant contacts. The issue is that more constrained networks span fewer *structural holes*, which means less *social capital* according to the *structural hole* argument. Therefore it is quite important to have a measure of that situation, like the one in Burt (2000), named *network constraint index*:[73]

$$C = \sum_i c_{ij} \text{ where } c_{ij} = \left(p_{ij} + \sum_q p_{iq} p_{qj}\right)^2 \text{ and } p_{ij} = \frac{x_{ij}}{\sum_q x_{iq}} \tag{3.17}.$$

In the case of *structural equivalence* and *block-modelling* applied to productive branches, it would be possible to build groups of branches according to their relations, and to study their characterisation. Moreover, that kind of measures allows for the

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[72] Euclidean distance is calculated as $d_{ij} = \sqrt{\sum_{k=1}^{g}\left[\left(x_{ik} - x_{jk}\right)^2 + \left(x_{ki} - x_{kj}\right)^2\right]}$, for $i \neq k$, $j \neq k$, its value is 0 when *i* and *j* are structurally equivalent. Correlation is obtained with $r_{ij} = \frac{\sum\left(x_{ki} - \overline{x}_{.i}\right)\left(x_{kj} - \overline{x}_{.j}\right) + \sum\left(x_{ik} - \overline{x}_{i.}\right)\left(x_{jk} - \overline{x}_{j.}\right)}{\sqrt{\sum\left(x_{ki} - \overline{x}_{.i}\right)^2 + \sum\left(x_{ik} - \overline{x}_{i.}\right)^2}\sqrt{\sum\left(x_{kj} - \overline{x}_{.j}\right)^2 + \sum\left(x_{jk} - \overline{x}_{j.}\right)^2}}$, its value is 1 for two structurally equivalent actors.

[73] Every c_{ij} is "the proportion of i's relation that are directly or indirectly invested in connection with contact j", Burt (2000, appendix, p. 4).

simplification of the available information through the group aggregation and the study of their relations.

3.3.2.2.3. Centrality and centralisation

After having applied the most basic measures to study the structure of a network, the most interesting calculations to gain greater understanding about such structure are *centrality* and *centralisation*.

High *centrality* for a node *i*, $C(n_i)$, refers to an actor occupying a central position, in the sense that it is highly linked, in relative terms, to all other actors inside the network, and then it is involved in many ties. *Centrality* can be measured for actors and groups.

The *centralisation* of a group of actors *A*, C_A, refers to the group position when it is organised around a focal point. The larger it is, the more likely that a single actor is quite central with the remaining actors being considerably less central. It measures how variable or heterogeneous the actor *centralities* are.

There are three generally recognised measures of *centrality*, known as *degree*, *betweenness* and *closeness centrality*. The three of them are explained in this section as they offer important information in the study of a network structure.

Degree centrality can be defined as a test of the existence of high *indegree* and high *outdegree*. For undirected data it would be the number of adjacent links to or from an actor, that is, the *degree* of the node or the number of its direct links and therefore considering only direct connections. A general measure can be found in Wasserman and Faust (1994) for undirected data, once values have been transformed into binary to quantify number of links:

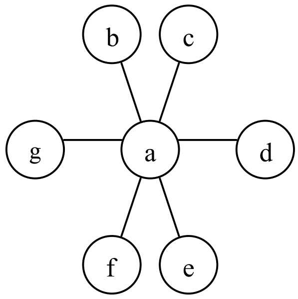
$$C_D(n_i) = d(n_i) = x_{i+} = \sum_j x_{ij} = \sum_j x_{ji} \tag{3.18}$$

It depends on the network *size*, and its maximum value is *(g-1)*. This measure can be standardised to make it independent of the number of nodes in the network, *g*, and therefore comparable with other centrality values, in the following way,

$$C_D^{'}(n_i) = \frac{d(n_i)}{g-1} \tag{3.19}$$

With this new measure, the *degree centrality* value can be compared across networks of different sizes. For directed data the index is calculated with *outdegree* instead of *degree*.[74] Its value is between zero, isolated node, and one, centre of a network simulating a star as shown in figure 3.3.

Figure 3.3: Star network



Betweenness centrality is defined as the extent to which an actor falls between pairs of other actors on the shortest paths, or *geodesics*, connecting them. A general measure is similarly found in Brass and Burkhardt (1992), Krackhardt (1992), Wasserman and Faust (1994) and Degenne and Forsé (1999):[75]

$$C_B(n_i) = \frac{\sum_i^n \sum_j^n \left(\frac{g_{ij(i)}}{g_{ij}} \right)}{\frac{(g-1)(g-2)}{2}}, \ j \neq k \neq i, j \langle k, \ 0 \leq C_B(n_i) \leq 1 \tag{3.20}$$

[74] Both *indegree* and *outdegree* can be calculated, although it is generally accepted that centrality focuses on choices made and therefore *outdegree* should be used.

[75] *i* is the actor for which the centrality is measured, $g_{ij}(i)$ is the number of shortest paths, or geodesics, between *i* and *j* in the network, including the node *i*; g_{ij} is the number of geodesics without including *i*.

The denominator in the above index allows for its comparison among networks, making it relative, as it is the maximum *betweenness centrality* value.[76]

Wasserman and Faust add that *betweenness centrality* can be applied to directional data according to Gould (1987), implying the strong assumption that asymmetric dyads are ignored. Directional are transformed into non-directional relations as mutual dyads are considered lines and asymmetric dyads are ignored.[77] An actor with high *betweenness* is in a position to act as gatekeeper for flows through the network. *Betweenness* is an indicator of non-redundancy of the source under exchange. There is high *betweenness* for *i* when without *i* two parts of the network are disconnected.

Closenness centrality is defined as the total graph theoretic distance from the measured node to all others in the network. A general measure, found in Degenne and Forsé (1999) and Wasserman and Faust (1994) is the inverse function of *geodesic* distances: [78]

$$C_C(n_i) = \left[\sum_{j=1}^{g} d(n_i, n_j)\right]^{-1}, \; 0 \leq C_C \leq (g-1)^{-1} \tag{3.21}$$

This measure depends on *g*, and its standardisation is convenient for comparison purposes:

$$C'_C(n_i) = \frac{g-1}{\sum_{j=1}^{g} d(n_i, n_j)} = (g-1)C_C(n_i), \; 0 \leq C'_C \leq 1 \tag{3.22}$$

This standardised centrality corresponds with the inverse average distance between actor *i* and all others.[79]

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[76] Without making it relative, $0 \leq C_B(n_i) \leq \frac{(g-1)(g-2)}{2}$.

[77] The index is multiplied by 2 when relationships are directional.

[78] $d(n_i,n_j)$ is the number of lines in the *geodesic* linking *i* and *j*. The index is $C_C = (g-1)^{-1}$ when the actor is adjacent to all other actors; $C_C = 0$ whenever one or more actors are not reachable from the actor in question.

[79] The index is the same for directed data.

There could be a problem when applying that index. As all nodes in the network are included in the centrality measure some of them could not be reachable, thus *d* would be infinite and the index undefined. A possible solution to that problem is to include only reachable pairs of actors as shown in (3.23) (Wasserman and Faust, 1994).

$$C_C^*(n_i) = \frac{\frac{J_i}{(g-1)}}{\frac{\sum d(n_i, n_j)}{J_i}}, \; J_i \in n_i \tag{3.23}$$

Where *J* includes all the actors in the influence range of *i*. The numerator is a fraction of the reachable actors and the denominator is the average distance of the actors reachable from *i*.

Brass and Burkhardt (1992) propose that direct links should be counted as one step, and indirect links should be given proportionally less weight. This would generate a new measure, interpreted as efficiency and also as independence.[80]

The three above explained centrality measures can be compared, as it has been done in Wasserman and Faust (1994) concluding that *betweenness centrality* is the most interesting but that it has limitations. One of them is that all *geodesics* have the same probability to be used, although it seems reasonable that *geodesics* with actors having large degrees are more likely to be used. Other important limitation is that it only considers *geodesic paths*, but some actors could have good reasons to choose *paths* that are longer than the *geodesic*, mainly in the case of communication flows.

Stephenson and Zelen (1989) propose, as an alternative, a *weighted betweenness* considering every *path*. In that case, *geodesics* would be given weights of unity, and longer *paths* would receive smaller weights based on the information that they contain.[81] Following that idea, Wasserman and Faust (1994) propose an *information*

[80] According to that idea, it should be realised that an actor with only few links may be central.

[81] The information of a *path* is defined as the inverse of its length. The information of a node is the harmonic average of the information for the combined *paths* from the node to all other nodes.

centrality measure, for which a new matrix should be obtained from the original data.[82] Then, an *information centrality* index is calculated, measuring how much information is contained in the *paths* that originate, and end, at a specific node.[83] The authors assert that they do not know how to generalise Stephenson and Zelen's theory for information indices to directed links. Therefore they recommend the use of *degree* and *clossenness* centrality indices for directed graphs.

In order to measure centrality in the case of valued data, Degenne and Forsé (1999), propose a *flow betweenness* measure and a *weighted flow betweenness* index.[84]

Other, not so general, indices of *centrality* use the eigenvector measure, or considers the *centrality* of all actors as in Bonacich (1987), where an actor's *centrality* is his summed connections to others weighted by the *centrality* of those others. Moreover, for Stephenson and Zelen (1989), *centrality* is not based on *geodesics*, but takes into account multiple shared *paths* between points, as resources do not always flow along the shortest *path*.

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[82] For this new matrix, the diagonal elements are 1 plus the sum of values for all lines incident to n_i. For the off-diagonal elements, there is a 1 if nodes n_i and n_j are not adjacent, and $1-x_{ij}$ if nodes n_i and n_j are adjacent. Once this matrix A is obtained, its inverse is calculated, obtaining a new matrix C for which isolated actors are dropped, and therefore there are not rows or columns of zeros, in order that A can be inverted. Using the new matrix, the sum of the diagonal is obtained, T, as well as the sum of anyone of the rows as all the row sums are equal, R.

[83] $C_I(n_i) = \frac{1}{c_{ii} + \left[(T-2R) \big/ g \right]} \geq 0$. For comparison purposes, a relative information index can be obtained, $C_I^{'}(n_i) = \frac{C_I(n_i)}{\sum_i C_I(n_i)}$, $0 \leq C_I^{'} \leq 1$, measuring the proportion of total information flow in a graph controlled by an individual actor, $\sum_{i=1}^{g} C_I^{'}(n_i) = 1$ (Wasserman and Faust, 1994).

[84] The flow betweeness index is $C_{AFi} = \sum_j^n \sum_k^n f_{jk}(i); i \neq j \neq k; j \langle k$, where f_{jk} is the maximum flow between j and k, and $f_{jk}(i)$ is the flow through i. The weighted flow betweenness index is $C_{NFi} = \frac{\sum_j^n \sum_k^n f_{jk}(i)}{\sum_j^n \sum_k^n f_{jk}}; i \neq j \neq k; j \langle k$.

When the position of groups in the net around a focal point, instead of a single actor, is studied, centralisation measures are calculated. One of the most general is shown in equation (3.24).

$$C_A = \frac{\sum_{i=1}^{g}\left[C_A(n^*) - C_A(n_i)\right]}{max\sum_{i=1}^{g}\left[C_A(n^*) - C_A(n_i)\right]}\ ,\ 0 \le C_A \le 1 \tag{3.24}$$

Where $C_A(n^*)$ is the largest value for *centrality* across the *g* actors in the *A* group, and therefore it is $\underset{i}{max}\, C_A(n_i)$. The denominator in the above measure is the theoretical maximum possible sum of differences in actor *centralities*. The index takes the value 0 when all actors have the same *centrality* index and 1 when one actor completely dominates the others.

Nevertheless, all the measures explained for the case of a particular actor or node can be adapted to the shape of groups in the network. Therefore, there are *degree*, *betweenness*, *closeness* and *information centralisation* indices.[85]

Everett and Borgatti (1999) explain the possibility of calculating *centralities* for groups, to search for central groups, where a minimal sub-group with maximal *group centrality* can be looked for. To obtain that information, one possibility is, in the case of *closeness* or *degree group centrality*, to find the smallest group of actors within the network. This should be done in a way that every actor outside the group is adjacent to a member of the group; the size of this group is called the *domination number* of a graph. Other possibilities are to demand a *group centrality* greater than another given value, to find a

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[85] A generally accepted measure of *degree centralisation* is $C_D = \frac{\sum_{i=1}^{g}\left[C_D(n^*) - C_D(n_i)\right]}{\max\sum_{i=1}^{g}\left[C_D(n^*) - C_D(n_i)\right]}$, $0 \le C_D \le 1$, where the denominator is $(g-1)(g-2)$. Other versions, considering the variance of degrees, betweenness, closeness and standardised indices, the number of paths or information centralisation can be found in Wasserman and Faust (1994).

group of fixed size and maximum *group centrality*, or to find a set of groups that maximize *centrality*.

Nevertheless, the general *centrality* measures explained earlier can be adapted to groups in the following ways:

- *Group degree centrality* can be measured as the number of non-group nodes that are connected to group members.[86] It is normalised by dividing the group degree by the number of non-group actors. Therefore, it considers the number of outsiders tied to at least one group member.

- *Group closeness centrality* should be measured as the total distance of the group to all non-members, usually defined as the minimum distance from outsiders to any insider. Larger numbers for this index indicate less *centrality*. It can be normalised by dividing the distance score into the number of non-group members, and then larger numbers indicate greater *centrality*.

- *Group betweenness centrality* measures the number of times that the shortest path between any two outsiders passes through a group member; that is, the proportion of *geodesics* connecting pairs of non-group members that pass through the group.[87]

In the structural analysis of *regional productive systems*, an important step is the use of *centrality* measures after the most basic calculations have been applied to the network as a whole to get a general idea of its structure, and after specific smaller groups have been identified inside the network. *Centrality* and *centralisation* indices allow for the identification of key branches according to the number of other branches linked to them, to the distance necessary to reach dependent branches, and to their position in several

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[86] Multiple ties to the same node are counted only once.

[87] It is calculated, according to Everett and Borgatti (1999), as $C_B(C) = \sum_{u<v} \frac{g_{uv}(C)}{g_{u,v}}, u, v \notin C$. C is a subset of a graph with vertex or node set V, $g_{uv}(C)$ is the number of geodesics connecting u to v passing through C, and g_{uv} is the number of geodesics connecting u to v. This index can be normalised by dividing each value by the theoretical maximum. All those measures can be found in Wasserman and Faust (1994).

walks. Moreover, its application helps to provide information about the structure of the network made of groups emerging as central or situated around central branches.

3.3.2.2.4. Cohesion, closure and connectivity

The three terms, *cohesion*, *closure* and *connectivity* help to understand the strength of the network or of groups inside it. Although graphically it is possible to advance the strength of the links, and the existence of key groups, there are several ways to evaluate them more precisely with the application of specific measures.

In general terms, *social cohesion* is understood in Emirbayer and Goodwin (1994), as the presence of a dense network with strong ties among a set of actors. Moreover, Contractor *et al* defines the existence of *group cohesion* when there are forces holding group members together.[88] They also argue that it is often measured as the average of each individual member's attraction to the group. In their empirical analysis, studying communication networks in organisations, they consider *cohesion* through the comparison of the *density* of the group including nodes *i* and *j* respect to the *density* of all groups in the network.

More specifically, in Wassermand and Faust (1994), a *cohesive subgroup* is a subset of actors among whom there are relatively strong, direct, intense, frequent, or positive ties. The general properties of *cohesive subgroups* are: the mutuality of ties, the closeness or reachability of subgroup members, the frequency of ties among members, and the relative frequency of ties among subgroup members compared to non-members. Following the same authors, a measure of subgroup *cohesion* is the degree to which strong ties are within rather than outside the subgroup.[89] Another measure proposed by the same authors is the probability of observing some *q* or more lines in a sub-graph.

[88] The reference for Contractor *et al*, without year of publication, appears in http://www.tec.spcomm.uiuc.edu/nosh/comp/comp.htm

[89] When $\dfrac{\sum_{i\in N_S}\sum_{j\in N_S} x_{ij} \Big/ g_S\left(g_s-1\right)}{\sum_{i\in N_S}\sum_{j\notin N_S} x_{ij} \Big/ g_S\left(g-g_S\right)} \rangle 1$, the ties within the subgroup are more prevalent on average than ties outside the subgroup. For dichotomous relations, the numerator is the *density* of the subgroup; for valued relations the numerator is the average strength of ties within the subgroup.

In order to measure *closure*, it should be observed that two nodes can be directly or indirectly linked, when indirect links are considered *paths* of any length connecting two nodes should be taken into account. This consideration helps in looking for the structural properties of the network. According to Degenne and Forsé (1999) a *transitivity closure matrix* can be obtained from the original one, when in a binary data matrix a 0 is substituted by a 1, in the case of a *path* of any length linking the two nodes. Once this matrix is obtained the new rows and columns can be organised by putting together the nodes showing higher *connectivity*.

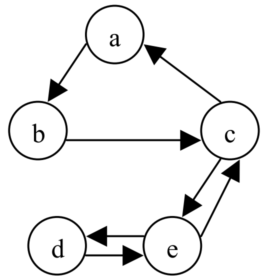
Point, or *node*, *connectivity* is defined in Iacobucci (1994) as the minimum number of nodes that must be removed to disconnect the graph. A threshold *k* value can be decided for that minimum number and then values higher than *k* would imply superior levels of *connectivity*. *Line*, or *edge*, *connectivity* is applied according to the minimum number of lines that must be removed to disconnect the graph or make it trivial.

More technically, there are specific definitions for different possibilities of *connectivities*, as it is the case of *strong connectivity*. It exists when nodes *i* and *j* always share a directed path in each direction, with a sequence of rows from *i* to *j* and from *j* to *I*, for all *i* and *j*. In a *strongly connected* sub-graph nodes are equivalent, all depending equally on each other.

Figure 3.4 (taken as an example from Degenne and Forsé, 1999, p. 74) shows the case of a network with *strong connectivity*. It can be easily checked that all nodes, represented by small letters, are connected and reachable from every node in the graph following the direction of the arrows.[90]

[90] The network is *strongly n-connected* when the directed *paths* have length $\leq n$. The same nodes would be *recursively connected* when they are strongly connected and the directed path from *i* to *j* uses the same nodes and arrows as from *j* to *i*. It is *recursively n-connected* when also the lengths of the paths are considered.

Figure 3.4: Strongly connected network



There is *semi strong connectivity* when *i* and *j* always share a directed path in at least one direction at any time. With a sequence of arrows from *i* to *j* or/and from *j* to *i*, for all *i* and *j*. *Semi strong connectivity* implies stratification and a hierarchy of nodes.

In a more strict definition, when the sequences are from *i* to *j* or from *j* to *i*, the situation is known as a network *unilaterally connected*, or *n-unilaterally connected* whether the length of the directed paths is considered.

Quasi strong connectivity or *weakly connected nodes* are identified when *i* and *j* merely share at least one common predecessor. There is a *semipath* but there is not a *directed path*, the direction of the arrows is irrelevant. In this case the nodes are incomparable, but they depend on the same nodes.[91]

The measures of this section can be applied to *productive systems* to identify regions inside the networks, by imposing some minimum level of *cohesion* or *connectivity* among the branches, or to characterise the already identified groups inside the networks. The most interesting situation would be the one where few groups, made of a short number of branches, appear in the structure of the network showing high *density* and *connectivity*. Therefore, those would be key groups for the productive specialisation of the area, explaining the effects of technological change, and related with the growth and development path of the region.

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[91] When the length is considered, there are *weakly n-connected* nodes.

There are several works using the previously mentioned basic measures offered by network analysis, applied to diverse subjects. Some examples for the study of international trade and the world economic system are Snyder and Kick (1979), Breiger (1981), Nolan (1983, 1987 and 1988), Lenski and Nolan (1984) and Nemeth and Smith (1985). Krackhardt (1992) focuses in the analysis of the strength of strong ties in a firm and Burckhardt (1992 and 1994) studies the existence of power and technology attitudes in organisations. Freeman (1997) is focused on the role of hierarchies in organisations, Ahuja and Carley (1998) studies the behaviour of a virtual organisation, Degenne and Forsé (1999) is dedicated to power in organisations and Burt (2000) focuses on social capital.

3.3.2.3. Specific calculations obtained from the most general measures

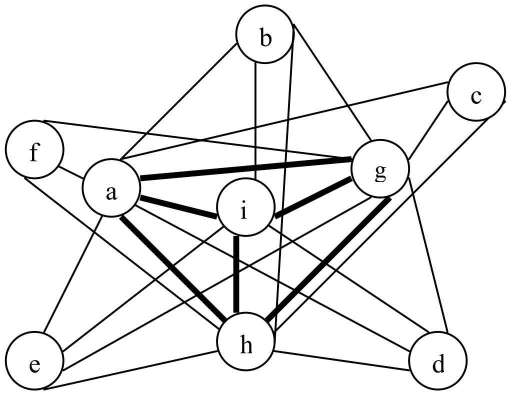
The commented general network measures are used to obtain more specific calculations for a deeper analysis of a network structure. The purpose of this section is to show some of the most relevant.

3.3.2.3.1. Identification of core-periphery structures

The structure of a network can show the existence of a *core* and a *periphery*, both made of nodes, or actors, linked in a particular form. In those kinds of networks three different regions can be identified: nodes constituting a *core*, nodes making a *periphery*, and a third group of nodes occupying a *core-periphery* region linked to the other two areas.

In strict terms, a *core* is understood as a subgroup of nodes inside a network which are all inter-related amongst themselves. In the *periphery*, nodes are not linked among them, but they have connections with the *core*. An example of this theoretical structure is the start shape of figure 3.3, or the following figure 3.5 taken from Borgatti and Everett (1999, p. 4).

Figure 3.5: Network with core-periphery structure



The defined structure is the theoretic ideal *core-periphery*, although there could be other network patterns showing some kind of less restrictive *core* and *periphery* structure. An alternative appears when there are ties only among *core* nodes and all other nodes are isolates. Another possibility would show that the *density* of *core* to *periphery* and *periphery* to *core* ties is a specific intermediate value between zero (the *density* of *periphery* to *periphery* ties) and one (the *density* of *core* to *core* ties). In another option the region for *core-periphery* links is treated as lost data and a maximum *density* in the *core* and a minimum in the *periphery* are looked for.[92]

Correlation can be calculated between the original data and the ideal structure to test whether a network has any of those structures, or even both groups of data can be just compared without applying correlation analysis. Moreover, a structure with a centroid and concentric circles can be looked for, then a cohesive group would be the *core* and the rest of nodes would constitute the *periphery* occupying different positions depending on their distance to the *core*.[93] Therefore, a core-periphery test can be done through correlation, by comparison, applying multidimensional scaling of geodesic

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[92] A valued network has a *core-periphery* structure to the extent that the difference in means across blocks is large relative to the variation within blocks.

[93] Following Everett and Borgatti (1999), *core* and *periphery* can be defined also considering the quantity of ties; therefore a *k-core* is understood as a maximal connected subgraph where the degree of all nodes is $\geq k$.

distances to obtain groups of concentric circles,[94] or analysing the clique structure of the network.[95]

Besides the applied technique, in a tripartite division of the original data there would be the members of the cohesive subgroup as a *core*, the *periphery* of that subgroup and the rest of the nodes in the network with some links among them.

There is a clear relationship between *coreness* and *centrality*, as the actors in a *core* are necessarily highly central, although not every set of central actors forms a *core*. Therefore, *coreness* measures can also be considered *centrality* measures.

In Barsky (1999) the test for the existence of a *core-periphery* structure is applied when studying relationships among managers. Moreover, Borgatti and Everett (1999) comment on some references of researchers in international trade looking for the existence of a core and a periphery by applying network analysis.[96]

In the case of this research, in looking for *regional production systems*, the identification of a region inside the whole network with a *centre-periphery* structure would be a sign that indicates the existence of a *production system*. Dependency relations would be identified among the branches constituting the *core*, and between the *core* and the *periphery*. Moreover knowing that the *core* area would have strong *cohesion*, the branches constituting the *centre-periphery* structure could be taken into account and studied as key branches belonging to a *regional production system*.

3.3.2.3.2.- Hierarchy, power and prestige

In the case of measures to identify *hierarchy*, *power* and *prestige* relations, it should be notice that in every network there could be nodes occupying specific positions, and therefore defining the structure of the network, controlling flows and generating dependency for other nodes. This situation leads to the existence of *hierarchies* among

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[94] Where the average distance between points within the circles increases monotonically with distance from the centre.

[95] Looking for the absence of relatively exclusive cohesive subgroups and therefore just one core subgroup.

[96] Some of those references are Snyder and Kick (1979), Breiger (1981), Nemeth and Smith (1985) and Smith and White (1992).

nodes and of nodes with a great influence and therefore *power* in the network. Those are factors which are highly linked to *centrality* and *connectivity* and help to understand the network structure.

Theoretically, there is *hierarchy* to the extent to which *redundancy* can be traced to a single contact in the network.[97] In the extreme case, a network is *hierarchical* when it is organised around one contact. Therefore, *centrality* measures can be applied as *hierarchy indices*. One of the recommended measures for such case is *betweenness centrality*, although there are others which are more specific indices for such a purpose. Burt (2000), in studying *social capital*, applies a measure of *hierarchy* depending on *redundancy*.[98]

For Ahuja and Carley (1998), in their application to virtual organisations, there is a *degree of hierarchy* depending on at which level relations in a network are directly or indirectly reciprocal, with unreciprocated relationships implying more *hierarchical networks*.[99] Moreover, there are *hierarchical levels* depending on the number of levels one must go through in order to obtain information.[100] The *degree of hierarchy*, *hierarchical levels*, and *centralisations* are indices determining the network dimension and structure.

Power is studied in Brass and Burkhardt (1992) establishing the relationship between *power* and *centrality* in the case that nodes are organisations. That relationship is not clear, as there could be negatively and positively connected networks. Two nodes are negatively connected when exchange in one diminishes or prohibits exchange in the other. Moreover, to acquire *power* actors must decrease their dependence on others and

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[97] The meaning of redundant contacts has already been expounded in sections 3.3.2.2.1 and 3.3.2.2.2.

[98] Burt applies the Coleman-Theil inequality, $\frac{\sum_j r_j \ln(r_j)}{N \ln(N)}$, where $r_j = \frac{c_{ij}}{C/N}$ and $C = \sum_i c_{ij}$ is a *network constraint index*. *N* is the size as the number of contacts in the network.

[99] *Degree of hierarchy*: $D_H = 1 - \left(\frac{V}{maxV}\right)$, *V* is the number of reciprocated links.

[100] *Hierarchical level*: $H_L = \frac{L-1}{N-1}$, *L* is the number of levels in a simplified or condensed graph.

others dependence on them must increase. *Dependency* is considered the basis of *power*, in graph terms this can be seen when nodes have to be linked, necessarily, to other particular nodes, without possibility of choosing alternative nodes for exchanges. Therefore, *power* depends on the structural position of each node.

The same idea appears in Degenne and Forsé (1999) and in Monge and Contractor (1998) where *power*, in terms of *exchange theory*, is defined as an inverse function of dependence on others in the network.[101] Dependence, in turn, varies with the benefit derived from the exchange and with its relative value when compared to exchanges offered by other sources. There is greater *power* for an actor when it offers larger access to valued material and informational resources. In positively connected networks, *power* seems to rise with *centrality* through co-ordination and therefore measures of *centrality* reflect different dimensions of *power*.

Following Degenne and Forsé (1999), *centrality* could be measured as *power*, by considering the *centrality* of the actors linked to the one for which *centrality* is being measured.[102] Nevertheless, *closeness* and *betweenness* are considered correlated with reputational measures of *power*.[103]

Inter-organisational communication and exchange networks are mechanisms by which organisations acquire and disperse scarce resources, creating and perpetuating a system of *power* relations. Therefore, organisations are dependent upon their positions in the network, influencing their ability to control flows of scarce resources. In that sense, dependency can imply vulnerability when, in graphical terms, the removal of a node in the graph isolates the vulnerable node from all other remaining nodes. Vulnerability decreases with the node proximity to the *core* or *cores*. Moreover, vulnerability for

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[101] In Degene and Forsé (1999) work there are comments for other researches focused in relations between organisations, like Levine (1972, 1985 and 1987), Mintz and Schwartz (1981), Stockman and Wasseur (1985), Scott (1987), Palmer *et al* (1986) and Berkowitz (1988).

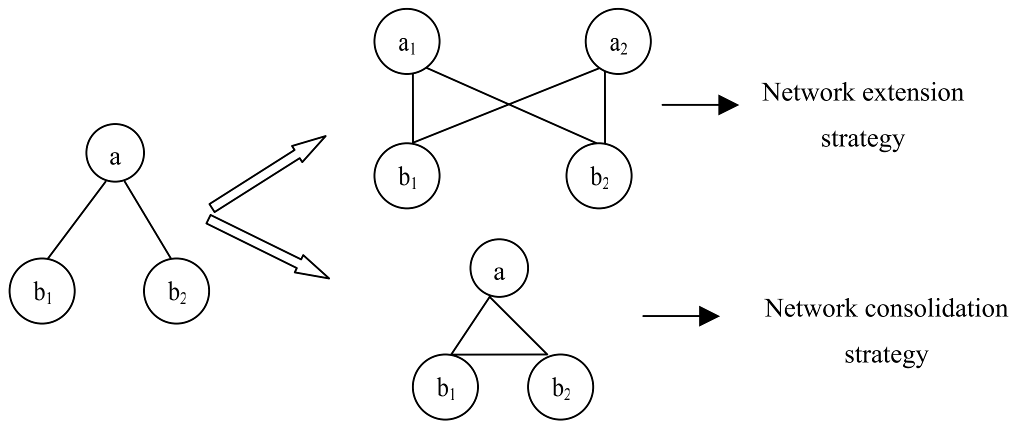
[102] $C_i = \sum_j r_{ij} C_j$, where r_{ij} is the value of the relation between *i* and *j*, that can be defined in different ways.

[103] Markovsky *et al* (1998), focused as well on *exchange networks*, apply a graph theoretic index of *power*, measuring each position *potential power*.

nodes will be different depending on whether the relations are of co-operation or of competition, consequently the effects of the removal of a node would be diverse.

More egalitarian distributions of *power*, and therefore less vulnerability, can be found when *power* is unequally distributed following two possible strategies. Through *network extensions* when weaker actors diversify partners, or through *network consolidation* when weaker actors unite to restrict the more powerful actors' options. Those two possibilities are shown in figure 3.6.

Figure 3.6: Strategies to reduce vulnerable network positions



The cases of undirected networks, with measures of *power*, and directed networks, with measures of *prestige*, are differentiated in Degenne and Forsé (1999). In that sense, and following Wasserman and Faust (1994), an actor is *prominent* if his ties make him particularly visible to other actors in the network. There are two types of *prominence*: *centrality* and *prestige*.[104] There is *prestige* for an actor who is the object of extensive ties, as a recipient of links, with high indegree, only measurable for directional relations. Actor *prestige* is also called *status*, *deference* or *popularity*. As a measure, the *degree prestige* is the *indegree* of each actor.[105]

[104] For Degenne and Forsé (1999) *centrality* implies *prestige*, because central actors enjoy better access to information and to other resources than marginal actors. Moreover, they are more actively involved in local issues, and they play a decisive role in building coalitions doing early negotiations upstream of actual decision-making.

[105] Another measure is the *proximity prestige*, this index weights *prestige* according to *closeness* or *proximity*.

The *prestige* of the actors linked to the one measuring its *prestige* is also important; therefore distances should be weighted by *prestige* measures of the actors in the influence domain. By doing that, the *status* or *rank prestige* can be calculated as the *prestige* of an actor on his net depending on the *prestige* of the other actors linked to him in the net.

The measures explained above, as a criterion for *power* and *prestige* can be complemented following Degenne and Forsé (1999),[106] with the calculation of *choice status*, *extended relations*, *exclusive relations*, *power* considering the exclusiveness of the relation and *reflected power* as complementary measures. [107]

The two last sections, offering information about specific calculations to study network structures, are useful to analyse productive systems. The emergence of a centre-periphery structure can be considered to be the origin of a production system. Centrality measures offer important information to understand the network structure. Conclusions can also be obtained from the existence of a *hierarchy* of branches according to their dependency relations and therefore for their *power* and *prestige* positions and strategies. All this is pretty clear in the case of input-output data, as different centrality and dependency relations always exist among the branches according to the available technology for their productive processes.

3.3.2.3.3 Embeddedness, weak ties and social capital

It would be of greater help to try to test the foundations of *social network analysis* developed in the previous chapter with some network measures. In that sense, there are studies focused on the empirical analysis of the concept of *embeddedness*, on proposals to measure *weak ties* and on techniques to identify *social capital*. All of these are discussed in this section, as their relevance is clear for the study of *regional productive systems*, according to the methodological exposition made in chapter two.

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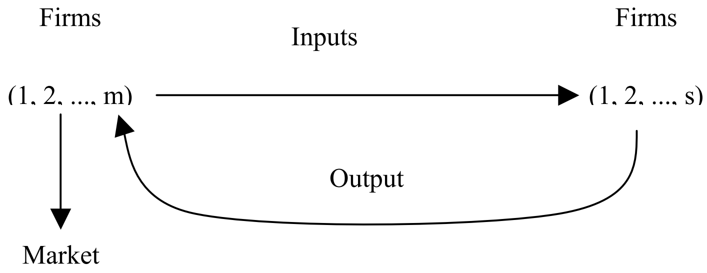
[106] Mainly when talking about economic organisations or, more widely, about exchange networks.

[107] The measures of all those concepts can be found in Degenne and Forsé (1999, p. 146).

The economic performance of organisations is studied in Uzzi (1996), proposing two related measures of *embeddedness*. For a better understanding of the proposed measures it is useful to represent graphically, as shown in figure 3.7, the situation of two groups of transacting firms.[108]

Figure 3.7: Trade links between two groups of firms



One of the measures, named *first order network coupling*, captures, according to the author, the idea of *embeddednes* as a network concept:

$$\sum_{j=1}^{g_m} P_{ij}^2 \text{ where } P_{ij} = \frac{x_{ij}}{x_i} \qquad (3.25)$$

The index approaches to 1 when the firm concentrates in few relations, in the opposite case it approaches to 0. In the case of a 0 index there are small parcels to many firms, and therefore *arm's length ties* are used to transact.[109] *Social capital embeddedness index* is near 1 whether a contractor has network ties to a limited business group and almost 0 in the opposite case.

The other proposed index is the *second order network coupling*:[110]

$$\frac{\sum_{j=1}^{g_m} Q_j}{g_m} \text{ where } Q_j = \sum_{i=1}^{n_s} D_{ji}^2 \text{, and } D_{ji} = \frac{x_{ji}}{x_j} \qquad (3.26)$$

---

[108] Source of figure 3.7: own elaboration.

[109] In equation (3.25) *x* are outputs. The term *arm's length* ties is applied by the author to identify exchange relations maintained with a high number of small firms and therefore corresponding to a situation of market competition.

[110] In equation (3.26) *x* are inputs.

Its value is 1 when all the work is done by one contracted firm, and 0 if there is a high number of small hired firms.

The *second order network coupling* has a low value when the network of *m* firms with which an *s* firm transacts uses, on average, arm's length ties. It has a high value when the network of which an *s* firm is tied is composed of *m* firms that use embedded ties to transact with *s* firms. It has a medium value when the *s* firm transacts with an integrated network composed of a mix of arm's length and embedded ties. As a conclusion it can be said that high concentration implies more *embeddedness*.

The generation and maintenance of *trust* is a key strategy to create an exchange environment identified with embedded relations. Therefore, the existence of *trust* ties should be considered to analyse the possibility of *embeddednes* more deeply. In Gulati (1995) *trust* is measured through the proxy of prior alliances between firms. Besides, geography should also be considered, as firms are expected to trust domestic partners more than international or interregional partners. In a domestic context, more and better information is available about firms, and the reputation consequences of opportunistic behaviour are greater.

Trust links are of great importance for efficient organisations, but also the use of weak ties with other groups is an efficiency strategy. A test of the *strength of weak ties theory* of Granovetter (1973) is proposed in Borgatti and Feld (1994). To apply that test a strength matrix and an overlap matrix should be built from the original data. The strength matrix should measure the strength of ties among all pairs of actors. The overlap matrix includes, for each pair of actors, the number of other actors that both actors are connected to, measuring the extent to which the neighbourhoods of each pair of actors overlap.[111] Finally, for each actor the correlation between the elements of the strength matrix and the overlap matrix are computed. According to Granoveter's theory, if there are strong ties between dyads, then their common elements should overlap. Consequently, there should be a positive correlation between the elements of the strength matrix and the elements of the overlapping matrix.

---

[111] The overlap matrix can be obtained from the strength matrix by doing it binary, applying a threshold value, and multiplying it by its transpose.

The whole set of links, with trust relations and weak ties, consists of the network *social capital*. Therefore, *social capital* as social structure constitutes a structural resource present in each network. But it works with different intensity depending on each network structure. Therefore, to value it would be very helpful in order to understand the evolution and performance of the analysed network.

There are several possibilities appearing in the literature for *social capital* measures. In some cases specific indicators are proposed, other authors recommend the visualisation of the structure through graphs, and some other times the suggestion is to relate *social capital* with traditional network measures. All those cases are explained, in summary, in this section.

In Burt (2000) it is asserted that there are two forms to measure *social capital*, one is counting the *bridge relationships*, and the other is with a *network constraint index* describing the extent to which a person's network is concentrated in redundant contacts.

Focusing on the first form, through *bridge relationships*, in Krackhardt (1992) *bridges* are measured through *betweenness centrality*. According to the author *betweenness* is an attribute of a node in the graph, while *local bridge degree* is an attribute of a tie. Therefore, both measure the degree to which actors reach disparate and unconnected parts of the network. The higher the degree of the *local bridge* a person is connected to, the higher that actor's *betweenness* score will be.

The second form to measure *social capital*, with a *network constraint index*, was already presented in this chapter, but in a more extensive analysis Burt (2000) relates it to *size*, *density* and *hierarchy* as follows:[112]

$$C = \sum_j C_{ij} = \sum_j \left(P_{ij}\right)^2 + 2\sum_j P_{ij}\left(\sum_q P_{iq}P_{qj}\right) + \sum_j\left(\sum_q P_{iq}P_{qj}\right)^2 \tag{3.27}$$

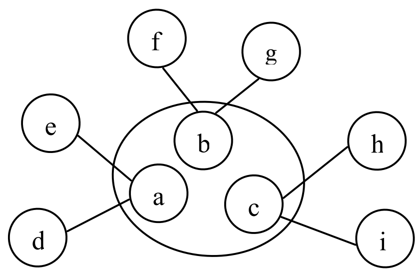
In the above equation the first term measures *size*, the second *density*, and the third *hierarchy*.

[112] The same equation but presented somewhat differently is (3.17) in section 3.2.2.2

According to Burt, the *social capital* level can be identified knowing the constraint of a network, differentiating among diverse possibilities, and distinguishing between group relations and links among group and non-group members. Then, network closure within group, implying internal lack of constraint, can be low (A) or high (B) and non-redundant contacts beyond group, understood as external lack of constraint, can be high (C) or low (D). The four combinations inferred from those possibilities can be drawn with nodes and lines, as in the examples shown in Burt (2000, p. 88) and reproduced in figures 3.8 to 3.11. In those examples the group (to represent cases A and B) is made of three members, (*a*, *b* and *c*) and there are six nodes out of the group, (*d*, *e*, *f*, *g*, *h* and *i*) to consider external constraint (cases C and D).

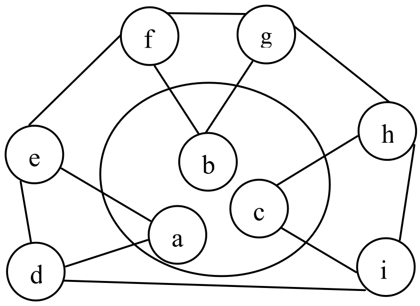
The case with the (A) and (C) situations is identified with a disintegrated group of diverse perspectives, skills and resources. Internal closure does not exist, nodes belonging to the group are not related, but there are external holes that can be exploited as contact among external actors does not exist. This situation could be represented as shown in figure 3.8:

Figure 3.8: Low internal closure and non redundant external contacts



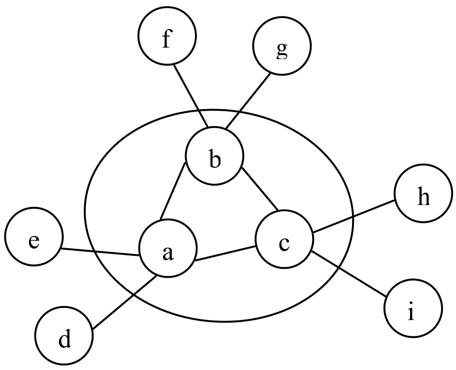
The situation with (A) and (D) represents minimum performance from *a social capital* perspective. An internal net with the profitable closure is not present and externally accessible rich flows are not evidenced, all external actors are related with redundant links as all external actors are related. This case would acquire the following form:

Figure 3.9: Low internal closure and redundant external contacts



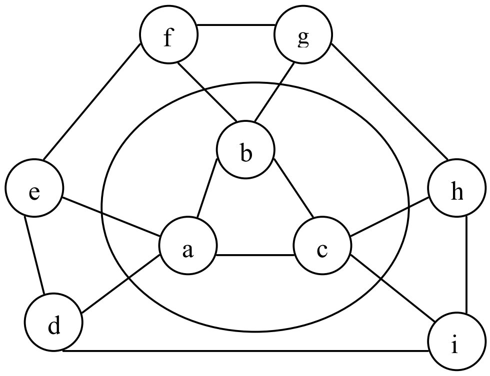
The case with (B) and (C) shows the maximum performance, as there is internal closure, all group members are related, and external holes, actors out of the group are not related, and therefore there are valuable resources to be exploited:

Figure 3.10: High internal closure and non redundant external contacts



The case with (B) and (D) represents a cohesive group having access to only one perspective and type of resource as all the actors have access to the same flows:

Figure 3.11: High internal closure and redundant external contacts



Although there is *social capital* in all the above structures, as all of them exhibit a net of relations, the third case, represented in figure 3.10, shows it with the highest intensity.

In Borgatti *et al* (1998) it is asserted that *social capital* can be measured with standard network indices, by relating them properly, instead of using specific measures as above. To explain those relations the authors distinguish between the type of actor (individual or group) and the type of focus (internal or external).

The case of internal and individual is empty, as this is the situation of a node related to itself. For the case of external and individual, *size*, *degree*, *heterogeneity*, *compositional quality* and *betweenness centrality* are positively related to *social capital* and *density*, *constraint* and *closeness centrality* are negatively related to *social capital*.[113] For the case of internal measures and collective actors, *social capital* shows a positive relation with *density*, *centralisation* and *core-periphery* structure and negative for *average* or *maximum distance* and *homophily*.[114] In the last case of external measures for collective actors, there are positive relations of *social capital* with *group degree centrality* and *group betweenness centrality*, and negative relations with *group closeness centrality*.

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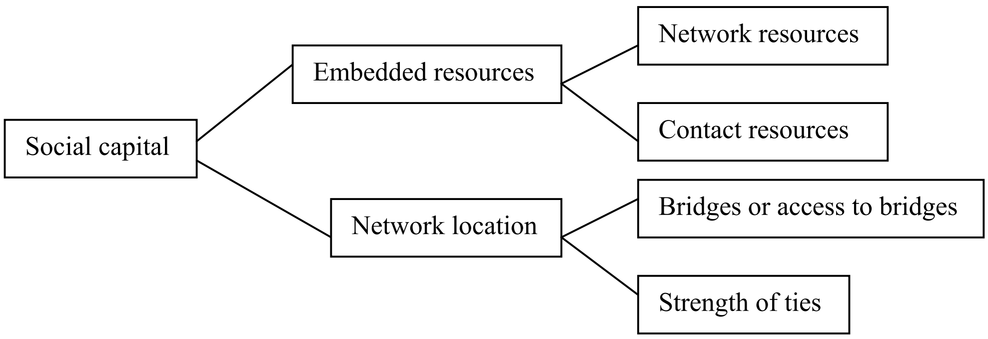
[113] In order to measure them, *heterogeneity* and *compositional quality* require attribute data on all nodes in addition to relational data.

[114] *Homophily*, understood as the extent to which members of the group have their closest ties to members who are similar to themselves, requires attribute data on all nodes in addition to relational data.

The same subject is analysed in Lin (1999), proposing to measure *social capital* as assets in networks and using sampling techniques to construct measures of *social capital*. The author does not offer specific measures of *social capital*, but he makes it clear that two factors should always be measured: the network resources, and the position. For *social capital* measured as assets in networks, *embedded resources* and *network location* should be considered. *Embedded resources* in turn, is analysed by measuring *network* and *contact resources*, and *network location* by measuring *bridges* or *access to bridges* and *strength of ties*. [115] All this is outlined in figure 3.12.

Figure 3.12: Social capital main factors in Lin (1999)



The author specifies the cases of *saturation technique*, *name generator technique* and *position generator technique* to construct measures of social capital with sampling techniques.[116]

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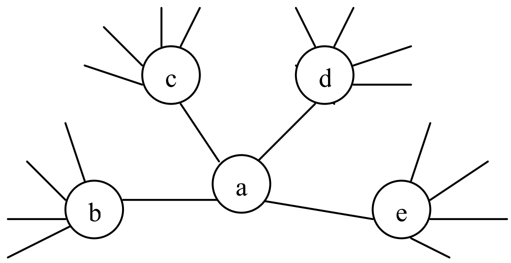
[115] The aspects that should be considered to measure *network resources* are: the range of resources among ties (distance between the highest and lowest valued resource), the best resource (upper reachability in a resource hierarchy), the variety or heterogeneity of resources, and the composition of resources (average or *typical resources*). To measure *contact resources*, contact's occupation, authority and sector should be considered. *Bridges* or *access to bridges* can be calculated through *structural holes*, *structural constraints* and *betweenness centrality*. *Strength of ties* should be considered through network bridge, intimacy intensity, interaction and reciprocity.

[116] *Saturation technique* should be applied through a complete mapping of the network; data from all nodes are needed, their relationships should be identified and then measurements of network locations can be developed. In *name generator technique* a customised content area and an ego-centred network mapping are needed, all ties and locations should be computed; measures such as composition, heterogeneity and upper reachability can be considered. To apply *position generator technique* a sample of hierarchical positions should be considered, multiple resources mapped and direct and indirect access computed, network resource indices can be built such as composition, heterogeneity and upper reachability.

More specifically, and as a final example with a wide application, in Burt (2000) there are three network forms of *social capital*, focused on the internal structure of economic organisations. More specifically, Burt's research is applied to the study of a particular organisation where the central node is a manager (node *a*) inside the institution. In that sense, the three network forms of *social capital* are *entrepreneurial network*, *clique network* and *hierarchical network*.[117]

The *entrepreneurial network* has a sparse and flat structure and there are independent relations sustained by the manager occupying the central position. There are abundant structural holes and low redundancy creating information and control benefits. This structure is associated with successful managers as there is high insiders' performance, and lowest performance for outsiders. All the flows pass through the manager, and he is the only contact to relate the other nodes. Graphically, the form of the network could be this:

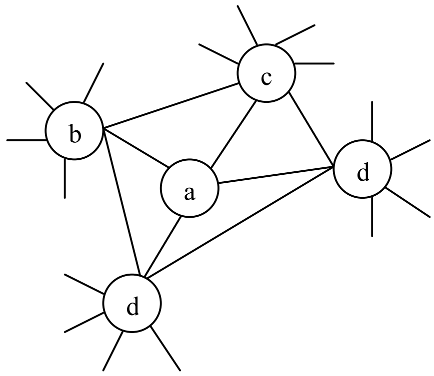
Figure 3.13: Entrepreneurial network



[117] Graphs are taken from Burt (2000, p. 91).

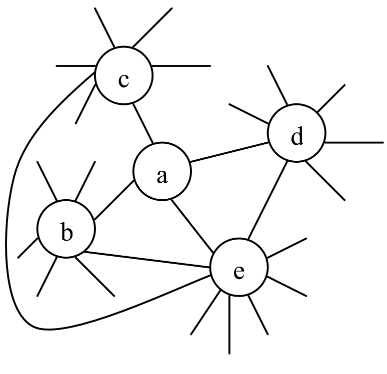
The *clique network* has a dense and flat structure. It has interconnected relations sustaining one another for the central node. There are not structural holes as all nodes are linked and receiving the same flows, and therefore there is high redundancy. It creates social support but minimal information and control benefits. This network is associated with unsuccessful managers offering low performance for insiders and average for outsiders.

Figure 3.14: Clique network



The *hierarchical network* has a sparse, centre-periphery structure. Its ties are sustained jointly by the manager and there are strategic structural holes borrowed from strategic partners near second-hand information and control benefits. It is associated with successful outsiders and unsuccessful insiders.

Figure 3.15: Hierarchical network



Those examples can be applied to other situations, as when the central node is a firm or a productive branch or sector in a *production system*. In that case the possibility of potential benefits obtained through structural holes or the change in some actor's position can be studied. Moreover, once links with other institutions have been included in the *productive system*, the relational structure shows the social capital working in the network more precisely. There are empirical studies studying those more concrete structures of relations, using 'trust' as a social capital measure and quantifying it through questionnaires. Once the information is obtained in that form, the social capital structure can be analysed as shown in this section.

3.3.2.4.- Correlation analysis and other techniques

In network data observations are not independent of each other and they do not constitute a random sample, with population distribution of variables unknown and probably not random. In a case such as this, correlation can be applied through the application of permutation matrices in the *quadratic assignment procedure* (QAP). Some references which apply this are Burkhardt (1994) studying technological change and Kilduff and Krackhardt (1994) analysing reputation in organisations, and generally when analysing *centre-periphery* structures.

Other techniques applied to the study of networks are *qualitative input-output analysis* (QIOA) and *minimal flow analysis* (MFA). Both imply structural analysis of networks, applying algorithms, graphs, and some of the measures explained in this chapter. The main difference between those techniques and *social network analysis* is that they do not offer a methodological framework, as it is the case of *network analysis*. They just apply them to the identification and study of several kinds of networks. Some interesting references are Drejer (1999) for different national systems of innovation, Fontela *et al* (2000) and Schnabl (2001) studying the input-output structure of several countries and regions and Aroche-Reyes (2001) for industrial complexes.

3.3.3 Overview of the methods applied in this research

This section shows a summary of the methods detailed in this chapter for their application to the cases of Andalusia and the Basque Country in the following chapters. There is also a brief explanation of mechanism causality as a method to test hypotheses that will be also used in the applied work of this research. Figure 3.16 shows how the analysed methods will be used in the next chapters to identify regional productive systems, and how mechanism causality will be applied to test hypotheses proposing relations between the systems' structure and evolution and regional development processes. The figure, therefore, represents the link between the theoretical research made in chapters 2 and 3 and the applied work that will be carried out in chapters 4 and 5.

3.3.3.1. Methods summary to identify regional productive systems

Two types of data are used through this research, input-output data and regional qualitative and quantitative information. In this second case, data from individual firms working in the region and from their more relevant institutions are included. The historical information is particularly useful for the selection and characterisation of the systems, as it makes it possible to consider the specialisation and the productive particularities of each region.

The first step in the applied research will be the identification and selection of regional production systems inside the social networks constituted by the available data. For this, network measures and a particular algorithm are used. However, not all the network measures explained in this chapter will be applied to the regional data used; in chapter 4, some measures have been selected for the systems identification process.

Once the production systems have been obtained, the next step will be to characterise them with input-output indices and with the results obtained from the application of the selected network measures. After the production systems have been identified and characterised for the two selected regions, institutional information will be added to transform them into regional productive systems. All of this sequence, followed in the methods application for the determination of regional productive systems, is schematised in figure 3.16.

3.3.3.2. Mechanism causality as the hypotheses testing method

A set of hypotheses will be proposed for testing, once the production and productive systems have been studied. The hypotheses will refer to the relationship between the systems structure and evolution and regional development paths. Therefore, the units of analysis are production and productive systems and branches. Then, the explanation of phenomena occurring at system level are found in its underlying structure, that is, in the process occurring at an inferior level, which in this analysis is the level of institutions and firms forming the productive branches. The process, that represents firms' actions, is explained in terms of mechanisms and therefore the analytical perspective considered in this study is *mechanism causality*.

This is one of the possible types of causality, as according to Doreian (2001 and 2002) causal relations working in a process can be presented and studied in four forms, mainly depending on the type of used data, the theoretical perspective adopted and the kind of analysis applied. Table 3.1 shows a brief description of these four different types of causality, as well as some references of works using network data in which they have been applied.

Table 3.1: Typology of causalities

Type of causality	Description	References applied to network data
System causality	A system of equations is specified to explain changes in the processes.	Padulo and Arbib (1974), Fararo (1989)
Statistical causality	Estimation of equations and predictions through regression analysis.	Wasserman and Pattison (1996), Morgan (1997)
Mechanism causality	Looking at social mechanisms and sequences of events to explain the process and to find general mechanisms.	Chase (1992), Fararo *et al* (1994), Morgan (1997)
Algorithmic causality	Application of algorithms where rules are encoded to transform input into output values.	Hummon and Fararo (1995)

The four types of causality can be applied to study processes occurring in social and economic networks; more specifically, all of them can be used to analyse their spatial and temporal changes. However, in our view, attending to the type of data used, to the increasing difficulty for the specification of equations, and considering that the objective is to explain a process, the most appropriate analytical approach in this research is *mechanism causality*.

Mechanism causality is applied to study sequences of events at the actor level, with the aim to account for them in terms of generalised mechanisms, which can be used for explanatory purposes. In other words, when *mechanism causality* is applied, the analysis of the processes occurring at the level of the actors that form the network provides the explanation of the processes or facts that are taking place at the macro level of the network.

In the *mechanism causality* approach, social processes are seen as the result of actions of complex intentional agents, taking place in an environment of time and space. In that case, through *mechanism*, or *event causality*, the interaction and action of firms in the two selected regions and systems are the underlying structure explaining the studied changes at branch level.[118]

A set of hypotheses can be proposed to test them when it is observed that certain network ties change, and therefore networks change, in time and space. The observations can suggest that there are general mechanisms explaining the changes. Therefore, to construct general descriptions of mechanisms and event sequences, both specific empirical event sequences and generalised sequences and mechanisms are needed.[119] Table 3.2 shows some examples of how this has been done in different research areas using network data.

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[118] "Events can be considered actions by a single actor or social interactions between actors" (Aunger, 1995, p. 106).

[119] According to Aunger (1995, p. 105) the constituent events and states of a given structure can be abstracted from historical accounts, observed directly in the field, or produced by a computer.

Table 3.2: Examples applying mechanism causality and sequences of events

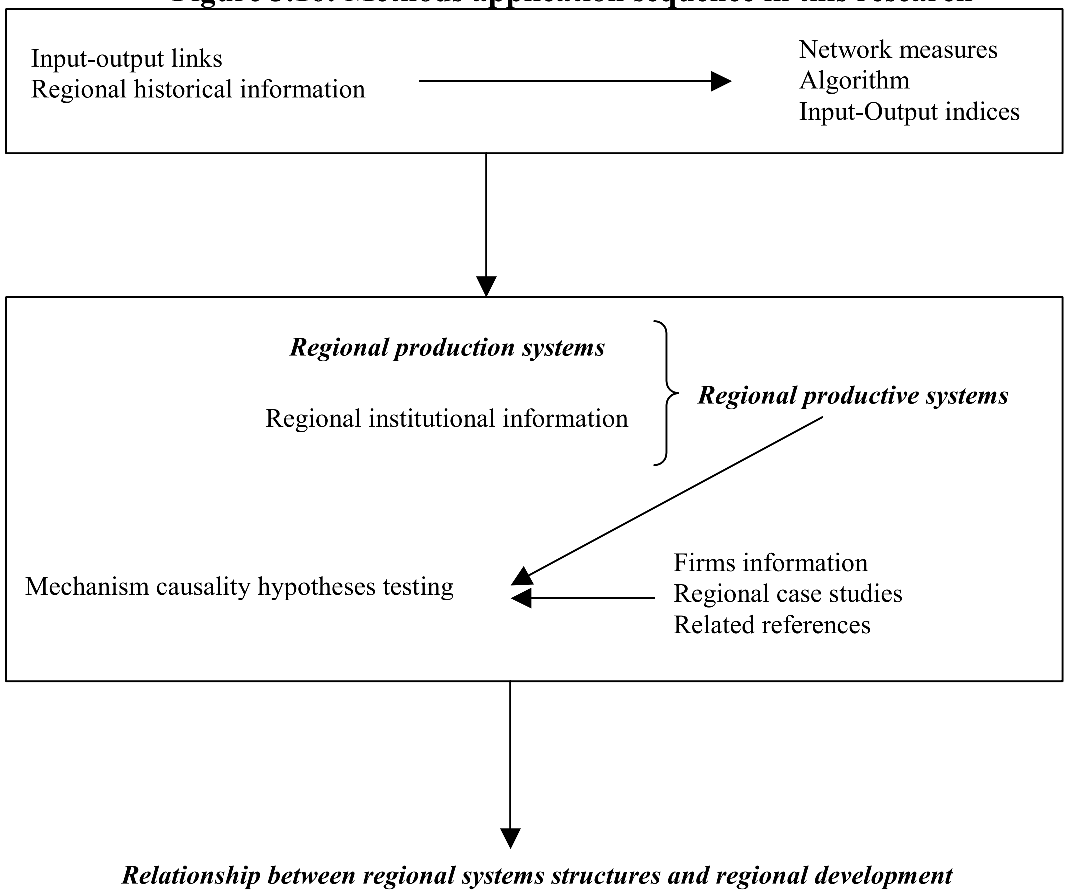
Reference	Description
Doreian (2002)	Testing the *theory of imbalance*.[120] Hypotheses: (H1) Through time, the proportion of balanced triples increases. (H2) Through time, the proportion of imbalance triples decreases. Sequences of events: (1) Relations among a group of monks in three time points, specified in three matrices of relations, experiment made in Sampson (1968). (2) Relations among 17 previously unacquainted young men during 15 weeks, specified in 15 matrices of relations, experiment made in Newcomb (1961).
Doreian (2001)	Testing isomorphic structures of similar schools of social work. Mechanisms: (1) Coercive. The administration imposes some minimum conditions. (2) Mimetic. The less efficient schools try to imitate the more efficient ones. (3) Normative. There are general compulsory rules.
DiMaggio and Powell (1991)	Testing the relations between mental health hospitals and a mental health foundation. Hypothesis: The greater the dependence of an organisation on another organisation, the more similar it will become in structure, climate and behavioural focus to yet other organisations that are dependent in the same fashion, on the same organisation. Sequence of events: Negotiation process between the two types of organisations. Mechanism: Coercive. The focal organisation has the power to impose certain minimum conditions.
Chase (1992) and Fararo *et al.* (1994)	Testing the formation of hierarchy relations among primates. Sequence of events: Observation of the behaviour of groups of primates. Mechanisms: (1) Fighting. (2) Bystanders.
Stinchcombe (1998)	Testing the market process. Mechanism: Monopolistic competition.
Abell (1987)	Testing a theory of rational action. Sequence of events: Individual behaviours in social interactions.
Abbott and Hrycak (1990)	Testing a typology of musical careers. Sequence of events: Stages of individual careers of German classical musicians during the Baroque and Classical eras.

It should be emphasised that the *mechanism causality* approach should not be confused with a purely descriptive approach. Mechanism causality does not describe, it explains: a purely descriptive approach aims to account for the unique chain of events that leads from one situation or event to another in a particular process, however, the mechanism causality approach looks for general explanatory mechanisms. Clearly, there are many possible mechanisms working at the same time, and not all need to be operative at a

[120] According to this theory, individuals relating in a group tend to equilibrate their relations, imbalance creates discomfort and this generates forces that move triples of individuals towards balance. An example of equilibrated or balanced relation in a group formed by three individuals could be *the friend of my friend is my friend*. However, the triple relation *I dislike the friend of my friend* constitutes an example of an imbalanced one.

given empirical context. Therefore, only some mechanisms are identifiable, but this is a limitation that is present in any kind of causality specification and explanation. Figure 3.16 also includes the step in which mechanism causality will be used in the applied side of this research.

Figure 3.16: Methods application sequence in this research



4. REGIONAL PRODUCTIVE STRUCTURES AND PRODUCTION SYSTEMS

4.1. Introduction

Regional production systems will be studied in this chapter. This will be done for the Spanish regions of Andalusia and the Basque Country, although for some parts of the analysis data related to the whole country could be offered as a reference point.

The regional productive characteristics will be analysed from a historical perspective as a first step, to get information about the main branches working in the productive fabric of every region.

Then, quantitative analyses will be applied to the regional input-output data. For this reason there is a section, previous to the empirical work, focused on some technical explanation of the coefficients and branches used in this part of the research.

Quantitative analyses are applied to the whole input-output net through descriptive statistics and social network analysis. Deductions from those calculations and from the application of a specific algorithm will be used to identify two groups of productive branches or *production systems*.

Once the regional productive fabric has been studied, from a historical, descriptive and network perspective, the identified *production systems* will be transformed in the next chapter into *productive systems* for their deep study, by including the necessary information.

The study of the whole net and the next focus on a subgroup of it (*production system*), allows us to understand the regional production net from a macro and a micro perspective. From a network structure view, the analytical approach for the actor aggregation in a particular unit of analysis can be, according to Burt (1980): actor, multiple actors as a network subgroup, and multiple actors as a structured system. The last two units of analysis are chosen in this part of the research, considering the macro and the micro levels. Moreover, the network analysis can be approached from a relational or positional perspective. The analytical tools offered by social network analysis allows for the study of both, as will be done in this chapter.

4.2. Regional historical characteristics: key productive branches

Every region inside Spain has its own peculiarities affecting its productive structure and its economic fabric in general. In the case of the two regions under study in this research, differences are quite important in size, population, productive specialisation, location, political situation and history. It is essential to have a previous picture of their main characteristics for a better understanding of their economic situation at present. This is the purpose of this section.

4.2.1. The Basque Country

The Basque Country is one of the 17 regions in Spain. It is located in the north of the country, boarded by the Cantábrico Sea and the south of France, a more developed area. It has an extension of 7,234 Km^2, and its population is 2,082,587 inhabitants in 2003. It is made of three provinces: Álava, Vizcaya and Guipúzcoa.

The productive specialisation of this region is clearly explained from its economic history, as shown in the first part of this section. There is also a peculiarity of the region that should be taken into account for a better interpretation of its economic evolution in recent decades. This is the case of the terrorist actions of ETA that will be mentioned in passing in a second part of this section.

4.2.1.1. The productive structure of the Basque Country from a historical perspective

Historical studies about the productive structure of the Basque Country mention its clear regional specialisation, with data from the eighteenth century, in ironworks.[121] Its geographic location with a sea port, its ore resources, its trade tradition, its craftsmanship linked to shipbuilding and to the iron and steel industry, its labour specialisation, and its business skills, intensified the region productive concentration throughout the nineteenth and twentieth centuries.

Other factors that enhanced the Basque productive tradition were its almost non existent tax system, the international protectionism and its investments in railways. The main factors for regional growth were its location and its ore resources. This led to high urban

[121] Fernández de Pinedo and Fernández (2001) and Domínguez Martín (2002).

concentration, higher industrialisation and higher railway investment than in other regions.

In the eighteenth century the Basque Country region was the main connection between the Sea and the interior national territory. This meant an important control of exports, and the incentive for the creation of a trade culture.[122] Those positive factors where applied to the product where the region had clear comparative advantages: iron ore. The first Basque modern iron-steel factory was established in 1841, while already in 1830 blast furnaces were created in Malaga and Seville (both in Andalusia) working with British iron ore. At the end of the century there was a period of crisis affected by changes in international trade and the effect of international and national competition. (Fernández de Pinedo and Fernández, 2001).

Throughout the nineteenth century there was an industrial process with the transformation of ironworks and foundries into iron and steel firms.[123] Their production was mainly focused on fire arms and other iron works.[124] Those other iron works, at the beginning, consisted of simple products with low value added, while iron products with more technology content were imported, mainly from Sheffield and Birmingham. The Basque Country became the first industrialised region in the country. This is a period of growth, with increasing *per capita* income, population growth, positive migration, increased capital, railway investment, human capital formation, life expectancy increase, new patents and other socio-economic positive factors that intensified the regional specialisation. Technological facts were the determinants of the origin of the modern Basque specialised industry at the end of the nineteenth century.

From the beginning of the twentieth century the industrialisation process went on with the creation of new iron and steel and sea transport firms,[125] and the modernisation and

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[122] Additional positive factors were the weather, the orography and abundant labour force coming from the agriculture.

[123] Another important sector pushed in this period is finance. In 1857 the *Banco de Bilbao* (Bilbao bank) was founded. Its creation came from the necessity to finance the regional business investments.

[124] The main Basque iron and steel industries at the end of nineteenth century were: *Santa Ana de Bolueta*, *Nuestra señora del Carmen*, *San Pedro de Araya* and San *Martín de Beasaín*.

[125] *Altos Hornos de Bilbao*, *San Francisco*, *La Vizcaya*, among others.

enlargement of already existent iron and steel firms. Throughout that century new firms appeared producing iron and steel products that had been imported up until that time, then instead of exporting the raw material (iron) and subsequently importing the transformed products, creating therefore an 'integrated iron industry'. One of its effects was the reduction in that type of imports within few years. This is also the case of high value added products and intensive in technology and skilled labour, leading to an import substitution.[126]

Following Fernández de Pinedo (2001) the Basque businessmen were almost the only in the country with a strategy for growth and not just for surviving. Their actions were to substitute imports taking advantage of protectionist measures, to buy and copy foreign technology, and to focus in the national market. Later on a chemical industry emerged in the region by using derivatives from the iron and steel firms. The main working links were established among heavy iron and steel production, chemical industry, shipyards and the agriculture sector from one side, and also between integral iron industry and basic iron and steel industry. Moreover, the development process and the expansion of the non-perishable consuming goods (white goods) favoured the regional economy. In the second half of the twentieth century there is a reduction in public subsidies and in protectionism measures and an economic depression that led to an industrial rationalisation process with firm closing and an unemployment rate increase. The most affected firms were those linked to iron and steel works; nevertheless, the surviving and new firms focused their production in similar goods but with modern technology and higher productivity. It is not possible to talk about an industrial diversification, with still a deep specialisation in the industrial fabric. The main change was the growing importance of the service sector. At the beginning of the twenty first century the Basque Country is considered as belonging to the richest group of regions of Spain but among the stationary regions, while the rich growing regions are Baleares, Madrid, Navarra and Catalonia.

To conclude, there is a clear productive concentration in the Basque productive structure based on historical factors: geographic location (seaport, tableland access,

[126] Agriculture machines, engines, copper machinery, wagons, coach and ships.

navigable seas and iron ore near the sea), technical and business skills, infrastructure from ironworks (dams, buildings), international and national trade knowledge and inexistence of manufacturing sector taxes. Together with those factors, some other mentioned facts pushed the creation of iron and steel plants, shipyards and a modern bank. This led to an increasing weight of mining, iron and steel, chemical, banking and sea transport productions.

4.2.1.2. The role of ETA terrorism in the economic evolution of the Basque Country

ETA terrorist group was founded in 1959, since then and to date it has committed 817 murders and 77 kidnappings (June 2003).[127] The link between this fact and the Basque economic situation should be taken into account for a better understanding of its socio-economic structure. Before the period of intense terrorist actions (1974) the position of the Basque Country in the national ranking was among the three first regions, considered a place of high growth and intense industrialisation. From that period its economic situation has dramatically changed, with lower rates of growth, less population growth and fewer investments. Although terrorist actions started in 1968, in the middle of 70s they became a large scale phenomenon. Nevertheless, there are other factors taking place in the same period that could have had even a bigger impact in the regional economic evolution, mainly the industrial crisis in the 70s.

Abadie and Gardeazabal (2001) have made a simulation comparing the situation of the region with a hypothetical Basque Country without terrorism. Their main result is that *per capita* GDP is 10 percent less than it could be with the region without the terrorism problem.[128] Among the explanations is the abandoning of the region by extorted businessmen and the reduction in foreign direct investment.

Reduction of foreign direct investment caused by terrorist attacks in Spain is studied in Enders and Sandler (1996).[129] Its main conclusion is that, on average, terrorism reduced

[127] 547 murders have been committed in the Basque Country.

[128] In average for the period analysed, 1968-1997.

[129] For those authors, the main effects of terrorism are: losses from tourist revenues, smaller inflows of investment from abroad, destruction of infrastructure and opportunity costs due to resources used to deter terrorist attacks and to capture terrorists.

annual net foreign direct investment in Spain by 13.5%, meaning an annual decline of $488.9 million, in the period 1975-1991, which is the equivalent of 7.6% of annual gross fixed capital formation.[130] Moreover, as foreign direct investment is an important revenue for technology transfer, and therefore for economic growth, its decrease will reduce growth. The harm to commercial interest comes, in part, from the imposition of an extortionist revolutionary tax that could reduce expected returns and dissuade foreign direct investments. Terrorism has permanent effects on net foreign capital holdings in Spain through its effect in the temporary decline in investment.

4.2.2. Andalusia

Andalusia is one of the biggest regions in Spain with an extension of 87,597 Km^2 located in the south of Spain, boarded by the Mediterranean Sea and the Atlantic Ocean. It is a periphery region in Spain, which is also a periphery country. It has a population of 7,478,432 inhabitants in 2003, distributed in eight provinces: Almería, Cádiz, Córdoba, Granada, Huelva, Jaén, Málaga and Sevilla.

This is a region which is highly specialised in agriculture and agribusiness. This characteristic is explained by history, location and social factors. Nevertheless, there are other sectors with an important weight in its industrial history, like metallurgy mainly in the past and services at present (Martínez Rodriguez, 1993).

4.2.2.1. The productive structure of Andalusia from a historical perspective

Natural resources in Andalusia are the key to understand its productive specialisation. It has always had highly fertile earth and rich subsoil, with its main natural resources linked to agriculture and mining. Moreover, its spatial location was a privilege for international trade relationships, mainly with America until the loss of colonies.

At the beginning of the twentieth century it was the Spanish region with more international trade links, most of its production being sent to international markets. Its export structure shows high concentration in transformed agriculture products (mainly wines and liquors in nineteenth century and olive oil and olives in the twentieth century)

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[130] The simulation made by the authors shows that a particular incident in Spain is estimated to cause a $23.8 million reduction in net foreign direct investment.

and mineral ores. Until the beginning of the twentieth century those two groups implied more than 80% of total exports. Throughout the twentieth century other groups with high weight in regional exports, together with the already mentioned two, were non transformed agriculture products, metal and mechanical products and chemicals.

The highly traditional productions in the region experienced an industrialisation process focused in the sectors were the region had comparative advantages: mining and agribusiness. Moreover, in the development process service sectors are having an increasing importance in the regional economic structure.

At the beginning of the twenty first century Andalusia can be considered as a backward region belonging to the poor side of the country. It has the lowest *per capita* GNP and the highest unemployment rate, together with Extremadura. History has much to explain for this present situation with high land property concentrations, unfair tenancy systems with highly seasonal labour market (agriculture), maximum labour exploitation and low productivity with low investment. Together with the big problem of extreme inequality for property and income distribution there was a situation of foreign firms renting and acquiring regional resources and of local traders without an interest in increasing production and regional wealth.

The industrialisation process experienced in other regions came to Andalusia more slowly. Economic growth has always been focused in primary specialisation and international trade, with the exploitation of mining through the creation of iron and steel production firms and of agriculture with the development of an agribusiness industry.[131]

[131] The first metallurgy firm in Spain, *La Concepción*, was opened in Andalusia, in the province of Málaga, (Bernal and Parejo, 2001).

More specifically, the productive structure of Andalusia, considering the period starting in the beginning of nineteenth century, could be considered to be reduced to the following type of products: energy (solid fuels and coke; electric energy and gas), non-energetic mineral ores (metal and non-metal ores), basic metal industry (iron, copper, lead and silver transformation), chemical industry (for the industry, from oil and coal, fertilisers and explosives, chemicals for domestic uses), metal transformation industry, non-metal transformation industry, textiles (cotton, wool), agro-food industry (flour, olive oil, wine, sugar, canned food), lead industry, paper, cork and wood.

In the first half of the nineteenth century the contribution of the olive oil industry to the regional industrial production was 16.4%, 11.8% for pyrites and copper and 10% for lead extraction and metallurgy. In the second half of the nineteenth century the main contributions were 12.6% for pyrites and copper, 10.2% for olive oil industry and 10.1% for lead extraction and metallurgy. In the first third of the twentieth century the main contribution to industry was olive oil with 24.3%.[132]

In the case of the iron and steel industry there were several problems impeding its development. One of the problems was the lack of infrastructures needed for the extraction process and for transportation. Another problem was that most of the capital linked to this industry was not regional but the property of Basque or foreign firms. Together with these circumstances, the industrialisation process was deeper and faster in the Basque Country, innovations were not adopted in Andalusia, foreign intervention was too high and prices too low. Therefore, the weight of the iron and steel industry of Andalusia in the whole country was decreasing and the relevant role for the regional economic growth was played by the agro-food industry.

There is a product in the productive structure of Andalusia that has been, and still is, a key for its economy: olive oil. This region is the first world producer, and has introduced increasing innovation techniques to improve productivity and quality. Moreover, there are other products (derivatives of olive oil and related to olive trees)

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[132] Data obtained from Parejo Barranco (1997).

acquiring benefits from this situation: oil distilled from olive refuse, soap and olives mainly.

To understand the present situation of Andalusia it should be said that its main problems avoiding its development have been: too high unequal income and property distribution, too high external dependency and the lack of social and institutional transformations. One of the main consequences is that, in crisis periods, industry has always been the sector suffering from it more deeply. Then, agriculture is always the sector trying to maintain the regional economic level. Throughout the whole of the twentieth century, agriculture, mining and related sub-sectors appear always in the top positions of production weights, followed by services (mainly basic services) and the last place is for industry.

Industry in Andalusia has always been used by other regions and countries for the most basic part of their production processes, avoiding its embeddedness in the regional fabric. Moreover, services needed for industry have not been developed in the region like in other parts of the country. And also there is an intense locality sense. The result is a region with a disarticulated and unstructured productive fabric.

4.2.3. Some deductions from the historical comparison between Andalusia and the Basque Country

A main question derived from the historical regional analysis should be made explicit here, as it will explain much of the results appearing in the input-output network analysis. Several authors (Bernal and Parejo, 2001, among others) have remarked the disarticulated and unstructured situation of the economy in Andalusia as one of the main problems restraining development. In fact, in long periods Andalusia have shown quite important growth rates but without development.

The duality of its production structure explains a big part of the present situation. This duality consists in a part of the production systems focused on agriculture, which is highly traditional, owned by regional producers, with low productivity, low innovation incorporations and appearing as the key sector in crisis periods. The other part of the production system is made of industrial activities, mostly owned by producers from other regions and even countries, with weak links to regional firms as they are used by other locations to develop part of their production processes. Historically, there were not links among industrial sectors, between industrial and primary sectors, or between industry and service sectors.

This situation has never taken place in the Basque Country, where the industry have traditionally been owned by regional producers, the production structure has been highly articulated, and natural resources, industry and services have been organised in order to increase efficiency, productivity and regional articulation.

As an illustrative example, in the case of services, while in Andalusia services have been focused in restaurants, hotels and trade, in the Basque Country they have been focused in business services and banking. In fact, the first Basque bank, *Banco de Bilbao* which is one of the main banks in the country at present, was created in 1857 to finance regional firms in their investments.[133] In Andalusia, in the nineteenth century there were only some savings banks (*cajas de ahorros*) belonging to the church, upper middle class and aristocracy. The first bank, *Banco de Málaga*, was founded in 1856 and absorbed by the Bank of Spain in 1874.

Another illustrative case is the creation of an agribusiness system in Andalusia that can be dated in the 1980s, following authors like Delgado Cabeza (1993). Agriculture has always been the main productive sector in the region, but it was not able to develop a system linked to it from the demand and supply sides. In the Basque Country, however, its main sector system, focused on metallurgy, was emerging from the beginning.

The regional productive structure of both regions in the period 1980-1995 is analysed in the following sections. This will be done by applying different perspectives and techniques. Therefore, the section following immediately after is focused on some explanation of the data and coefficients used for the analysis.

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[133] Originally BBVA was BB (*Banco de Bilbao*) and was transformed in BBV (*Banco Bilbao Vizcaya*) after merged to *Banco de Vizcaya* in 1988. In 1999 a new merge with Argentaria led to the actual BBVA bank (*Banco Bilbao Vizcaya Argentaria*).

4.3. Selection of the coefficients and data used in the empirical analysis

Descriptive and social network analyses will be applied to input-output data in relative terms, once they have been transformed into coefficients. Then, a first clarification of the selected coefficients is necessary.

Coefficients, once calculated, showed very low values for some branches. For this reason, threshold values have been selected to eliminate too low coefficients. Then, the quantitative analysis has also been done only for the coefficients selected by a set of filters.

Moreover, there are some productive branches presenting problems from a methodological point of view. Those problems will also be explained in a section showing the method applied to obtain homogenous branch classifications.

4.3.1. Selection of coefficients

Most of the works applying input-output data for a productive structure study use technical coefficients or inverse Leontieff coefficients. None of them have been chosen for this research. The purpose of this section is to explain why, and to show the coefficients that have been selected

According to de Mesnard (2001), the use of inverse matrices for their application to Network Analysis has no sense for the following reasons:

- The links between nodes in a network coming from B coefficients have no sense. B coefficients includes all the paths of any length connecting two nodes, therefore the arrow between two nodes does not have any sense. Direct relation coefficients should be used, and paths of length longer than two would show indirect relations.
- After the matrix of links is made binary the inverse loses its sense even more. When b_{ij} (coefficient in the inverse Leontief matrix) is higher or equal than a filter value it is made 1 (w_{ij}=1), when b_{jl} is higher than a filter value it is made 1 (w_{jl}=1). Therefore, according to transitivity, the binary value of the relation between *i* and *l* is 1 (w_{il}=1).[134]

[134] The matrix operation to measure transitive links is Boolean sum.

But the coefficient b_{il} already includes all the possible relations (of every path) between i and l, therefore w_{il} has no meaning.

- The Leontief inverse matrix can be decomposed as $B=A^0+A^1+A^2+...+A^\infty$. Therefore, the b_{ij} coefficients consider paths of any length, even infinite paths, then $b_{ij}b_{jl}$ should be higher than infinite, which has no meaning.

The above conclusions could lead to choose technical coefficients instead of inverse Leontief coefficients. However, neither are technical coefficients selected in the whole net analysis for this research.

In order to make a first analysis of the whole net, coefficients are calculated with respect to total sales or total purchases. Therefore, branches could be classified according to their weight in the whole economy structure using the following *relative intermediate transaction coefficients*.[135]

$$\frac{x_{ij}}{IS_T}\cdot 100 = \frac{x_{ij}}{IP_T}\cdot 100 \qquad (4.1)$$

That is, coefficients are not used in terms of production, like technical coefficients, but in terms of total intermediate sales and purchases, as the object of analysis is inter-sector relationships. Then, there are four matrices for each region: 1980 inside and total, 1995 inside and total. Although the analysis will be done with inside values, the total ones can be used for comparison, as with the data from Spain.

Once the whole nets has been analysed, the research will focus in the part of those nets constituting *production systems*. To have more detailed information at this level, the coefficients used are the following *relative intermediate sales* and *relative intermediate purchases coefficients:*[136]

$$\frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}}\cdot 100 = \frac{x_{ij}}{IS_i}\cdot 100 \qquad \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}}\cdot 100 = \frac{x_{ij}}{IP_j}\cdot 100 \qquad (4.2)$$

[135] IS_T: total intermediate sales; IP_T: total intermediate purchases.

[136] An example of works using that type of coefficients is Peeters *et al* (2001).

Both types of coefficients have been calculated after the main diagonal of inter-sector relationships has been eliminated. As explained in the previous chapter, the main interest of this research is in inter but not intra, sector relationships. Moreover, the case in which a branch has very high sales to itself and therefore, when calculating the coefficients all the intermediate sales appear very small, will be avoided in this way.

4.3.2. Selection of threshold values to eliminate trivial relationships

A frequency statistical analysis has been applied to the coefficients, for total and inside values, to have data ordered according to their trade intensity.[137] Each matrix of coefficients has been divided in 20 groups (percentiles). As an example, in order to select approximately 20% of the relationships with highest values, only relations with coefficients equal or above 1% should be considered.

An important deduced piece of information is that, in all the cases, the first 35% of potential relationships have coefficients with only zero values. Then, positive value coefficients start in the percentile corresponding to 40%.

4.3.3. Final number of branches and their classification

A homogeneity process has been done in order to use the same number of branches in both years, 1980 and 1995, for each region. Nevertheless, even after homogeneity has been done some branches presented methodological problems and in some cases they had to be eliminated. Once a final categorization is decided they have been classified again in bigger groups according to their sector characteristics, their technology content and their input-output links. Moreover, it should be remembered that the inter-branch relationships being considered only refer to intermediate transactions. Therefore, capital transactions are not reflected in the data.[138]

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[137] In the case of the relative intermediate transaction coefficients (4.1) the average value changes between 1.91 and 2.12.

[138] The final classifications are detailed in annex 4.1.

4.3.3.1. Branches with methodological problems

The methodological problems mainly come from service branches and some of them had to be eliminated. Nevertheless, the situation is somehow different in each place.

4.3.3.1.1. The Basque Country

The input-output table of 1980 has 73 branches and 83 in 1995. They have been made homogeneous leading to a classification with 49 branches. However, among those 49 productive branches there are methodological problems with some of them, and therefore 3 more branches have been eliminated as is explained in this section. Then, the final homogeneous classification has 46 branches.

Some of the main problems appear in services, as is the case of the eliminated branches:

- 'Activities of private households' branch (domestic service) is eliminated as it does not have any trade relation as seller or as buyer.
- 'Public administration, defence and social security' branch in the year 1980 made sales of goods and services to 47 branches. However, in 1995 it did not make any intermediate sale to any productive branch. There is a clear methodological change as the same situation can be observed in Andalusia. The branch will be eliminated in both regions to avoid bias in the result.
- 'Education' branch in the year 1980 did not make any intermediate sale to any other productive branch. However, in the year 1995 it made sales to 29 branches. It will be eliminated.

For the industry productive branches there is a particular methodological problem of high importance in the case of this region:

- 'Manufacture of machinery for metallurgy'. It is a key branch in the Basque Country according to the region productive specialisation. However, in the Input-Output data it is a branch with very few links and very low coefficients. Moreover, in 1980 its intermediate sales are 0, indicating that it did not sell to any other branch. The explanation is that its production goes to final demand (investment and exports).[139] The weight of exports on branch production was 86.6% in 1980 and 74.8% in 1995. The weight of investment on branch production was 13.5% in 1980 and 20.2% in 1995. This particularity should be considered in the region analysis because of the importance of the branch in the Basque Country.

4.3.3.1.2. Andalusia

This region has 64 branches in the input-output table of 1980 and 89 in the table of 1995. The homogeneous classification would have 47 branches, however three branches have been eliminated because of methodological problems and the final classification has 44 productive branches.

- 'Public administration, defence and social security' branch in 1980 made intermediate sales to all the branches, while in 1995 it did not sell to anyone. This situation is similar to that of the Basque Country, and the branch is eliminated according to methodological problems.
- 'Health' and 'education' in the year 1980 made intermediate sales to 40 and 34 other branches respectively while in 1995 they were selling to 10 and 7 other branches. The methodological or empirical reasons are unknown and the branches are eliminated.

4.3.3.1.3. Spain

The input-output table in 1980 has 85 branches and in 1995 there are 70 branches. The final classification, once homogeneity has been done and one of the branches has been eliminated, has 42 productive branches:

- 'Public administration' branch, including health, is eliminated.[140]

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[139] The increase between 1980 and 1995 of its investment was 394% with inside values (694% with total values). The increase of its exports was 183%. The increase in final demand was, in inside values 211% and in total values 275%.

[140] It seems not fortuitous that the problematic branches are 'health', 'education' and 'public administration' as all of them are related and have some peculiarities: Consumption made by market producers of collective administration services are not considered intermediate consumption but collective consumption. The input-output methodology of the Basque Country in 1980 offers a note clarifying that the activity of the sector 'public administration' is not all for collective use, there are partial payments for services offered to all the economic activities and therefore its row is not zero.

4.3.3.2. Branches classification according to economic sectors, technology content and input-output links

Once there is a final homogeneous branch categorisation for each of the two regions, they have been classified according to the sector they belong to, their technology content and their input-output links. The intention is to elaborate a deeper analysis and to get richer conclusions. It is generally accepted that more developed areas show a specialisation on, or a tendency towards, productive branches with high technology content and belonging to the service sector. Those conclusions can be tested for the cases of the Basque Country and Andalusia by using the proper classifications.

Moreover, a third classification is offered in this section as a contribution of this research. While the other two widely known classifications focus on branch attributes, the new proposed classification focuses on branch input-output links. With its complementary application, conclusions about regional development can be explained more deeply according to each productive structure.

Table 4.1, corresponding to a sectoral differentiation, shows the first of the three classifications used.

Table 4.1: Sector classification. Branches belonging to each sector

	Andalusia	**Basque Country**
1. Agriculture, hunting and fishing	1-4 (4)	1-3 (3)
2. Ore industries	5 (1)	4,8 (2)
3. Manufacturing industries	6,10-36 (28)	5,9-33 (26)
4. Electricity, gas and water	7-9 (3)	6,7 (2)
5. Construction	37 (1)	34 (1)
6. Services	38-44 (7)	35-46 (12)

Note: The total number of branches in each group is included in brackets.

The above classification is based on EAS-95 (European Accounting System-95). At a more aggregated level, it tries to divide all the productive activities in three big groups: agriculture (primary sector), industry (secondary sector) and services (tertiary sector). The version offered in table 4.1 is more specific, separating the three big sectors in six groups.

Table 4.2 corresponds to the classification focused on the technology content of productive branches.

Table 4.2: Technology content classification. Branches belonging to each group

	Andalusia	Basque Country
1. Low technology content	1-12,15,16,22-34,37,39,40 (30)	1-13,21-30,33,34,36-40 (30)
2. Medium technology content	17,19,20,35 (4)	15,16,18,19,31,32 (6)
3. High technology content	13,14,18,21,36,41,44 (7)	14,17,20,41,44 (5)
4. ICT	38 (1)	35 (1)
5. Main ICT users	42,43 (2)	42,43,45,46 (4)

ICT: Information and Communication Technology.
Note: Branches selected as both, high technology content and ICT are included in group 3 of high technology content: 18, 36, 41 and 44 for Andalusia; 17, 41 and 44 for Basque Country. See note in table 4.1.

Several sources have been used for the above classification.[141] The final selected classification combines the intensity of technology content and the characterisation of some branches as ICT (Information and Communication Technology) or ICT users. Therefore, five groups are obtained, although some branches could belong to two different groups richer conclusions can be obtained if they are separated.

‘Trade’ branch is considered an ICT branch, although just a part of it is recognised as such.[142] Official statistics (OCDE, INE) usually include ‘machinery, equipment and components trade’, ‘wholesale machinery and office equipment trade’, ‘wholesale electric and electronic components trade’ and ‘other retail trade’ in the ICT group. As this branch does not belong to any other category there is just one group for it. The intention of this is to have more information in the analysis made in this chapter.

The two above classifications can be particularly useful when relating the regional structural analysis with the development and growth stage of each region. There is a general recognition that higher states of development and growth are linked to a higher weight of service activities and of technology intensive and ICT productive activities.

[141] CNAE-93 (INE), OCDE, Pulido (2000).

[142] This branch corresponds to code 38 in Andalusia and 35 in the Basque Country.

Table 4.3 collects the conclusion of this research about a third classification focused on the structural equivalence of the input-output links maintained by all productive branches.[143]

Table 4.3: Input-Output links classification. Branches belonging to each group

	Andalusia	Basque Country
1. Agriculture and hunting	1,2,3	1,2
2. Fishing and agribusiness	4,22-28	3,21-26
3. Transport machines	19,20,21	18,19,20
4. P-S-T	6-9,16,18,30-38,41-43	5-7,17,28-35,41-43
5. Transport services	40	37-40

Note: Group 4 includes branches from the three basic productive sectors (primary, secondary and tertiary) and then it receives the name of P-S-T.

The above classification has been obtained with the CONCOR algorithm to every input-output table (Andalusia, the Basque Country and Spain, 1980 and 1995) after applying a sequence of threshold values.[144]

CONCOR is an algorithm based on a positional analysis,[145] by making partitions of actors into subsets. The objective of the algorithm is to find positions of approximately structurally equivalent actors. Therefore, after the partition is made, productive branches within each subset, as a result of the partition, are closer to being structurally equivalent than are branches in different subsets. That is, branches in the same subset are 'nearly' sending and receiving intermediate inputs from the same other branches.

From a more technical perspective, the procedure of the algorithm is based on the convergence of iterated correlations of the original matrix of data. More specifically the algorithm works as follows: first, it computes correlations among rows and columns of the original matrix of data, obtaining a correlation matrix. Then, it calculates correlations of rows or columns of the correlation matrix, obtaining a correlation of correlations matrix. The procedure goes on by calculating correlations of correlations and therefore by getting new correlation matrices. After several iterations the values of all correlations in the last matrix are +1 or -1.

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[143] The concept of structural equivalence has been already explained in chapter 3, section 3.3.2.2.2

[144] The CONCOR algorithm is expounded in Breiger *et al* (1975). In this work CONCOR algorithm has been used as part of the UCINET package (Borgatti, Everett and Freeman, 2002).

[145] Positional analysis was explained in chapter 3, section 3.3.2.2.2.

Then, the rows and the columns of the last obtained matrix are permuted to identify two subsets. One of the subsets shows correlations, between pairs of actors within it, of +1. The other subset shows that correlations between pairs of actors belonging to different subsets are -1. Each subset contains actors that have similar links to and from other actors in the network. As perfect structural equivalence is difficult to find, the final correlation matrix may show more than two positions within it (+1, -1). In this case, the algorithm may be repeated on the sub-matrices defined by an earlier partition to produce finer partitions.

Groups have been selected after their link structure has been observed. Once the algorithm made groups applying structural equivalence, the objective was to check with which other groups they related and why (mainly as buyers, as sellers, both; only with one group, with all of them or with some).

The five groups in table 4.3 do not include all productive branches as some of them are highly difficult to assign in a common group. However, in the three places and for the two mentioned years the common structure presented in table 4.3 can be generally deduced. Nevertheless there are some peculiarities that should be clarified:

- Groups 1 and 2 are the only very clear groups of branches appearing in every case as separated groups. Group 1 can be seen as seller and buyer, although its' buying and selling links are maintained with a particular group of branches. It sells mainly to itself, to agribusiness, to 'hotels and restaurants' and to 'business services'. It buys mainly from itself, from P-S-T group (electricity, petroleum, gas, paper industry, construction), from 'transports' and from 'business services'.
- Group 2 can be characterised as a buying group because its' selling links have a certain importance only for itself and for 'hotels and restaurants'. It includes all the agribusiness branches together with a traditionally considered primary branch ('fishing').
- Group 3 is also a buying group, which is even more evident than group 2. Sales can not be considered of importance for the branches belonging to it. Nevertheless, in some cases this is a group which is difficult to separate from group 4.

- Group 4 is a selling group as it sells to all the others, but it buys significant quantities only from itself, from ‘metallurgy’ and from ‘hotels and restaurants’. This is also a peculiar group because it includes basic fundamental branches for the productive process (petroleum, gas, water, electricity), industry branches (wood, paper, plastic, textiles), construction, and services (trade, telecommunications, financing, insurance). It is made of general inputs, incorporated in most of the productive process.
- Group 5 is more difficult to separate from group 4 although it is made of branches appearing always together and it is a key group for all the others.

4.4. Whole net analysis

It is convenient to analyse the whole trade net before selecting and studying a particular group within it (*production system*). This is the objective of section 4.4. This kind of analysis will help to understand the productive structure of the regions under study and therefore the context in which the selected *production systems* work. Going from the macro structure (whole net) to micro structures (*production systems*) a reference stage is built. Moreover, the branches constituting the *production system* can be studied considering their position and links in their micro system as well as in the regional structure.

The whole net analysis will be done descriptively first, and following the network perspective after, for inside or domestic data. In both cases results will be linked to the three classifications offered in the previous section to obtain richer conclusions.

4.4.1. Descriptive analysis

In this section the characteristics of branches and links will be described. In some cases calculus will be done for the complete net, and some other times they will be done once threshold values, or filters, are imposed on inside data.

4.4.1.1 Branches analysis

The ten most important branches, according to their intermediate sales (*IS*) and purchases (*IP*), are shown in table 4.4. They have been selected because they present the highest value as intermediate seller or buyers. Data offered in that table refer to the percentage of each selected branch intermediate sales or purchases on the regional values:

$$IS = \frac{IS_i}{IS_T} \cdot 100; \qquad IP = \frac{IP_i}{IP_T} \cdot 100 \qquad (4.3)$$

Table 4.4: Ten most important branches in Andalusia and the Basque Country, 1980 and 1995.

1980	Andalusia	Basque Country
IS	(1) ‘Agriculture’: 17.27% (6) ‘Coke, petroleum and radioac. ores’: 10.42% (40) ‘Transports’: 10.32% (44) ‘Business services and other ac.’: 7.96% (38) ‘R., r. and trade’: 6.87% (2) ‘Farming and h.’: 4.98% (16) ‘Wood, cork and furniture’: 4.79% (7) ‘Electricity’: 4.34% (26) ‘Other food ind.’: 3.37% (5) ‘Mining and quarrying’: 2.68% Σ: 73.00%	(5) ‘Coke, petroleum and natural gas’: 13.52% (9) ‘Metals’: 13.24% (35) ‘R., r. and trade’: 10.54% (44) ‘Business services’: 7.00% (6) ‘Electricity’: 5.98% (15) ‘Metal products and machinery’: 5.92% (37) ‘Other land transport’: 5.14% (10) ‘NFM and basic chemic.’: 3.21% (2) ‘Farming, h. and forestry’: 3.02% (17) ‘Office machinery, p. and p.’: 2.77% Σ: 70.35%
IP	(37) ‘Construction’: 8.76% (26) ‘Other food ind.’: 8.44% (22) ‘Oils and fats’: 8.04% (39) ‘Hotels and restaurants’: 7.36% (38) ‘R. r. and trade’: 6.98% (1) ‘Agriculture’: 5.53% (40) ‘Transports’: 5.31% (2) ‘Farming and h.’: 4.97% (27) ‘Spirits, alcohol and wine’: 4.52% (7) ‘Electricity’: 3.87% Σ: 63.78%	(15) ‘Metal products and machinery’: 20.15% (9) ‘Metals’: 13.10% (34) ‘Construction’: 6.73% (37) ‘Other land transport’: 4.14% (17) ‘Office machinery, p. and p.’:4.09% (35) ‘R., r. and trade’: 3.58% (6) ‘Electricity’: 3.45% (36) ‘Hotels and restaurants’: 2.81% (30) ‘Paper’: 2.67% (39) ‘Water and air transport’: 2.46% Σ: 63.2%
1995	**Andalusia**	**Basque Country**
IS	(44) ‘Business services and other ac.’ 16.41% (1) ‘Agriculture’: 11.96% (40) ‘Transports’: 10.43% (38) ‘R., r. and trade’: 9.98% (7) ‘Electricity’: 6.77% (6) ‘Coke, petroleum and RO’: 5.78% (11) ‘Cement’: 3.92% (41) ‘Post and telecom.’: 3.61% (42) ‘Financial interm.’: 3.15% (16) ‘Wood, cork and furniture’: 2.46% Σ: 74.47%	(44) ‘Business services’: 18.66% (35) ‘R., r. and trade’: 11.36% (34) ‘Construction’: 8.83% (9) ‘Metals’: 7.32% (15) ‘Metal products and machinery’: 5.76% (6) ‘Electricity’: 5.47% (17) ‘Office machinery, p. and p.’: 4.59% (5) ‘Coke, petroleum and natural gas’: 4.56% (37) ‘Other land transport’: 3.82% (41) ‘Post and telecom.’: 3.05% Σ: 73.42%
IP	(38) ‘R., r. and trade’: 16.31% (37) ‘Construction’: 14.61% (39) ‘Hotels and restaurants’: 9.86% (22) ‘Oils and fats’: 8.62% (40) ‘Transports’: 6.10% (44) ‘Business services and other ac.’: 5.18% (1) ‘Agriculture’: 3.87% (26) ‘Other food ind.’: 3.27% (25) ‘Fish and vegetable ind.’: 2.67% (42) ‘Financial interme.’: 2.34% Σ: 72.83%	(15) ‘Metal products and machinery’: 15.66% (34) ‘Construction’: 11.31% (44) ‘Business services’: 10.70% (35) ‘R., r. and trade’: 9.02% (9) ‘Metals’: 6.73% (36) ‘Hotels and restaurants’: 5.43% (17) ‘Office machinery, p. and p.’: 3.77% (18) ‘Motor vehicles’: 3.10% (37) ‘Other land transport’: 2.98% (46) ‘Social, personal and com. Ac.’: 2.58% Σ: 71.28%

Note: The names of the branches have been abbreviated in the table; the whole names are shown in annex 4.1. Andalusia has 44 branches and the Basque Country 46.

Before commenting the deductions obtained after comparing the data, it is worth remarking the increase (between 1980 and 1995) in the cumulative percentage of intermediate sales and purchases, for both regions, of the first ten branches. This shows an increase in the concentration level of both, intermediate sales and purchases, although it is more evident from the purchases perspective.

By using all the information in table 4.4, the cumulative percentage has increased in average 5.47 percent points. Moreover, in 1995 just five branches accumulate more than half of the regional intermediate sales and purchases in both places. There is an increase in intermediate transaction concentration for the most important branches in the period 1980-1995. This process is explained by the regional specialisation and by the presence of key branches, as it will be explained in this and in the following sections.

4.4.1.1.1. Regional comparison: common aspects

When comparing the results among Andalusia, the Basque Country and Spain it seems clear that there is a general scheme showing the common situation of developed areas:[146]

- 'Trade', 'business services', 'transports' and 'electric power' appear in both years and in the three places among the most important intermediate sellers.
- 'Construction', 'hotels and restaurants' and 'trade' are always among the most important intermediate purchasers.
- In 1995 'business services' and 'trade' are selected for both aspects, among the highest values for intermediate sales and purchases, in the three places, showing their character as key branches.
- The common dynamism can also be observed with the evolution of the primary sector reducing its importance in every regional productive structure.

[146] Data for Spain are not offered in table 4.4.

For the branches increasing their participation there is a common path for ‘business services’, ‘trade’, ‘post and telecommunications’, ‘construction’ and ‘hotels and restaurants’. It can be asserted that service sectors appear as the most dynamic economic activities, participating in economic and technological flows and creating productive dependencies. This situation is generally related with growth and development and therefore also to the case of Spain and its regions.

4.4.1.1.2. Regional comparison: peculiarities

There are also clear regional specifics, particular to the specialisation, endowments, culture and history of each place. In the case of Andalusia, in both years, among the most outstanding intermediate sellers are ‘agriculture’ and ‘manufacture of wood, cork, metal products and furniture’. For the intermediate purchasers the selected branches in both years are ‘agriculture’, ‘oils and fats’ and ‘manufacture of other food products’. The key branch in the region, appearing always, in 1980 and 1995, according to both aspects, buying and selling, is ‘agriculture’, although in 1995 ‘financial intermediation’ is also in both groups.

In the Basque Country the specifics are even more evident as the branches of ‘metals’, ‘metal products and machinery’ and ‘manufacture of office machinery, and electrical goods’ are in 1980 and 1995 among the sectors with highest selling and buying values, showing a permanent character of key branches.

The historical and cultural character of Andalusia and the Basque Country commented in the second section of this chapter give strength to the explanation of those branches appearing as the core for the productive specialisation in any of the two regions. The importance of the agriculture sector and agribusiness in Andalusia and of metals and metal products in the Basque Country is therefore permanent and corroborated.

Although only inside values are shown here, another useful comparison can be established among total and inside values: after comparing, a general conclusion is that in both regions there are clear differences with higher values for the total case. Therefore, some goods imports are needed for every regional productive process generating dependency in the regional economy. The clearest cases are ‘mining and quarrying' and 'coke, petroleum and radioactive materials' in Andalusia, and 'non-ferrous metal ores and basic chemicals' in the Basque Country.

4.4.1.1.3. Time comparison

The information of the branch intermediate sales and purchases can also be analysed dynamically, according to the relative changes happening between 1980 and 1995, like in graphs 4.1 and 4.2. Those graphs show the variations in the percent weight of intermediate sales and purchases. Graph 4.1 refers to Andalusia and graph 4.2 to the Basque Country. Each graph has been divided into six areas:

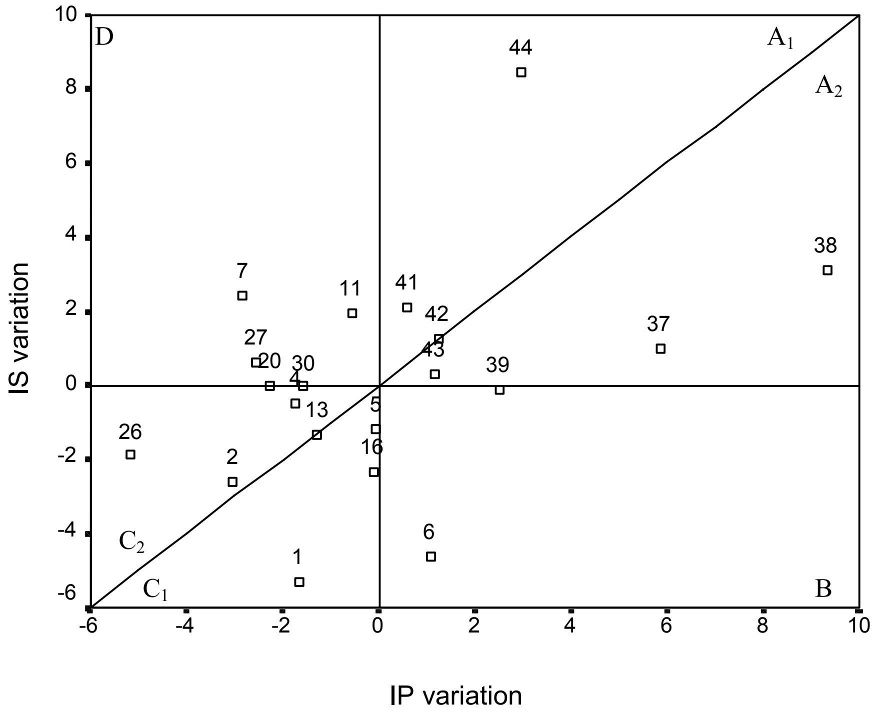
- *A* areas are made of branches in expansion from both perspectives, sales and purchases, although in A_1 the expansion of sales are higher than of purchases (ΔIS>ΔIP) and in A_2 the other way around (ΔIS<ΔIP). The first sub-area includes branches that can be characterised as 'expansion intensified in sales', and the second as 'expansion intensified in purchases'

- *C* area includes branches in decline, differentiating a group, C_1, where the decrease is higher for intermediate sales (∇IS>∇IP) and other, C_2, where the reduction is higher for intermediate purchases (∇IP>∇IS). The first sub-area could be labelled as 'decline intensified in sales' and the second 'decline intensified in purchases'.

- In the other side, *B* area is made of branches showing an expansion in intermediate purchases but a reduction in intermediate sales (ΔIP, ∇IS). This can be a 'purchases expansion area'.

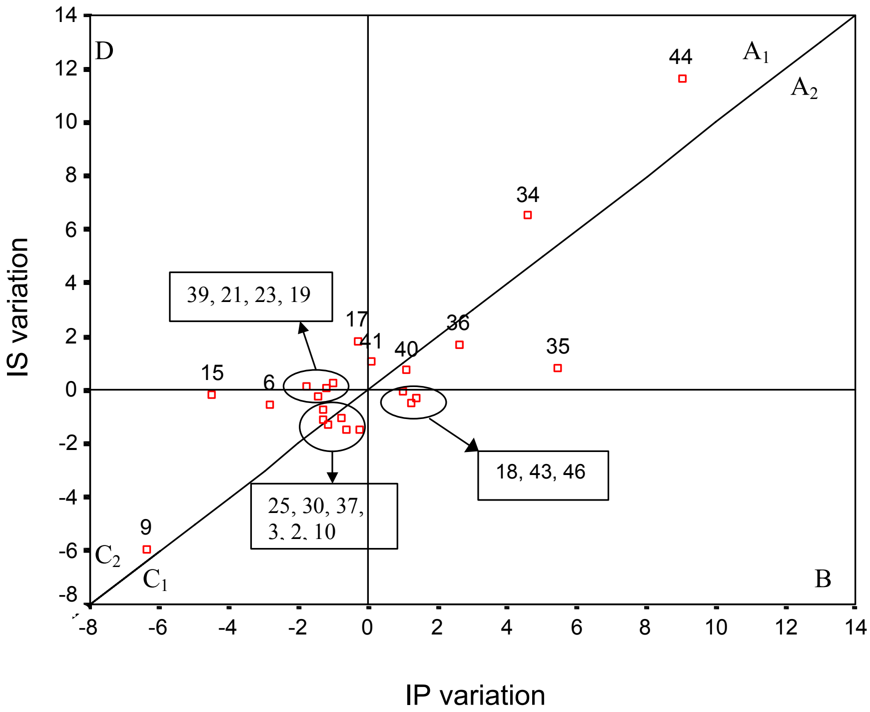
- *D* area contents branches showing expansion in intermediate sales but reduction in intermediate purchases (∇IP, ΔIS). This is a 'sales expansion area'.

Graph 4.1: Branch intermediate trade dynamics, Andalusia 1980-1995



Note: Represented values are the difference in percent points between 1995 and 1980, for intermediate sales and purchases. Only branches with changes higher than 1 percent point, in absolute terms, in sales or purchases, have been represented.

Graph 4.2: Branch intermediate trade dynamics. Basque Country 1980-1995



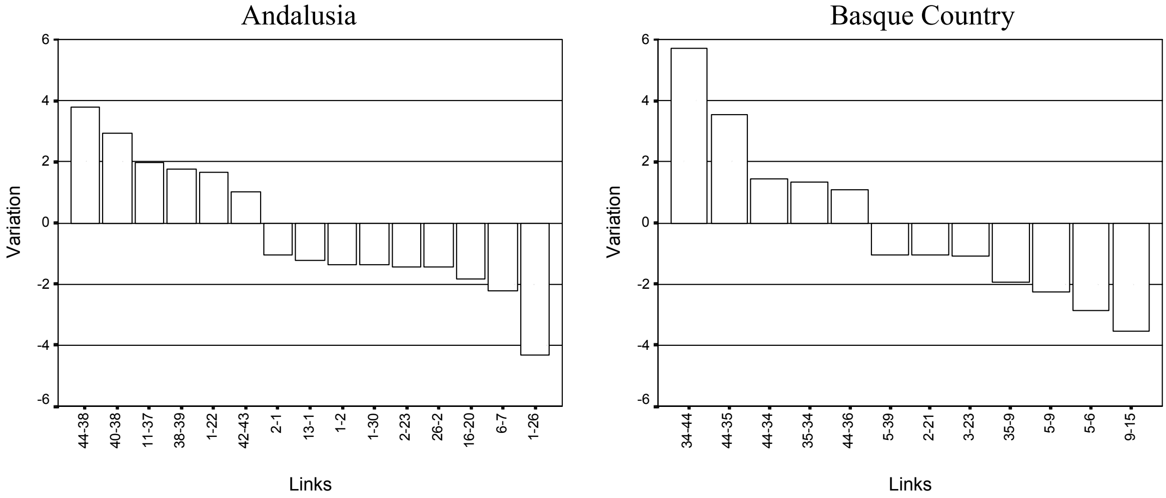
See note in graph 4.1.

In the case of Andalusia, although data are only shown at inside level the situation is similar for the total values, presenting branches with an obvious positive or negative dynamic behaviour. 'Agriculture' (1), 'farming' (2) and 'other food industry' (26) are branches with a clear decrease in their intermediate sales and purchases at inside and total levels. Nevertheless, according to the analysis of section 4.2 based on the specifics of the regions, and on the links analysis that will be shown next, a strong agro-food system is maintained in Andalusia, but with increasing importance of the agro-food industry and lower importance of the basic primary sector (agriculture, farming, hunting and fishing). On the other side, with obvious increases in sales and purchases there are the expected service sectors of 'trade' (38) and 'business services' (44), and 'construction' (37).

When analysing the situation in the Basque Country, there are important reductions in sales and purchases for branch 'metals' (9). Services are again the most important branches showing high increases in their intermediate sales and purchases, mainly in the cases of 'business services' (44), 'trade' (35) and 'hotels and restaurants' (36). 'Construction' (34) is another branch with general high rises proper of the Spanish development path.

To explain more deeply the branches dynamic, graph 4.3 represents the links that have experienced changes higher than one percent point in a positive or negative sense (>|1|). Those selected links have been represented with the label of highest variation links. As an example, the link going from branch 44 to 38 in Andalusia has the highest increase in the analysed period the link going from branch 40 to 38 is the second highest and so on.

Graph4. 3: Highest variation links, 1980-1995, Andalusia and Basque Country



In Andalusia there are six relationships remarked because of their positive evolution and nine for their negative change.[147] In the positive side the most important links go from 'business services' (44) and 'transports' (40) to 'trade' (38), showing once again the regional growth and development process. In the negative side there is evidence of the loss of importance of agriculture and farming of animals, as sellers and buyers, that used to be key in the agro-food industry but, as it has already been said before, now the industrial side has higher importance than the primary sector. The link with the highest decrease goes from 'agriculture' (1) to 'manufacture of other food products' (26).

In the Basque Country the situation is similar to Andalusia. The links with higher increases relate to a general process of development and refer to business services and trade (from 'construction' to 'business services' and from this to 'trade').[148] The links showing the highest decrease are focused in the regional specialisation productive process (from 'metals', (9), to 'metal products and machinery', (15)).

In Spain the changes are much smaller than in Andalusia or the Basque Country, as when comparing the intensity of intermediate branch transactions. To understand it, the compensation effect occurring when data are at more aggregated level should be considered. With national information, the highest variation is 1 percent point.

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[147] The total number of links is 1,892.

[148] Five links out of 2,070 have been selected

4.4.1.2.- Relationships analysis

The most important links, or relationships, have been selected by calculating the *relative intermediate transaction coefficients* as presented in section 4.3.1. Once the calculations have been made, the links with a value higher than 1% have been represented for both years 1980 and 1995. Table 4.5 corresponds to Andalusia and table 4.6 to the Basque Country.

Table 4.5: Most important links in Andalusia, 1980 and 1995

	1		2	7	20	22		23		24	25		26	30	37		38		39		40		42	43
	80	95	80	80	80	80	95	80	95	80	80	95	80	80	80	95	80	95	80	95	80	95	95	95
1			2.04			5.63	7.27				1.32	1.76	5.23	1.49										
2	1.06							2.61	1.19	1.19														
6				2.38																	2.27	2.41		
7																		1.5		1.03				
10															1.65									
11															1.91	3.88								
13	1.8																							
16					1.86											1.82								
26			2.06																					
28																			1.77	1.35				
38		1.24														1.43				2.11	1.16	1.44		
40													1.08			1.21	1.22	4.16						
42																								1.01
44																1.39	2.44	6.23		1.51			1.38	

Note: Intra-branch links have been omitted. There are two columns per branch, the first shows the data for 1980 and the second for 1995. When the percentage is higher than 1 only for one of the two years, just once column appears. Outstanding branches have been shaded.

Table 4.6: Most important links in the Basque Country, 1980 and 1995

	6	9		15		18	21	23	25	34		35	36	37		39	42	43	44	46
	80	80	95	80	95	95	80	80	80	80	95	95	95	80	95	80	95	95	95	95
1									0.93											
2							1.17													
3								1.32												
5	2.89	2.81												1.62	1.05	1.33				
6		2.15	1.22																	
9				9.98	5.45					1.09										
10				1.36																
13										1.18	1.6									
15		1.01	0.86			0.9				1.54	1.78									
17											0.99								1.39	
29				1.11																
34																			6.18	
35		2.7		1.41	2.38						1.68			1.27						
37				0.93																
44			0.84	1.35	1.92						1.63	3.92	1.14				1.27	1.16		0.88

4.4.1.2.1. Andalusia

There are two outstanding relationships in 1980,[149] with values higher than 5%, with the exchanges going from 'agriculture' (1) to 'oils and fats' (22) and to 'manufacture of other food products' (26).

In 1995 there are even bigger differences, as the trade from 'agriculture' (1) to 'oils and fats' (22) implies more than 7% of the total intermediate transactions, followed by the sales of 'business services' (44) and 'transport' (40) to 'trade' (38) (>6% and >4% respectively) and 'cement' (11) to 'construction' (37) (>3%).

As a summary, it can be said that most of the links disappearing in 1995 belong to manufacturing sectors, mainly belonging to the branch 'other food industry'. Nevertheless, there is an important number of links of the agriculture, hunting and fishing sector that are also disappearing. Moreover, most of those branches are of low technology content and, according to our third classification, most of them are in the agriculture group.

For the links appearing in 1995, most of them belong to the service sector, mainly for 'trade' and 'hotels and restaurants'. They are of low technology content, and are in the P-S-T group. The remaining branches can be characterised as service branches ('trade' and 'transport'), low technology content, and they are part of the P-S-T and agribusiness group.

Attention should be paid to the branch 'agriculture', as it is in several links. It disappears in its two sense link with 'farming of animals', buying chemicals and as a seller for 'other food industry' and 'textile'. It appears as a buyer from trade. It stays (increasing its percentage) as a seller for 'oils and fats' and 'fish and vegetable industry'.

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[149] Out of 1,892 relationships.

The regional specialisation and also the growth and development process are reflected in the data. Andalusia is a region clearly focused in the agro-food system, and where the production of olive oil is in the centre of the productive process, showing a clear expansion.

Another tested fact is the role of 'business services', 'trade' and 'transport' in every development path. The first of those service branches has a particularly relevant role associated to a development process.

Lastly, construction is having a remarkable participation in the whole national economy with an expansion path.

4.4.1.2.2. The Basque Country

In the Basque Country both processes (specialisation and development) emerge again from the link data. In 1980 the sales of 'metals' (9) to 'metal products and machinery' (15) had an intermediate trade higher than 9% over the total transactions.[150] In 1995 there are three relationships which should be highlighted: from 'construction' (34) to 'business services' (44) (>6%), from 'metals' (9) to 'metal products and machinery' (15) (>5%) and from 'business services' (44) to 'trade' (35) (>3.5%).

The disappearing branches in 1995 are mainly from manufacturing industries (mainly 'metals' and 'metal products and machinery'), with low technology content and belonging to the P-S-T group. The new appearing branches are from services (business services mainly), with high technology content and from the P-S-T group.

The branch of 'metal products and machinery' has a particular behaviour that should be commented. It disappears always as a buyer of industrial products and appears as a seller for 'motor vehicles'.

[150] It has the higher value and therefore it is the most outstanding relation out of 2,070 links.

Agriculture and agribusiness branches loss there most important links in this 15 years period, while at the same time services, and mainly ‘business services’, emerges with the most outstanding links, sharing its significance with the already recognised importance of ‘metals’.

4.4.1.2.3. Inside and total data comparison

In Andalusia, at the aggregate level there are two new relations appearing among the most important that did not emerge at inside level. Those links are from ‘mining and quarrying’(5) to ‘coke, petroleum and radioactive materials’(6), reflecting the petroleum dependency of the country, and from ‘manufacture of wood, cork, metal products and furniture’(16) to ‘construction’(37). Those differences with the inside results show the importance of necessary imports of some intermediate goods in different processes.

In the case of the Basque Country there is a new important link from ‘trade’(35) to ‘metals’(9) but only in 1980.

4.4.2.- Network analysis

The whole regional intermediate transaction nets will be analysed in this section using the most significant network analysis measures and concepts. The relational and positional approaches will be applied in this case to the ‘multiple actors/subgroups as a structured system’ as labelled in Burt (1980) when the analysis is focused at the macro whole net level.

The applied concepts were explained in a general sense in the previous chapter, here calculations and interpretations have been done. The results are complementary to the conclusions obtained in section 4.4.1.

4.4.2.1. Net Size

The most basic network measure is the size of the net, taking into account the number of nodes and links, this information is offered in table 4.7.[151]

Table 4.7: Net size, Andalusia and Basque Country, 1980 and 1995

	Andalusia		Basque Country	
	1980	**1995**	**1980**	**1995**
Nº of nodes	44	44	46	46
Nº of directed links	1150 (60.8%)	1207 (63.8%)	1337 (64.6%)	1286 (62.1%)

At the beginning of the period, 1980, the relative number of links is higher in the Basque Country than in Andalusia. However, In Andalusia there is an increase of 5% in the number of links, while in the Basque Country the dynamic is just the opposite (reduction of 3.8% in the relative number of links). Therefore, the situation changes, in 1995 there are more relative links in Andalusia than in the Basque Country showing, from this perspective, an approaching or convergence between the two regions.

From this basic net size analysis it is possible to develop a deeper study. The above information shows the size considering the whole net, but it can be useful to see the result once several threshold values have been imposed. Moreover, with the branch classifications shown in section 4.3, we will have a clearer picture.

Therefore, as the number of branches and the number of links determine the net size, the following analysis is focused on the number of branches disappearing and the number of links staying, when different filters are considered. The selected branches are also classified in groups according to their productive sector, their technology content and their input-output links.

[151] In network analysis links can be considered directed or undirected. In that case the direction of the link is taken into account to measure each relationship.

4.4.2.1.1. Branches disappearing according to several filters

Tables 4.8 to 4.11 offer information about the branches disappearing according to their transaction intensity. In order to do that, increasing threshold values have been applied to the net of intermediate relationships, to observe the branch disappearing sequence.

In the tables shown below, vanishing branches according to a filter sequence (increasing threshold values) are divided in quartiles. The number of the branch disappearing in each case is included in its corresponding group (sector and technology content) and quartile for which it disappears. The first quartile branches are considered of low intensity, as they are the first disappearing when a filter is imposed. The second quartile is made of medium-low intensity branches, the third with medium-high intensity branches. According to the information obtained from those tables, there are some branches with very high intensity in their links as they stay even with very high threshold values, this is the case of branches belonging to the last quartile and called 'high' because of the intensity of their transactions.

Table 4.8: Vanishing sequence, by economic sector, Andalusia, 1980 and 1995

Group	Nº of branches	Low		Medium-low		Medium-high		High	
		1980	1995	1980	1995	1980	1995	1980	1995
1	4	3	3	4	4		2	1,2	1
2	1			5	5				
3	28	14,17,21, 29,32,34, 35,36 (25.6%)	14,17,19, 20,21, 29,30,31, 32,36 (35.8%)	12,15,18, 19,31,33 (21.4%)	12,13,15, 18,33,34, 35 (25%)	10,11,13, 16,20,24, 25,27,28, 30 (35.7%)	10,23,24, 26,27,28 (21.4%)	6,22,23,26 (14.3%)	6,11,16, 22,25,32 (17.9%)
4	3	9		8	8,9		7	7	
5	1					37			37
6	7	43 (14.3%)		41,42 (28.6%)		39 (14.3%)	41,42,43 (43%)	38,40,44 (42.9%)	38,39,40, 44 (57%)

Note:[152] Values refer to first quartile, low, C_i< 0.27 (1980), 0.21 (1995), second quartile, medium-low, 0.27 (1980), 0.21 (1995) ≤ C_i< 0.8; third quartile, medium-high 0.8≤ C_i< 2; the fourth quartile, high, C_i ≥2.4

[152] *C_i : Relative intermediate transaction coefficients.*

Table 4.9: Vanishing sequence, by technology content, Andalusia, 1980 and 1995

Group	Nº of branches	Low		Medium-low		Medium-high		High	
		1980	1995	1980	1995	1980	1995	1980	1995
1	30	3,9,29,32, 34 (16.7%)	3,29,30, 31,32 (16.7%)	4,5,8,12, 15,31,33 (23.3%)	4,5,8,9,12, 15,33,34 (26.7%)	10,11,16, 24,25,27, 28,30,37, 39 (33.3%)	2,7,10,23, 24,26,27, 28 (26.7%)	1,2,6,7,22, 23,26,40 (26.7%)	1,6,11,16, 22,25,32, 37,39,40 (30%)
2	4	17,35	17,19,20	19	35	20			
3	7	14,21,36 (42.9%)	14,21,36 (42.9%)	18,41 (28.6%)	13,18 (28.6%)	13 (14.3%)	41 (14.3%)	44 (14.3%)	44 (14.3%)
4	1							38	38
5	2	43		42			42,43		

See note in table 4.8

Table 4.10: Vanishing sequence, by economic sectors, Basque Country, 1980 and 1995

Group	Nº of branches	Low		Medium-low		Medium-high		High	
		1980	1995	1980	1995	1980	1995	1980	1995
1	3		3		1	1,2	2	3	
2	2	4	8	8	4				
3	26	12,20,24, 27,28,31, 33 (26.9%)	12,19,20, 23,25,27, 28,33 (30.8%)	11,16,18, 19,26 (19.2%)	10,11,21, 22,24,30, 31,32 (30.8%)	13,14,17, 21,22,25, 29,30,32 (34.6%)	5,14,16, 18,26,29 (23.1%)	5,9,10, 15,23 (19.2%)	9,13,15, 17 (15.4%)
4	2			7			7	6	6
5	1							34	34
6	12	38,40,45 (25%)	38,45 (16.7%)	36,41,42, 43,46 (41.7%)	39 (8.3%)		37,40,41, 46 (33.3%)	35,37,39, 44 (66.7%)	35,36,42, 43,44 (41.7%)

Note: First low quartile, C_i<0.32 (1980), 0.25 (1995); medium-low quartile 0.32 (1980), 0.25 (1995) ≤ C_i< 0.72 (1980), 0.48 (1995); medium-high quartile 0.72 (1980), 0.48 (1995) ≤ C_i< 1.2 (1980), 1.1 (1995); high quartile $C_i \geq 1.4$.

Table 4.11: Vanishing sequence, by technology content, Basque Country, 1980 and 1995

Group	Nº of branches	Low		Medium-low		Medium-high		High	
		1980	1995	1980	1995	1980	1995	1980	1995
1	30	4,12,24,27, 28,33,38, 40 (26.7%)	3,8,12,23, 25,27,28, 33,38 (30%)	7,8,11,26, 36 (16.7%)	1,4,10,11, 21,22,24, 30,39 (30%)	1,2,13,21, 22,25,29, 30 (26.7%)	2,5,7,26, 29,37,40 (23.3%)	3,5,6,9,10, 23,34,37, 39 (30%)	6,9,13,34, 36 (16.7%)
2	6	31 (16.7%)	19 (16.7%)	16,18,19 (50%)	31,32 (33.3%)	32 (16.7%)	16,18 (33.3%)	15 (16.7%)	15 (16.7%)
3	5	20	20	41		14,17	14,41	44	17,44
4	1							35	35
5	4	45	45	42,43,46			46		42,43

See note in table 4.10

4.4.2.1.1.1. Andalusia

All branches belonging to the group of agriculture and agribusiness (attending to the input-output link classification) are branches with the most intense links, and therefore last in the vanishing sequences. All of them belong to the groups 'medium-high' or 'high' in both years. Moreover, in 1980 'agriculture', 'oils and fats', and 'other food industry' have the highest intensity overall. Those links go from 'agriculture'(1) to 'oils and fats'(22) and to 'other food industry'(26), with coefficients higher than 5% in both cases. In 1995 the situation is similar. Therefore once again the productive specialisation of the region is tested, focused in branches of low technology content.

The most clear difference in the analysed period refers to service branches, in 1995 all of them are in the groups characterised as 'medium-high' and 'high' because of the increases in the link intensity of 'hotels and restaurants', 'telecommunications', 'financial services' and 'insurances'. The two most intense increasing links between 1980 and 1995 go from 'agriculture' to 'fats and oils' (C_i>7%) and from 'business services' (high technology content) to 'trade' (ICT) (C_i>6%).[153]

It can also be observed that branches disappearing in the first place have low technology content and belong to the manufacturing sector. Moreover, attending to the input-output classification presented in table 4.3, all branches belonging to group 3 (transport machines) are in 1995 in the first vanishing group. It is useful to remember that, for the intermediate sales side, only intermediate transactions are considered in the data used, while investment sales should have considerable importance for those goods. Nevertheless, for the intermediate purchases side there is also a loss of importance in the region and imports should participate more intensively in their productive processes.

Another deduction from tables 4.8 and 4.9 is that all branches moving from 'low' to 'medium-low' in the analysed period, and therefore increasing their link intensity, belong to group 4 attending to the input-output classification. That is, they are basic branches with high presence in most of the productive processes and with increasing participation in the regional economy.

[153] In the lowest intensity links are tobacco industry, in both years, and leathers and footwear.

4.4.2.1.1.2. The Basque Country

The highest intensity belong to the link between two manufacturing branches, ‘metals’(9) and ‘metal products and machinery’(15) because of the link maintained between them, from (9) to (15) with a coefficient of almost 9%. Those are branches of low and medium technology content that shows the strength of the regional specialisation. In fact, there is a change in the period, leading to a movement of most of the metallurgy branches towards the groups characterised as ‘medium-high’ and ‘high’.

Nevertheless, in 1995 there is another change referred to ‘construction’ and services. The link from ‘construction’ ((34), low technology content) to ‘business services’ ((44), high technology content) has in this year a coefficient above 6%.[154]

Most of the branches in the first vanishing group, and considered as low intensity branches, have low technology content. Although this situation was also present in Andalusia, in the Basque Country it is even more evident, 9 out of 12 branches in 1995 in the ‘low’ group have low technology content and most of them belong to the manufacturing sector. Primary sector and agribusiness branches are also in the ‘low’ group and also weaken their presence in the regional productive structure. There is the peculiarity that the fishing value chain appears as decreasing its presence in the region: ‘fishing’(3), ‘fish industry’(23) and ‘ships’(19).

4.4.2.1.1.3. Regional comparison and dynamics

Some more conclusions can be obtained from the regional comparison, as tendencies show similarities and differences. Among the similarities there are the intensity increase for ‘construction’ and the intensity decrease in ‘agriculture’, although this is deeper in the Basque Country. The clearer differences appear when comparing the results for technology content groups, because there are higher intensity branches with high technology content in the case of the Basque Country and their intensity continuously increases.

[154] The less intense branches are ‘tobacco industry’ (27) in both years and ‘metal ores’ (8).

From the information shown in tables 4.8 to 4.11 it is possible to get some richer information. The dynamics of the branches can also be observed by combining the threshold and group classifications (by sectors and technology content). This is the purpose of tables 4.12 and 4.13.

The position of a branch in any of the '<1' group means that the highest coefficient of that branch is lower than 1. Therefore, the '≥1' group have branches with their highest coefficient higher or equal to one, taking 1980 as the reference year.

The other two classifications (Δ, ∇) refer to branches increasing, or decreasing, their highest coefficient. Four types of branches can be distinguished:

- 'Decreasing weakness branches': Branches belonging to the group with coefficients <1 but increasing.
- 'Increasing intensity branches': Branches in the group with increasing coefficients ≥ 1.
- 'Increasing weakness branches': Branches in the group with decreasing coefficients <1.
- 'Decreasing intensity branches': branches in the group with decreasing coefficients ≥1 can be labelled in that form.

Table 4.12: Links dynamics, Andalusia and Basque Country, 1980-1995, sector groups

	<1					≥1					
	Agricul.	Ore I.	Manufac.	Electric.	Services	Agricult.	Manufac.	Electric.	Construc.	Services	
Δ			12,17,18, 29,33,35,36	9	**41**,**42**,**43**	1	6,11,22,25		37	38,39,40, 44	**Andalusia**
		4	**17**,18,24, 26,31,33		**36**,40,41, **42**,**43**,46		13		34	35,44	**Basque C.**
∇	3,4	5	14,15,19, 21,27,31, 32,34	8		2	**10**,**13**,16, **20**,23,**24**, **26**,28,**30**	7			**Andalusia**
		8	12,14,16, 19,20,22, 27,28,30,32	7	38,45	1,**2**,**3**	5,9,**10**,15,**21**,**23**,**25**, **29**	6		37,**39**	**Basque C.**

Note: Branches in bold have changed from <1 to ≥ 1 or the opposite, they have been assigned to the group in 1980. The total number of branches for agriculture in Andalusia is 4 and the Basque Country 3, ore industries in Andalusia 1 and the Basque Country 2, manufacturing in Andalusia 28 and the Basque Country 26, electricity in Andalusia 3 and the Basque Country 2 and services in Andalusia 7 and the Basque Country 12.

Table 4.13: Links dynamics, Andalusia and Basque Country, 1980-1995, technology groups

	<1				≥1				
	Low Technology	**Medium technology**	**High technology**	**ICT users**	**Low technology**	**Medium technology**	**High technology**	**ICT**	
Δ	9,12,29,33	17,35	18,36,**41**,**42**,**43**		1,6,11,22,25,37,39,40		44	38	**Andalusia**
	4,24,26,33,**36**,40	18,31	11,**17**,41	**42**,**43**,46	13,34		44	35	**Basque C.**
∇	3,4,5,8,14,15,27,31,32,34	19	21		2,7,**10**,**13**,16,23,**24**,**26**,28,**30**	**20**			**Andalusia**
	7,8,11,12,22,27,28,30,38	16,19,20,32	14	45	**1**,**2**,**3**,**5**,6,9,**10**,**21**,**23**,**25**,**29**,37,**39**	15			**Basque C.**

The total number of branches is for low technology in Andalusia and the Basque Country 30, for medium technology in Andalusia 4 and the Basque Country 6, for high technology in Andalusia 7 and the Basque Country 5 and for TIC users in Andalusia 2 and the Basque Country 4.

The most outstanding group of branches is the one of increasing intensity. In the case of Andalusia we can find in that group:

- Services: ‘business services’, ‘trade’, ‘transports’ and ‘hotels and restaurants’. The first three branches not only have intense links but they are also linked to a high number of other branches in the production system. The last one however is a branch with strong presence for a reduced group of branches, mainly agribusiness branches.
- Petroleum. This can be considered a basic productive branch, with intense presence in a high number of productive processes in the system.
- A group of branches showing the clear productive differentiation of the region: ‘agriculture’, ‘oils and fats’ and ‘fish and vegetables industry’. Those are activities closely related among them and with the reduced group of agribusiness branches.
- Two branches of increasing importance in the whole country: ‘cement’ and ‘construction’. The first of those two has a high intense link with ‘construction’, while this last branch appears with many links in the system.

Another important characteristic of Andalusia is the general increase of its coefficients (even if they are in the ‘<1’ group). Nevertheless, branches with a more relevant role in the economy according to their intensity and their evolution have low technology content. Although the technology content is also mainly low in the increasing weakness group. The main difference is that in this ‘weak’ group branches belong mainly to the manufacturing sector, with the important exception of ‘fishing’, an activity that has substantially lost its presence in the region.

In the case of the Basque Country the increasing intensity branches (‘ceramics and construction materials’, ‘construction’, ‘trade’ and ‘business services’) show a situation that can be generalised to every developed region. The first mentioned branch stands out because of its link with the second one, the others because of its general presence in the regional structure. ‘Office machinery’ appears as an ‘increasing intensity branch’ in 1995, which is important for the region productive differentiation. For the ‘increasing weakness’ group, like in the case of Andalusia, most of the branches show low technology content and belong to the manufacturing group.

According to the regional specialisation in Andalusia, in the group of agriculture and agribusiness all branches but one (‘spirits, alcohol and wine’) are in the ‘≥1’ sector. In the Basque Country, however, none of its metallurgy branches, representing its specialisation, is in that sector.

There are some relevant conclusions that can be generalised to both regions:

- There is a tertiary process, with the service branches increasing the intensity of their links, according to their maximum coefficient.[155]
- There is an increasing importance of ‘construction’. This leads also to a higher importance of related branches like ‘cement’, ‘ceramics’ and ‘stone’.
- A process of post-industrialisation, or even de-industrialisation as marked by several authors for developed areas could be identified.[156] In the above tables, most of the manufacturing branches decrease their maximum intensity link. Only few manufacturing relations (just one for the Basque Country, ‘ceramics’, which is a construction related branch) appear as ‘increasing intensity’ branches.

4.4.2.1.2. Links staying according to several filters

Tables 4.14 to 4.17 offer the information of the number of links existing in every group (sector and technology content) for different threshold values, and therefore considering also the intensity of the links.

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[155] The exceptions found in table 4.12 are for transports and health in the Basque Country.

[156] Bell (1973), Cohen and Zysman (1987) and Tomlinson (1997).

It should be clarified that all the links, except the relationships maintained by branches belonging to the same group, appear twice. This happens because links are directed, and therefore the sending and receiving branches could belong to different groups.[157]

Table 4.14: Number of links, sector and technology content groups, increasing filters, Andalusia, 1980

Sector groups	0	0.01	0.5	1	3	Technology groups	0	0.01	0.5	1	3
1	160	64	13	10	2	1	1018	433	41	21	2
2	49	20	1	0	0	2	187	63	1	1	0
3	967	387	28	17	2	3	378	155	10	2	0
4	182	68	5	1	0	4	68	54	7	3	0
5	67	36	7	3	0	5	119	48	1	0	0
6	437	256	21	7	0	**Total**	1170	756	60	27	2

Note: Five threshold values are shown, although calculation has been made for a wider group of filters. Outstanding groups have been shaded.

Table 4.15: Number of links, sector and technology content groups, increasing filters, Andalusia, 1995

Sector groups	0	0.01	0.5	1	3	Technology groups	0	0.01	0.5	1	3
1	134	67	10	4	1	1	1059	456	32	17	4
2	58	23	0	0	0	2	199	73	0	0	0
3	1027	396	18	7	3	3	417	175	12	5	1
4	189	77	3	2	0	4	73	62	10	8	2
5	72	42	9	5	1	5	117	51	3	2	0
6	454	291	25	15	3	**Total**	1865	817	57	32	7

Table 4.16: Number of links, sector and technology content groups, increasing filters, Basque Country, 1980

Sector groups	0	0.01	0.5	1	3	Technology groups	0	0.01	0.5	1	3
1	129	40	7	2	0	1	1171	499	33	16	1
2	72	18	1	0	0	2	284	153	17	7	1
3	1051	471	38	17	1	3	306	189	7	1	0
4	144	67	3	2	0	4	75	66	4	3	0
5	76	51	4	3	0	5	247	103	2	0	0
6	716	354	12	6	0	**Total**	2083	1010	63	27	2

[157] This is the reason why the sum of links for every threshold value does not coincide with the real number of links in the net (as an example, Andalusia 1980 has 1,150 directed links but the sum of the links by sectors for a 0 threshold is 1,820).

Table 4.17: Number of links, sector and technology content groups, increasing filters, Basque Country, 1995

Sector groups	0	0.01	0.5	1	3	Technology groups	0	0.01	0.5	1	3
1	117	35	1	0	0	1	1117	452	24	9	2
2	63	15	0	0	0	2	283	137	11	4	1
3	1012	409	24	8	1	3	305	180	18	8	1
4	138	78	3	1	0	4	79	64	10	3	1
5	75	55	6	5	1	5	239	96	3	2	0
6	707	339	26	11	2	**Total**	2023	929	66	26	5

4.4.2.1.2.1. Andalusia

Conclusions are complementary to the results obtained from the branch analysis and the comments made until now. In 1980 most of the links belong to the manufacturing and low technology groups. But the links staying at the highest threshold value are from groups 1 and 2 in the input-output link classification. That is, they belong to agriculture and agribusiness, going from ‘agriculture’(1) to ‘oils and fats’(22) and to ‘other food industry’ (26).

In 1995 there is an important change when comparing the above results. With low filters the highest number of links is in the manufacturing and low technology groups, as in 1980. But when filters increase, there is a change in the sense that the most numerous links are in the service sector group. Nevertheless, the staying links at the highest filter are again in the agriculture and agribusiness link groups, from ‘agriculture’ (1) to ‘oils and fats’ (22).

Therefore, the productive specialisation of the region is proved again, and also the movement towards a tertiary economy, although with the prevalence of low technology activities. But a reduction in the number of links in the primary sector can be observed in the analysed period, while all the other groups increase their links.

4.4.2.1.2.2. The Basque Country

In this region the situation is similar to the one in Andalusia. In 1980 manufacturing and low technology are the groups with the highest number of links for all the threshold values. Regional specialisation is also shown, as the link staying at the highest filter goes from ‘metal ores’ (9) to ‘metal products and machinery’ (15).

Once again there is a change in 1995, when filters are increased the highest links go from manufacturing to services. In this case, the link from 'construction' ((34), low technology) to 'business services' has the highest intensity (higher than 5.5). Nevertheless, the next highest link (filter of 4) goes again from 'metal ores' to 'metal products and machinery'. Therefore tertiary and specialisation processes are also present in the economic evolution of the Basque Country.

4.4.2.1.2.3. Regional comparison

From the information offered in tables 4.14 to 4.17 more conclusions can be obtained by comparing the regional dynamics. For the case of Andalusia, and according to the sector classification, only sector 1 (agriculture, fishing and hunting) decreases its links when comparing the two years, but for the other five sectors the situation is the opposite, higher number of links in 1995 continuing in the sequence of threshold values. According to the technology content classification, the number of links is always higher in 1995 than in 1980 (although it is clearer for group 4, ICT branches).

Therefore, there is a general situation of more dense and complex net of relationships with higher number of links, for all the technology content groups and with the exception of the agriculture sector.

In the case of the Basque Country the situation is different. Sectors one to three (agriculture, ore and manufacturing) decrease their links for all the thresholds sequence. Only the construction sector shows a clear increase in its links, although services also show a rise for relatively high intense links. When the focus is in the technology content groups again there are clear differences with Andalusia, as most of the groups show reductions in their link number. Nevertheless, it is possible to distinguish the cases of high technology content and ICT users showing a denser presence in the regional system. As it has already been remarked, those are characteristics that can be generalised to more developed regions.

4.4.2.2. Net density

Density is a basic network measure that gives information about the complexity of the net. It calculates (as it was explained in chapter 3, equation 3.15) the proportion of effective over potential relationships. The threshold values applied in table 4.18 have been calculated by considering the hypothetical possibility of totally homogeneous branches in each region. As the total number of branches is different in each place, that threshold value also varies. [158]

Table 4.18: Net densities

	Values/Regions		1980	1995	Variation rate
Without filter	Inside	Andalusia	0.6089	0.6379	4.8%
		Basque Country	0.6459	0.6213	-3.8%
	Total	Andalusia	0.6358	0.6443	1.3%
		Basque Country	0.6628	0.6512	-1.7%
Filter: 0.05285 (An), 0.0483 (BC)	Inside	Andalusia	0.1231	0.1234	0.2%
		Basque Country	0.1328	0.1376	3.6%
	Total	Andalusia	0.1284	0.1321	2.9%
		Basque Country	0.1304	0.1492	14.4%

Andalusia shows an increase in its links net in this fifteen years period, with a rise in its density net, while in the Basque Country the situation is the opposite. This happens in such a way that in 1980 the density of the Basque Country was higher than in Andalusia and in 1995 the situation reverses.

There could be different hypotheses explaining that situation. Those hypotheses will be expounded, as generally in the literature there is the assertion that there is a positive relationship between the level of development and the links density. Therefore, according to this idea, there should be higher density levels in the Basque Country, a highly developed region, when compared with Andalusia, a less developed region. However, the Basque Country shows a reduction in its density, in the direct links of most of its branches and also in the intensity coefficients except for a few particular

[158] Data for Spain, without filter, are: 0.6887 (inside 1980), 0.8577 (inside 1995), 24.5% (inside variation rate), 0.6882 (total 1980), 0.8589 (total 1995), 24.8% (total variation rate). The increase in the total values could be related to outsourcing and innovation.

branches.[159] Andalusia, however, clearly follows the expressed general theory of increasing development associated to higher net density and links intensity.[160]

One of the hypotheses is that the higher development level in the Basque Country corresponds to a more dense net of relationships when considering non-technical links, at the formal and informal levels. In the formal sense the creation of technology parks, research institutes and other institutions should be tested. This hypothesis will be tested in the next chapter, compiling direct data about those types of formal as well as informal relationships. Moreover, it could be that the situation of Andalusia in 1995 could be similar to that in the Basque Country in 1980. That is, still trying to build a solid net of physical links with diversification, while in the Basque Country there is a focus in high technology and ICT productive branches.

Another hypothesis refers to regional specialisation. As it has already been said, Andalusia is highly specialised in agriculture and agribusiness. That is, in a group made of a relative high number of branches from every sector: primary (agriculture, fishing, hunting), secondary (agribusiness) and tertiary (hotels and restaurants). In the Basque Country, however, productive specialisation is in metallurgy, where only a few secondary branches are implied. Therefore, the number of links derived from the specialisation group is higher in Andalusia than in the Basque Country. Moreover, there is a necessity for diversification when growth is based on agriculture, because of the problems coming from having this sector as the economic engine. Those problems refer to demand as explained in the Engel Law. That is, the development process shows that higher income levels are associated with lower foodstuffs consumption. There is a demand substitution with higher income percentages expended in service activities and lower percentages for food consumption.

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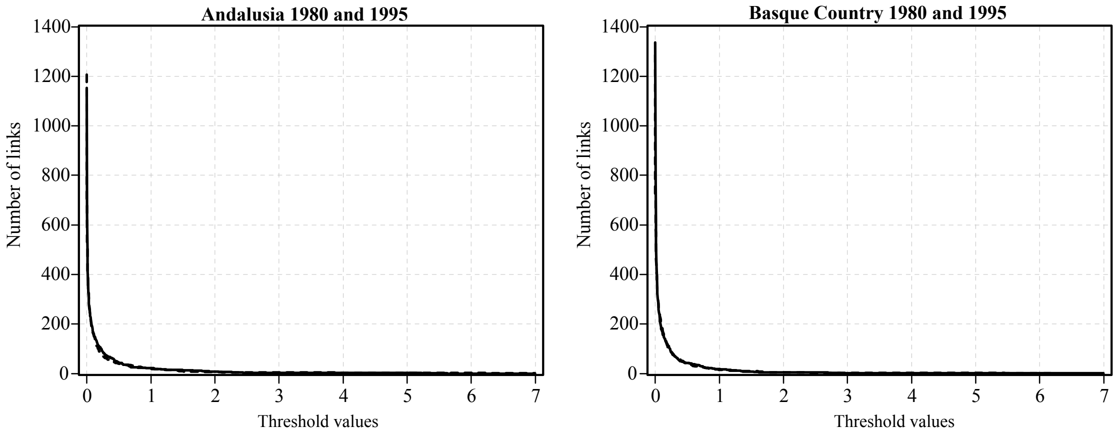
[159] There is also in its redundancies, referred to the links maintained by the nodes directly linked to each ego, as it will be explained later. Exceptions are for the branches ‘construction’, ‘business services’ and medium-high technology content branches.

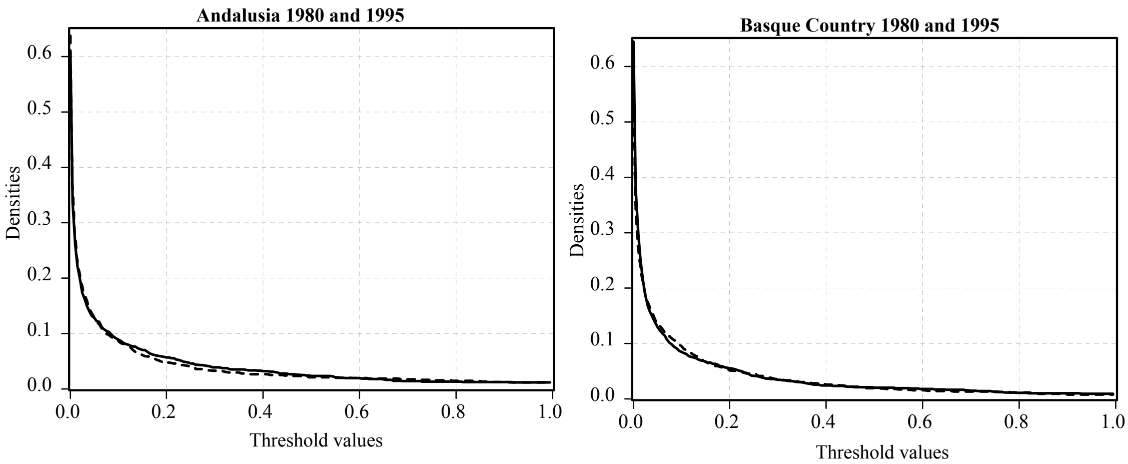
[160] This even happens in all the groups: agriculture, manufacturing, construction, services; low, medium and high technology content.

Densities for both regions and years have also been obtained for a sequence of 1400 threshold values, to make spatial and dynamic comparisons.[161] Therefore, density evolution can be studied from graphs 4.4 and 4.5 when coefficients intensity is considered.

Graph 4.4: Number of links in Andalusia and Basque Country



Graph 4.5: Density sequence in Andalusia and Basque Country



[161] Threshold values go from 0 to 7 in 0.05 intervals. That is, between the thresholds 0 and 1 there are 200 values.

The two above graphs show the fast decrease in the number of links, and therefore in density, when the filter value is increased. The sequence is quite similar between both regions and years. Even if for the most general situation, without any threshold value, shown in table 4.18, there has been an increase in density for Andalusia and a decrease for the Basque Country, when a threshold is imposed there are not such differences. Even the situation reverses for a significant filter (around 0.07 in Andalusia and 0.02 in the Basque Country).

To point out the fast decrease in links and density, it is possible to observe that for an approximated filter of 0.035 in any case, 75% of links have vanished. Moreover, without any filter densities are always above 0.6 and for a filter of just 0.02 densities falls to 0.2, 0.1 for approximately 0.075 and 0.05 for around 0.2. The explanation is that most of the branches have a very small participation in the regional intermediate transactions, and only a few branches, as shown in table 4.4, have a significant coefficient weight.

4.4.2.3. Net cohesion

Cohesiveness in the net is calculated to know the level at which nodes are linked. When all nodes are directly connected (minimum distance), cohesiveness is maximum (as explained in section 3.3.2.2.4). The measurement of a cohesion index,[162] based on distance, with values between 0 a 1 (1 means maximum cohesion) shows that all nodes are linked among them with a longest path of 3 steps, therefore all nodes are reachable.

Table 4.19: Cohesion index

	Region/Period	1980	1995	Variation rate
Without filter	Andalusia	0.793	0.819	3.3%
	Basque Country	0.812	0.799	-1.6%
Filter: 0.05285 (An), 0.0483 (B.C.)	Andalusia	0.384	0.421	9.6%
	Basque Country	0.387	0.431	11.4%

[162] Doreian (1974), Burt (1976).

The same explanations expounded as hypotheses in the above section can be applied to base the diverse regional evolution observed in table 4.19. The productive structure of the Basque Country, leads to an increasing emphasis towards ICT and high technology branches, and focuses its economic growth in a few branches. Nevertheless, all branches are reachable but not necessarily through direct links, mainly for particular branches (low technology and from primary and secondary sectors). Andalusia, however, with a process of diversification, needs to increase its direct productive links. Moreover, regional specialisation in Andalusia, implying a high number of branches, embodies a process of innovation adoption (new processes, synthetic products, chemicals, new containers). Throughout this process both old and new inputs coexist, increasing the number of links.

In any of the cases there is high cohesion in the net. In both regions and for both years there is only a *weak component*, a *strong component* (including all or almost all branches) and a *block*.[163] General cohesion has increased in this sense in Andalusia, as the number of branches not included in the components reduces, while in the Basque Country it is similar in both years.

At the same time, those cohesive structures are made of subgroups with some of them showing high cohesion. This has been measured through the *lambda-sets* analysis.[164] In Andalusia 1980 the group with highest cohesion is made of 18 branches that need to delete 43 branches in order to disconnect them (43-set of 18 branches). The 43-set in 1995 is made of 13 branches. In the Basque Country the highest cohesive group is a 45-set of 19 branches in 1980 and 8 in 1995. The reduction in the number of included branches is obvious in this region, in accordance with the explanations for the different evolution patterns. Moreover, among the staying branches in the set there are some of the most important for its productive specialisation.

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[163] Depending on the year and the filter Andalusia could not include 'tobacco', 'forestry', or 'skin and footwear'. This is the case in the Basque Country for 'machinery for metallurgy', 'tobacco', 'health' or 'metal ores'. *Weak component*: nodes are connected, in any form, at least in one direction. *Strong component*: nodes are connected, in any form, in both directions. *Block*: subgroup divided by a cut-point.

[164] *Lambda-set*: subgroup where a lambda number of links should be removed to disconnect its nodes.

Table 4.20: Lambda-sets

Andalusia: 43-set	Basque Country: 45-set
Common branches in 1980 and 1995	
‘Petroleum’ ‘Electricity’ ‘Water’ ‘Wood, cork and furniture’ ‘Machinery’ ‘Paper’ ‘Rubber and plastic’ ‘Construction’ ‘Trade’ ‘Hotels and restaurants’ ‘Transports’ ‘Post and telecommunications’ ‘Business services’	‘Electricity’ ‘Chemicals’ ‘Metal products and machinery’ ‘Office machinery’ ‘Business services’ ‘Trade’ ‘Other land transport’
Branches disappearing from 1980	
‘Other chemicals’ ‘Electrical goods’ ‘Clothing and skin’ ‘Leather and footwear’ ‘Publishing and printing’	‘Petroleum’ ‘Auxiliary transport’ ‘Post and telecommunications’ ‘Financial intermediation’ ‘Insurance’ ‘Textile and footwear’ ‘Wood and cork’ ‘Other manufacturing’ ‘Construction’ ‘Hotels and restaurants’ ‘Tr. Railways’

When threshold values are considered, those groups are much smaller, and the highest cohesion in Andalusia appears between ‘transports’ and ‘business services’. In the Basque Country the situation changes between 1980 and 1995, in the sense that while the most cohesive groups in 1980 were made of ‘petroleum’-‘trade’ and ‘metal products and machinery’-‘trade’, in 1995 this last group stays and there is also, and with highest intensity, the ‘trade’-‘business services’ group.

When measuring the net cohesion there are some cases with a peculiar behaviour in the *matrix of distance cohesion* (number of necessary nodes in the shortest path to reach all other nodes) that should be commented. Those are branches that do not make any intermediary sale to any other branch and therefore they are not linked as sellers to the others:[165]

[165] They are not connected through rows but they are through columns, as buyers, directly or indirectly.

- Andalusia 1980, 'tobacco'[166]
- Basque Country 1980, 'machinery for metallurgy'
- Basque Country 1995 'tobacco'[167]

4.4.2.4. Centrality and centralisation

Several centrality measures have been calculated for each net.[168] Some of them focus on the number of links enjoyed by each branch and some others in the length of the paths connecting each pair of branches. Only the most interesting cases are shown in this section (*normalised degree centrality* and *centralisation*), for all the values and also imposing two threshold values of 0.005 and 0.05. Those filters allows for around a 60% of the total links in the first case and for a 20% in the second.[169]

Table 4.21 shows the network centralisation values for *in* and *out degree* (as in equation 3.24). Those values could change from 0 to 100. For a 0 value all branches have the same centrality index. For a value of 100 there is a branch dominating all other branches in centrality terms. Therefore, it measures the position of the whole net around particular branches. The higher the centralisation the higher the probability that a unique branch is highly central with respect to the others. In other words, it measures how heterogeneous branch centralities are and helps to identify strategic branches in the *regional production system*.

[166] In 1995 'tobacco' made intermediary sales to 'fishing', 'fish and vegetable industry' and 'water and air trade'.

[167] In 1980 'Tobacco' made intermediary sales to 'hotels and restaurants' and 'water and air trade'.

[168] *Normalised degree centrality* (in and out), *degree* (in and out) *closeeness* (in and out), *normalised betweenness*, *betweenness*, *normalised flow betweenness*, *flow betweenness*, *power* and *information*.

[169] The first 0.005 threshold value implies considering transactions at least of 739,874 millions € in Andalusia 1980 and 3,136,752 mill. € in 1995, for the Basque Country it corresponds with 410,027 mill. € in 1980 and 1,979,671 mill. € in 1995. The second 0.05 corresponds with transactions with a minimum value of 2.2 mill. € in Andalusia 1980, 9.4 mill. € in Andalusia 1995, 1.2 mill. € in the Basque Country 1980 and 5.9 mill. € in the Basque Country 1995.

Table 4.21: Network degree centralisations (%)

Filters/ Centralisations		Andalusia		Basque Country	
		1980	1995	1980	1995
Without filter	Indegree	25.8	34.7	20.3	20.5
	Outdegree	40.1	37.1	36.2	38.7
Filter: 0.005	Indegree	37.0	37.0	34.1	32.5
	Outdegree	63.2	63.2	61.4	62.0
Filter: 0.05	Indegree	34.5	31.9	34.4	36.1
	Outdegree	60.7	60.5	57.1	58.9

The first conclusion derived from those data is that *outdegree* values are always higher than *indegree* values. In some cases differences are clearly evident. *Indegree centralisation* indicates the purchases structure of productive branches. Therefore, with low results there is not a key 'purchaser' branch but this structure is disperse. *Outdegree*, however, indicates the sales structure of branches. In that case there could be some branches occupying a strategic position, offering their production to most of the other branches in the system. Then, *outdegree centralisation* can reach a high value, around 60%, when a threshold value is considered.

In order to test those theoretical ideas for the *indegree* and *outdegree centralisation* evolution, a centrality analysis for every branch has been done with the same filters, the two regions and for both years.

4.4.2.4.1. Andalusia

In Andalusia, *indegree centralisation* reaches a maximum value of 37%, while the *outdegree* index leads to the value of 63.2%, showing a high increase when a filter is imposed. In this second case there should be few branches acting as strategic because they sell relatively high quantities to an important number of other branches. Tables 4.22 and 4.23 show branches with the highest *normalised indegree* and *outdegree centrality* values (applying equations 3.18 and 3.19). From branches appearing in those tables, a group of branches in strategic position in the regional system could then be selected.

Table 4.22: Highest normalised indegree centralities, Andalusia

	1980	1995
Without filter	'Other food industry' (86) 'Hotels and restaurants' (79.1) 'Transports' (79.1)	'Business services' (97.7) 'Hotels and restaurants' (93) 'Construction' (67.4)
Filter:0.005	'Other food industry' (69.8) 'Hotels and restaurants' (67.4) 'Business services' (60.5)	'Business services' (97.7) 'Hotels and restaurants' (67.4) 'Construction' (58.1)
Filter:0.05	'Hotels and restaurants' (46) 'Other food industry' (30.2) 'Construction' (37.2)	'Hotels and restaurants' (44.1) 'Construction' (44.1) 'Business services' (34.8)

Note: Values in brackets indicates the branch centrality value for a minimum theoretical of 0 and a theoretical maximum of 100.

In 1980 'other food industry' has a quite high centrality value, although this is a branch maintaining a high number of links through relatively small quantities. With the 0.05 filter its centrality index is much lower and the only branch emerging, although not in a clear way, is 'hotels and restaurants'. In 1995 centrality values are much higher appearing as clearly central 'business services' and 'hotels and restaurants'.

Table 4.23: Highest normalised outdegree centralities, Andalusia

	1980	1995
Without filter	'Petroleum' (100) 'Electricity' 'Water' 'Wood and cork' 'Clothing and skin' 'Printing and publishing' 'Rubber and plastic' 'Construction' 'Trade' 'Transports' 'Telecommunications' 'Business services'	'Petroleum' (100) 'Electricity' 'Water' 'Wood and cork' 'Machinery' 'Printing and publishing' 'Rubber and plastic' 'Construction' 'Trade' 'Transports' 'Telecommunications' 'Business services'
Filter:0.005	'Transports' (95.3) 'Business services' (92) 'Trade' (90.6)	'Transports' (97.7) 'Business services' (97.7) 'Trade' (93)
Filter:0.05	'Transports' (72) 'Business services' (55.8) 'Trade' (46.5)	'Transports' (72.1) 'Business services' (72.1) 'Trade' (51.1)

See note in table 4.22. All centrality values without filter are 100.

As it was already presumed, *outdegree centralities* are quite high, even with restrictive threshold values. Nevertheless, there are a high number of branches showing the maximum centrality index without a filter, but with the filter their centrality indices fall a lot. An example is the case of 'clothing and skin' with respective filters centrality values of 100, 27.9 and 0. Those are branches selling quite small quantities to all other branches in the system. There are also three branches in the system that can be named as strategic because of their high outdegree centrality, increasing in the period 1980-1995, considering the number of outlinks and their intensity. They also appear with the highest centrality for most of the other centrality measures:[170]

- 'Transports'.
- 'Business services'.
- 'Trade'.

4.4.2.4.2. The Basque Country

According to the *indegree* branch centrality, concentration is not evidenced as was the case for Andalusia, reaching a maximum value of 36.1%. For the *outdegree*, however, again there are high and increasing centralisation values, indicating a sales structure with strategic branches. Tables 4.24 and 4.25 helps in the understanding of those structures showing the branches with the highest centrality values (applying equations 3.18 and 3.19).

Table 4. 24: Highest normalised indegree centralities, Basque Country

	1980	1995
Without filter	'Other food industry' (84.4) 'Health' (84.4) 'Hotels and restaurants' (73.3) 'Metal products and machinery' (66.6)	'Health' (82.2) 'Fishing' (77.8) 'Social, personal and com. Ac.' (77.8) 'Metal products and machinery' (73.3)
Filter:0.005	'Hotels and restaurants' (73.3) 'Metal products and machinery' (62.2) 'Health' (57.7) 'Other food industry' (55.5)	'Metal products and machinery' (66.7) 'Construction' (62.2) 'Social, personal and com. Ac.' (62.2) 'Office machinery, p and p.' (57.8)
Filter:0.05	'Metal products and machinery' (46.6) 'Metals' (44.4) 'Hotels and restaurants' (37.7) 'Construction' (33.3)	'Metal products and machinery' (48.9) 'Construction' (44.4) 'Trade' (37.8) 'Hotels and restaurants' (37.8)

Note: With the 0.05 filter in 1980 'Health' has a centrality of 11.1 and 'other food industry '13.3. In 1995 with a filter of 0.05 'health' has a value of 17.7.

[170] *Inclosseness*, *outcloseness*, *betweenness*, *flow betweenness*, *power* and *information*.

With filters, *indegree centrality* values fall to low values, although the case of 'metal products and machinery', a very important branch in the specialised productive structure of the region, should be highlighted. Its centrality value is relatively high and also it increases in the period 1980-95, acquiring intermediate goods from an important number of branches staying in the net.

For the *outdegree*, there is always an increase in the centralisation value in 1995, showing an even clearer structure with few highly central branches. Those branches will emerge from table 4.25.

Table 4.25: Highest normalised outdegree centrality branches, Basque Country

	1980	1995
Without filter	'Petroleum' (100) 'Electricity' 'Gas and water' 'Metal products and machinery' 'Office machinery' 'Textile and footwear' 'Construction' 'Trade' 'Hotels and restaurants' 'Other land transports' 'Tr Railways' 'Auxiliary transport activities' 'Post and telecommunications' 'Financial intermediation' 'Insurance' 'Business services'	'Electricity' (100) 'Gas and water' 'Metal products and machinery' 'Trade' 'Other land transports' 'Business services'
Filter:0.005	'Trade' (97.8) 'Petroleum' (93.3) 'Electricity' (91.1) 'Business services' (91.1)	'Trade' (95.5) 'Business services' (91.1) 'Other land transport' (86.7) 'Electricity' (86.7)
Filter:0.05	'Trade' (68.8) 'Business services' (57.7) 'Petroleum' (48.8) 'Electricity' (48.8)	'Business services' (71.1) 'Trade' (64.4) 'Electricity' (53.3) 'Other land transport' (37.8)

The increase in the *centralisation* value between 1980 and 1995 corresponds with a reduction in the number of the most central branches. Most of the branches showing the maximum possible centrality value decrease their index in a very intense way with the filter condition. Therefore, there is a selling structure with a high number of 'necessary' branches for all the others, linked through very low transactions.[171] In this central selling structure a couple of branches can be found as strategic. They have also maximum centrality values for other measures and in one of the cases ('business services') its index increases in the considered period:

- 'Trade.
- 'Business services'.
- 'Electricity'.

The above results can be complemented with a *core-periphery* analysis to test the possibility that the most central branches make a core group, highly differentiated from the other branches, occupying a periphery position. However, as has been already lightly inferred, a defined core-periphery structure can not be found in any of the cases.

Nevertheless, in both regions, the situation with the 0.005 threshold value in 1995 is the most similar to a *core-periphery* structure.[172] Branches in the core would be those in table 4.26, ordered according to their coreness level (as explained in section 3.3.2.3.1). When comparing the evolution of this structure, in Andalusia the most significant change corresponds to the branch 'basic chemicals', that in 1980 did not belong to the core, neither at 12º level and in 1995 it is in its 4º position. In the Basque Country there is no case as clear as this.

[171] The clearest case is 'textile and footwear' with the following centrality values for the three filters: 100, 24.4, 2.2.

[172] The correlation coefficient when compared with an ideal *core-periphery* structure is 0.55 in Andalusia and 0.59 in the Basque Country.

Table 4.26: Branches in the core in a core-periphery structure

Coreness level	Andalusia	Basque Country
1	'Business services'	'Trade'
2	'Trade'	'Business services'
3	'Construction' 'Transports'	'Metal products and machinery' 'Construction'
4	'Hotels and restaurants'	'Office machinery' 'Hotels and restaurants'
5	'Electricity'	'Other land transport'
6	'Petroleum' 'Machinery' 'Post and telecommunications'	'Auxiliary transport activities'
7	'Financial intermediation'	'Petroleum' 'Electricity'
8	'Wood, cork and furniture'	'Gas and water' 'Chemicals' 'Social, personal and community activities'
9	'Basic chemicals'	'Paper' 'Post and telecommunications' 'Insurance'
10	'Water' 'Other food industry' 'Paper'	'Metals'
11	'Electrical goods'	'Non ferrous metals and basic chemicals' 'Plastic'
12		'Motor vehicles' 'Wood and cork' 'Financial intermediation'

4.4.2.5. Subgroups

There are two strategies when trying to find subgroups inside the whole net: one is to go from the micro towards the macro level (bottom-up) and the other goes from the macro to the micro level (top-down). Both perspectives have been applied, through several measures, to the regional input-output matrices, without a threshold value and with a sequence of filters. The bottom-up perspective helps, in a better way, to identify branches playing a crucial role from the identification of cohesive groups. This is the perspective adopted in this section, where only the most representative case (*cliques* identification) is shown.[173] The top-down perspective, however, helps in the characterisation of the net from another point view: cohesiveness and highly dense subgroups, as seen in section 4.4.2.3.[174]

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[173] The other bottom-up measures that have been applied are: *n-clique*, *n-clan*, *k-plex* and *k-core*.

[174] Measures in that case are: *component*, *block*, *lambda-set* and *faction*.

Remembering the *clique* definition as a group of nodes all directly linked among themselves, table 4.27 shows the most important branches in the overlapping sequence of cliques with a minimum size of five branches (making use of the concepts explained in section 3.3.2.1.2.). Those are branches appearing in most of the identified *cliques* (in all of them in some cases) for different threshold values.

Table 4.27: Remarking branches in the overlapping clique structure.

	Andalusia		Basque Country	
Filter	**1980**	**1995**	**1980**	**1995**
0	'Petroleum' 'Electricity' 'Water' 'Other chemicals' 'Wood and cork' 'Machinery' 'Electrical goods' 'Clothing and skin' 'Leather and footwear' 'Paper' 'Publishing and printing' 'Rubber and plastic' 'Construction' 'Trade' 'Hotels and restaurants' 'Transports' 'Telecommunications 'Business services' (59/59)	'Petroleum' 'Electricity' 'Water' 'Wood and cork' 'Machinery' 'Paper' 'Rubber and plastic' 'Construction' 'Trade' 'Hotels and restaurants' 'Transports' 'Telecommunications' 'Business services' (26/26)	'Petroleum' 'Electricity' 'Gas and water' 'Chemicals' 'Metal products and machinery' 'Office machinery' 'Textile and footwear' 'Wood and cork' 'Other manufacturing' 'Construction' 'Trade' 'Hotels and restaurants' 'Other land transport' 'Tr. Railways' 'Auxiliary Tr.' 'Telecommunications' 'Financial intermediation' 'Insurance' 'Business services' 'Social and personal activities' (72/72)	'Electricity' 'Gas and water' 'Chemicals' 'Metal products and machinery' 'Office machinery' 'Trade' 'Other land transport' 'Business services' (61/61)
0.005	'Petroleum' 'Transports' (143/152)	'Trade' 'Business services' (152/157)	'Petroleum' 'Trade' (88/94)	'Metal products and machinery' 'Trade' (77/80)
0.01	'Transports' 'Business services' (98/103)	'Trade' 'Transports' (109/114)	'Petroleum' 'Trade' (74/86)	'Trade' 'Other land transport' (81/88)
0.05	'Trade' 'Transports' (29/49)	'Trade' 'Transports' (24/29)	'Metal products and machinery' 'Trade' (50/89)	'Trade' 'Business services' (44/45)

Note: The ratio in brackets indicates the number of cliques including the selected branches over the total number of cliques.

Most of the branches appearing in table 4.27 were already selected in the centrality analysis. From this subgroup view, some of them increase their key character as generating dependency links with a big group of other branches. In Andalusia this is mainly the case for the following branches:

- 'Trade'
- 'Transports'
- 'Business services'

In the Basque Country the branches to be selected are:

- 'Trade'

- 'Metal products and machinery'
- 'Business services'

4.5.- Identification of relevant production systems

The main objective of this chapter was to study the productive structure of Andalusia and the Basque Country from historical, descriptive and network perspectives to conclude with the identification and characterisation of the most relevant *production systems* in each region.

This study is completed now by applying an algorithm based on Peeters *et al* (2001) for the systems identification. Productive branches showing great mutual dependency, by their deliveries and purchases, have been classified in the same system in the following way: A relationship is considered relevant whether it is important from the seller or buyer perspective, then branches with links overcoming a filter value, for sale and purchase, are selected. The coefficients used for the algorithm are the *relative intermediate sales* and the *relative intermediate purchases* explained in section 4.3.1. With those coefficients, links are selected according to their importance for the involved branches and not for the whole economy, as was the case in the previous analysis. More technically, the selection process is the following one:

In the sequence of the algorithm the most important sale (for every seller) and purchase (for every buyer) are first of all selected, then a filter is applied by rows (in a second step by columns) and another one by columns (in a second step by rows). As an illustrative example, the most important sale of a seller is selected only if its relative value is higher or equal to 0.2 and if this exchange value is higher or equal to 0.05 when considered as a purchase by the corresponding buyer. The algorithm has been repeated for several threshold values and without considering the maximum criteria.

Other criteria could have been applied, such as the algorithms employing *depth first search* and *graph analysis* in Aroche Reyes (2001). According to this author 'industrial complexes' are identified by looking for *strongly connected components*. That is, groups where there is a chain in both senses between each pair of nodes. This view is not applied in the present research to allow the branches in the *production systems* to be strongly linked just in one direction. Another possibility is to apply factor and cluster analysis like in Feser and Bergman (2000). However, through the application of this technique similar branches according to selected attributes are grouped together. The perspective of the present research does not look for similar branches but for highly linked branches that could show very different characteristics or attributes. Moreover, network measures allows for the search of those types of groups, like *factions*,[175] although this is not the chosen technique it has also been applied to study the network characteristics.

There is a net in every region where sub-groups or production systems can be identified, once the selected algorithm has been applied. In both regions, among the relevant sub-groups, the agro-food and the metal-mechanical systems have been selected. In figure 4.1 it can be observed that in Andalusia the most relevant system is the agro-food one, although there is a small metal-mechanical system that will be also studied for comparative purposes. Another three small systems are also found: construction-mining-cement-glass-electricity-transports, business services-public administration-health-financial intermediation-insurance-trade and textiles-clothing-other transport equipment. However, only the agro-food is chosen from this region (and the metal-mechanical for comparison with the Basque Country) as branches on it have already been considered as the most relevant from the historical, descriptive and network analyses made before.

Figures 4.1 and 4.2 show the significant *production systems* for the respective threshold values of 0.2 and 0.05. In the Basque Country the agro-food and the metal-mechanical systems are clearly identified. Another two groups can be selected, one of them mainly made of transport branches and including the fishing value change. There is another around 'business services' and a third sub-group related to construction activities. Another criteria for selecting the *production systems*, together with the algorithm rules, are the social and historical characteristics of each territory and branches, considered as relevant in each regional productive structure, and the descriptive and network analyses results. Branches constituting both production systems in both regions are shown in table 4.28.

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[175] *Faction*: Partition where actors within each subgroup have maximum similarity, higher density inside the subgroup than between subgroups.

Figure 4.1: Production systems in Andalusia, 1995

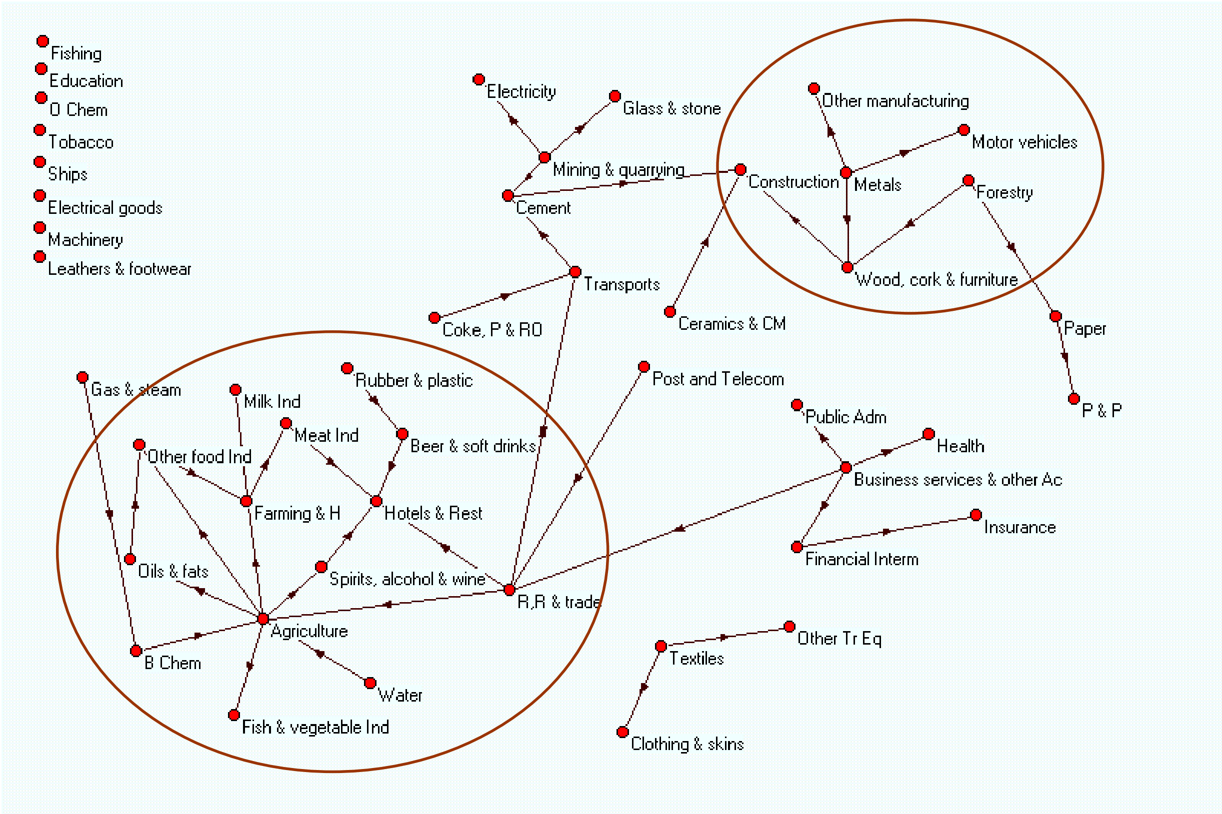

Figure 4.2: Production systems in the Basque Country, 1995

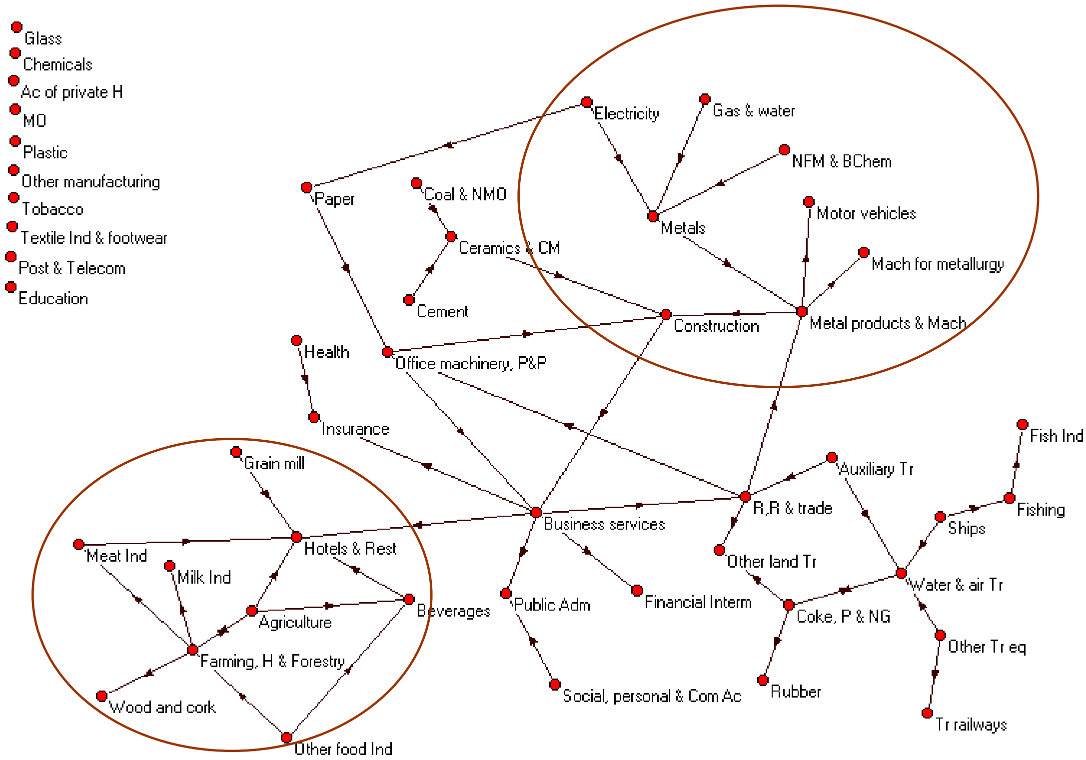

Table 4.28: Agro-food and metal-mechanical production systems

	Andalusia	Basque Country
Agro-food Production System	**Common branches in 1980 and 1995**	
	'Agriculture' 'Farming' 'Milk industry' 'Meat industry' 'Other food industry' 'Hotels and restaurants' 'Spirits, alcohol' 'Beer and soft drinks' 'Oils and fats' 'Fish and vegetable industry' 'Basic chemicals' 'Trade'	'Agriculture' 'Farming' 'Milk industry' 'Meat industry' 'Other food industry' 'Hotels and restaurants' 'Beverages' 'Grain mill'
	New branches in 1995	
	'Water' 'Rubber and plastic'	'Wood and cork'
	Branches disappearing from 1980	
	'Textiles' 'Fishing' 'Coke, petroleum' 'Glass and stone' 'Paper'	'Glass' 'Paper'
Metal-mechanical Production System	**Common branches in 1980 and 1995**	
	'Metals' 'Construction' 'Wood and cork' 'Forestry'	'Metals' 'Construction' 'Non ferrous metals and basic chem.' 'Metal products and machinery' 'Machinery for metallurgy' 'Motor vehicles' 'Electricity' 'Trade'
	New branches in 1995	
	'Other manufacturing' 'Motor vehicles'	'Gas and water'
	Branches disappearing from 1980	
	'Mining and quarrying' 'Cement' 'Glass and stone' 'Ships'	'Coke, petroleum' 'Wood and cork' 'Plastic' 'Ships'

There are some particularities in the selected systems that should be commented before studying them deeply. For the *agro-food production system*, 'fishing' has a peculiar behaviour. In Andalusia 1980 it appears in the system because of its sales to 'fish and vegetable industry' and to 'hotels and restaurants'. However, in 1995 its identification in the production system is not clear as it appears in the system only with very low filters. Moreover, in the Basque Country this is a branch linked in a peculiar group: 'fishing', 'fish and vegetable industry' and 'ships', apart from the agro-food system.

The *metal-mechanical production system* is a clearly defined group in the Basque Country while it is not in Andalusia. Some of its branches have great importance in the productive structure of the region but there is not a consolidated system structure.

Table 4.28 shows that there are a different number of branches for each region in any of the two production systems. The number of branches is always higher in the region where the system is more representative (agro-food in Andalusia and metal-mechanical in the Basque Country). One of the reasons for that is the branch aggregation level. Each region has adapted the input-output methodology to its productive characteristics and therefore they work with higher specification for branches with more presence in the regional economy. Another explanation is the region specialisation emerging from the threshold values selection. In that sense, branches like 'fish industry' or 'basic chemicals' do not appear in the Basque agro-food system, while 'machinery' is not in the metal-mechanical system of Andalusia.

For the dynamism of the systems, there is a group of branches disappearing from both regions, that could be indicating an import substitution process. This is the case of 'glass and stone', 'paper', 'plastic' and 'petroleum'. There is also another group of branches, which have already been analysed, reducing its presence in the regional economy in a significant way. This is the case for textile related branches in Andalusia and the fishing chain value in both places.

The main characteristics of the two production systems, relating to descriptive and network analyses and to the application of the main input-output coefficients are shown in the next sections.

4.5.1.- Agro-food production system

Tables 4.29 and 4.30 summarise the characterisation of the branches in the agro-food system for each region. The first four columns relate to a descriptive analysis, columns five to seven show the results after having applied the three main input-output coefficients commented in chapter three. Columns eight to twelve summarise the network analysis results.

Table 4.29: Branches characterisation in the agro-food production system of Andalusia

	10F	Tech	Dynam.	Dep.	Ch-W	Streit	Rasm	I-O C.	Centrality		Core/ Periphery	Clique	Densit
									IN	OUT			
Milk I.	-	L	SIP*	A/S	III	M	I	2	M	L	P	N	O
Meat I.	-	L	SIP	A/S	II	M	I	2	M	M	P	N	O
Oils	P	L	EIP*	A/S	III	M	I	2	M	M	P	N	-
Fish and v.	P	L	SIP*	A/S	III	M	I	2	H	M	P	N	O
Other food	P	L	SIP	A	IV	M	I	2	H	M	C10	N	-
Spirits	-	L	SE	A/S	III	M	I	2	M	L	P	N	I/O
Beers	-	L	PE*	A	II	M	I	2	M	L	P	N	I/O
Agriculture	S/P	L	SIS	A/S	II(1)	L	IV(2)	1	M	M	P	N	-
Farming	S	L	SIP	A	I	M	III	1	M	M	P	N	O
Hotels	P	L	PE	A/S	III	H	I	-	H	H	C4	Y	-
Basic che	-	H	SIS	A/S	II	M	II	-	M	M	C9	N	-
Trade	S/P	ICT	EIP	A/S	I(3)	H	III(4)	4	H	H	C2	Y	-
Water	-	L	EIS*	A/S	II	M	I	4	M	M	C10	Y	I
Rubber	-	M	EIS*	-	I	M	III	4	M	M	P	Y	I

10F: Ten most important branches (table 4.4), P (in purchases), S (in sales).
Tech.: Technology content (table 4.2), L (low technology content), M (medium), H (high), ICT (information and communication technology).
Dynam: Coefficients dynamic (some of the data are in graphs 4.1 and 4.2). SIP (decline intensified in purchases), SIS (decline intensified in sales), EIS (expansion intensified in sales), EIP (expansion intensified in purchases), PE (purchases expansion) SE (sales expansion).
Dep.: regional dependency, A (autonomy) when the percentage of inside intermediate sales on total intermediate sales is higher than 50%, S (self-sufficiency) when the percentage of inside intermediate purchases on total intermediate purchases is higher than 50%.
Ch-W: Chenery-Watanabe coefficients (groups explained in chapter 3).
Streit: Streit Coefficients, data have been classified in quintiles, H (high) corresponds to the first quintile, M (medium), and L (low) corresponds to the last quintile.
Rasm: Rasmussen coefficients (similar groups than in Ch-W).
I-O C: input-output classification (table 4.3).
Centrality: indegree (IN) and outdegree (OUT) with a threshold value of 0.005, data have been grouped in quintiles, H (high) first quintile, M (medium), L (low) last quintile.
Core/periphery: P (periphery) C (core level) (table 4.26).
Clique: According to the overlapping structure of table 4.27, yes (Y), no (N).
Densit.: egonetwork density, 'I' when the egonetwork density is higher than the average when considering only incoming links, 'O' when the egonetwork density is higher than the average when considering only outgoing links.
(1) The sub-branch 'vegetables and fruits crops' is in group IV.
(2) The sub-branch 'vine and olive trees crops' is in group III.
(3) The sub-branch 'retail trade' is in group IV.
(4) The sub-branch 'retail trade' is in group IV.
(*) Change is lower than one percent point.

Table 4.30: Branches characterisation in the agro-food production system of the Basque Country

	10F	Tech.	Dynam.	Dep.	Ch-W	Streit	Rasm.	I-O C.	Centrality		Core/ Periphery	Clique	Densit
									IN	OUT			
Meat I.	-	L	SIP	-	II	L	I	2	M	M	P	N	O
Other food	-	L	SIP	-	IV	M	I	2	M	M	P	N	-
Agriculture	-	L	SIS*	S	II	L	IV	1	M	M	P	N	I/O
Farming	-	L	SIS	A/S	II	M	II	1	M	M	P	N	O
Milk I.	-	L	SIP*	S	III	M	I	2	L	M	P	N	O
Grain mill	-	L	EIS*	A/S	IV	M	IV	2	L	M	P	N	O
Beverages	-	L	SE*	-	IV	M	IV	2	M	L	P	N	I/O
Wood	-	L	PE*	A/S	II	M	I	4	M	M	C12	N	I
Hotels	P	L	EIP	A/S	IV	H	III	-	H	M	C4	N	-

According to the results summarised in tables 4.29 and 4.30 it is verified that there is a clear specialisation in the agro-food system in Andalusia while this is not the case for the Basque Country. In Andalusia, seven out of fourteen branches in the production system are among the ten first branches shown in table 4.4. In the Basque Country just one out of nine is included among the ten most important branches. Those are branches with low technology content, working in a highly closed system, as the region has high autonomy and self-sufficiency, both as intermediate seller and for its intermediate inputs.

Branches in this system are intensely linked with other branches,[176] although those links are especially strong in a backward sense (Chenery-Watanawe). That is, intermediate purchases have a high weight in those branches production, and therefore value added is low in their production processes. There are some differences between the two regions in this sense. In Andalusia there are also five branches with strong forward links and in the Basque Country there are four with low relationships in both senses. This is a system highly integrated in Andalusia while links are weaker in the Basque Country.

In both places those are branches with high diffusion effects in the whole economic system (Rasmussen) mainly through their indirect linkages. Although their direct relationships can be considered with a medium level (Streit), branches belonging to this system are highly interwoven in the system. There are some exceptions to this general

[176] They have been selected after imposing high threshold values.

situation: ‘hotels and restaurants’ and ‘trade’. Those two could be considered as key branches, not only from a descriptive and input-output coefficients view showing a differentiated behaviour with high direct linkages, but also attending to its dynamics and to the network results. The evolution of those two branches show an expansion trend intensified in purchases, while most of the system branches are in decline. Moreover they are highly central and participate in most of the production process, as shown in the clique overlapping information.

Nevertheless, there is a general situation of branches with a medium centrality level, working in the periphery of the system and mainly linked among them, without participating, directly, in other processes. The dynamic evolution of the coefficients show that the decline is intensified in purchases, in a system where just the main links act in a backward sense. That is, the most strong links (backward) are weakening. This idea is reinforced from the autonomy/self-sufficiency indicators, as inside intermediate purchases fall in the 1980-1995 period for all the branches with the only exception of ‘basic chemicals’ and ‘trade’. The strongest interlinks in the sector with higher presence in the regional productive structure show a process of import substitution.

There is high cohesion among the agro-food production system branches in both regions but not when considering their participation in the whole system. This can be proved from figures 4.1 and 4.2 and with the network indicators in tables 4.29 and 4.30 showing low overlapping (clique in the tables) and a periphery location (core/periphery in the tables). There are, nevertheless, as shown before, two exceptions to this general situation for the two branches that have been labelled as key (‘hotels’ and ‘trade’).

4.5.2.- Metal-mechanical production system

Tables 4.31 and 4.32 show the characterisation summary for the branches belonging to the *metal-mechanical production system* in the Basque Country and Andalusia.

Table 4.31: Branches characterisation in the metal-mechanical production system of the Basque Country

	10F	Tech.	Dynam.	Dep.	Ch-W	Streit	Rasm.	I-O C.	Centrality		Core/ Periphery	Clique	Densit
									IN	OUT			
Electricity	S	L	SIP	A/S	II	H	II	4	M	H	C7	Y	I
Construct.	S	L	EIS	A/S	II	H	II	4	H	H	C3	N	-
Metals	S/P	L	SIP	-	II(1)	H	II(2)	-	M	M	C10	N	O
Metal pr.	S/P	M	SIP	A/S	III(3)	M	I(4)	-	H	H	C10	Y	-
Machinery	-	M	SE*	S	III	M	I	-	M	L	P	N	I/O
Motor v.	P	M	PE	A/S	III	M	I	3	H	L	C12	N	I/O
NFM	-	L	SIS	-	IV	M	IV	-	M	M	C11	N	I
Trade	S/P	ICT	EIP	A/S	III(5)	H	III(6)	4	H	H	C1	Y	-
Gas and w.	-	L	EIS*	A/S	I(7)	M	III(8)	4	M	H	C8	Y	I

For an explanation of the indicators see note in table 4.29.
(1) The sub-branch 'foundries' is in group I.
(2) The sub-branch 'foundries' is in group IV.
(3) The sub-branch 'mechanical engineering' is in subgroup II.
(4) The sub-branches 'mechanical engineering' and 'other machinery' are in group II.
(5) The sub-branches 'recycling' and 'vehicles repairing and selling' are in group III, sub- branch 'retail trade' is in group IV.
(6) The sub-branches 'recycling' and 'vehicles repairing and selling' are in group I, sub-branch 'retail trade' is in group IV.
(7) The sub-branch 'water' is in group I.
(8) The sub-branch 'water' is in group III.

Table 4.32: Branches characterisation in the metal-mechanical production system of Andalusia

	10F	Tech.	Dynam.	Dep.	Ch-W	Streit	Rasm.	I-O C.	Centrality		Core/ Periphery	Clique	Densit
									IN	OUT			
Metals	-	L	SE*	A	IV	M	III	-	M	M	P	N	I/O
Motor v.	-	M	SE*	A	IV	M	IV	3	M	L	P	N	I
Forestry	-	L	PE*	A/S	I	M	IV	1	L	L	P	N	I
Wood	S	L	SIS	A	I(1)	M	IV(2)	-	H	M	C8	Y	-
Other man.	-	H	EIP*	-	IV	L	IV	4	L	M	P	N	I
Construct.	P	L	EIP	A/S	III(3)	H	I(4)	4	H	H	C3	Y	-

(1) The sub-branch ' wood and cork' is in group II and 'furniture' in group III.
(2) The sub-branches 'wood and cork' and 'furniture are in group I.
(3) The sub-branch 'buildings preparation, installation and finishing' is in group IV.
(4) The sub-branch 'buildings preparation, installation and finishing' is in group III.

Information in tables 4.31 and 4.32 verify that the Basque Country shows a high specialisation in the metal-mechanical system, where branches have a medium/low technology content. In Andalusia, this sector is not so developed and it is focused in low technology activities.

In general, this is a system that is highly embedded in the territory (self-sufficiency) even considering only intermediate transactions and knowing the great importance of their destination in final demand as investment, not considered in the used input-output data.

The low importance of this system in Andalusia can also be observed in the input-output coefficients, with most of the branches showing low backward, forward and indirect links (Chenery-Watanabe and Rasmussen). In the Basque Country, however, those are branches strongly linked through their productive processes (intermediate sales and purchases). Moreover, they have a high diffusion effect in the whole economic system, very embedded, although not because of their direct links (medium Streit coefficients).

More importantly in the Basque Country those are highly central branches, mainly according to their out links (*outdegree*). They are not just central and fundamental branches in their proper production system, as can be seen in figure 4.2 and in the density column, but also in the whole regional system. Most of them belong to the core of the system and participate in most of the other processes, as seen in the clique overlapping structure.

'Trade' in the Basque Country, again as in the case of the agro-food system in Andalusia, can be considered a key branch. It is among the ten first branches in the system, it is a branch in expansion, with a high Streit coefficient, high in and outdegree centrality, located in the core, and participating in the overlapping of most of the cliques.

From this analysis some more conclusions can be obtained when comparing the productive structure of Andalusia and the Basque Country. There are differences among the two structures that are observed only from the network analysis results and having important implications for a growth and regional development focus. The high productive specialisation in the agro-food system in Andalusia and in the metal-mechanical system in the Basque Country makes the structure of those systems essential in the evolution of the regions. And those structures show that in Andalusia the agro-food system has a high cohesion among its branches but not when considering its embeddedness in the whole system, with medium centrality, located in the periphery, and not participating in other cliques. In the Basque Country, however, the metal-mechanical system shows high centrality, it is in the core, and participates in most of the other processes overlapping in most of the cliques taking place in the net.

Although in the case of the agro-food system it can be deduced that it is a generally weakly embedded system, also in the other regions or the country, the implications for Andalusia are quite relevant as this is a region with a productive and economic structure focused on it.

This assertion will be taken up again in the next chapter where the two selected *production systems* will be complemented with relevant institutional information to treat them as *productive systems*. Once the new systems are obtained, a set of hypotheses, focused on the relationship between each region's technical and institutional interlinks and the territory growth and development, will be tested.

Annex 4.1: Whole branch names and corresponding abbreviations

Andalusia

(1) Agriculture ⇒ Agriculture

(2) Farming of animals and hunting ⇒ Farming and H.

(3) Forestry ⇒ Forestry

(4) Fishing ⇒ Fishing

(5) Mining and quarrying ⇒ Mining & quarrying

(6) Production and processing of coke, refined petroleum and radioactive materials and ores ⇒ Coke, P & RO

(7) Electric power ⇒ Electricity

(8) Gas and steam ⇒ Gas & steam

(9) Water ⇒ Water

(10) Ceramic products and building and construction materials ⇒ Ceramics & CM

(11) Cement, lime and plaster ⇒ Cement

(12) Manufacture of glass and stone ⇒ Glass & stone

(13) Manufacture of basic chemicals ⇒ B Chem.

(14) Manufacture of other chemical products ⇒ O Chem.

(15) Manufacture of basic metals and fabricated metal products ⇒ Metals

(16) Manufacture of wood, cork, metal products and furniture ⇒ Wood, cork & furniture

(17) Manufacture of machinery and equipment ⇒ Machinery

(18) Electrical goods ⇒ Electrical goods

(19) Manufacture of motor vehicles, trailers and semi-trailers ⇒ Motor vehicles

(20) Building and repairing of ships and boats ⇒ Ships

(21) Manufacture of other transport equipment ⇒ Other Tr. Eq.

(22) Oils and fats ⇒ Oils & fats

(23) Production, processing and preservation of meat ⇒ Meat Ind.

(24) Milk and dairy products ⇒ Milk Ind.

(25) Fish and vegetable preserves ⇒ Fish and vegetable Ind.

(26) Manufacture of other food products ⇒ Other food Ind.

(27) Spirits, ethyl alcohol and manufactured wines ⇒ Spirits, alcohol & wine

(28) Beers, malt, soft drinks and mineral waters ⇒ Beer & soft drinks

(29) Tobacco products ⇒ Tobacco

(30) Manufacture of textiles ⇒ Textiles

(31) Clothing and skin goods ⇒ Clothing & skins

(32) Leathers and footwear ⇒ Leathers and footwear

(33) Manufacture of paper and paper products ⇒ Paper

(34) Publishing, printing and reproduction of recorded media ⇒ P & P

(35) Manufacture of rubber and plastic products ⇒ Rubber & plastic

(36) Other manufacturing products ⇒ Other manufacturing

(37) Construction ⇒ Construction

(38) Recycling, repair of motor vehicles, wholesale and retail trade ⇒ R, R & trade

(39) Hotels and restaurants ⇒ Hotels and Rest.

(40) Transport via railways, other transport, supporting and auxiliary transport activities ⇒ Transports

(41) Post and telecommunications ⇒ Post. And telecom.

(42) Financial intermediation except insurance and pension funding ⇒ Financial Interm.

(43) Insurance and pension funding ⇒ Insurance

(44) Business services provided to enterprises, community, social and personal service activities ⇒ Business services & other Ac.

The Basque Country

(1) Agriculture ⇒ Agriculture

(2) Farming of animals, hunting and forestry ⇒ Farming, H. & Forestry

(3) Fishing and aquaculture ⇒ Fishing

(4) Mining and processing of coal and non-metal ores ⇒ Coal & NMO

(5) Mining and processing of coke, crude petroleum and natural gas ⇒ Coke, P & NG

(6) Electric power ⇒ Electricity

(7) Gas and water ⇒ Gas & water

(8) Mining and processing of metal ores ⇒ MO

(9) Manufacture of basic metals and fabricated metal products ⇒ Metals

(10) Non-ferrous metal ores and basic chemicals ⇒ NFM & BChem.

(11) Cement, lime and plaster ⇒ Cement

(12) Manufacture of glass and glass products ⇒ Glass

(13) Ceramic products and building and construction materials ⇒ Ceramics & CM

(14) Chemical products ⇒ Chemicals

(15) Metal products, domestic appliances, machinery, equipment and furniture ⇒ Metal products & Mach.

(16) Manufacture of machinery for metallurgy ⇒ Mach. For metallurgy

(17) Manufacture of office machinery, machinery, electrical goods, publishing and printing ⇒ Office machinery, P & P

(18) Manufacture of motor vehicles, trailers and semi-trailers ⇒ Motor vehicles

(19) Building and repairing of ships and boats ⇒ Ships

(20) Manufacture of other transport equipment ⇒ Other Tr. Eq.

(21) Production, processing and preservation of meat ⇒ Meat Ind.

(22) Milk and dairy products ⇒ Milk Ind.

(23) Fish preserves and other sea food ⇒ Fish Ind.

(24) Manufacture of grain mill products ⇒ Grain mill

(25) Fruit and vegetable preserves, oils and fats, starches, prepared animal feeds and manufacture of other food products ⇒ Other food Ind.

(26) Beverages ⇒ Beverages

(27) Tobacco products ⇒ Tobacco

(28) Textile, clothes, leathers, skins and footwear ⇒ Textile Ind. & footwear

(29) Manufacture of wood and cork ⇒ Wood and cork

(30) Manufacture of paper and paper products ⇒ Paper

(31) Manufacture of rubber products ⇒ Rubber

(32) Manufacture of plastic products ⇒ Plastic

(33) Other manufacturing products ⇒ Other manufacturing

(34) Construction ⇒ Construction

(35) Recycling, repair of motor vehicles, wholesale and retail trade ⇒ R, R & trade

(36) Hotels and restaurants ⇒ Hotels & Rest.

(37) Other land transport ⇒ Other land Tr.

(38) Transport via railways ⇒ Tr. railways

(39) Water and air transport ⇒ Water & air tr.

(40) Supporting and auxiliary transport activities ⇒ Auxiliary Tr.

(41) Post and telecommunications ⇒ Post and telecom.

(42) Financial intermediation except insurance ⇒ Financial Interm.

(43) Insurance ⇒ Insurance

(44) Business services provided to enterprises ⇒ Business services

(45) Health ⇒ Health

(46) Social, personal and community activities and social work ⇒ Social, personal & Com. Ac.

5. REGIONAL PRODUCTIVE SYSTEMS AND DEVELOPMENT PROCESSES

5.1. Introduction

The economic literature that focuses on the analysis of the processes of development and growth is very wide, attempting to account, among other themes, for the causes explaining the persistence of different development levels between countries and even regions within the same country.[177] Among the main references are Krugman, 1995; Porter, 1996; Storper, 1997; Amin, 1999 and Barro and Sala i Martín, 1999. Numerous works study the possibility of convergence as the regional dynamic towards *per capita* income approximation, and its explanation. According to those studies the main explanatory factors for convergence are decreasing capital returns, technological catching-up, migratory movements and inter-sectoral reallocation of productive factors. Some Spanish analyses in this respect are Dolado *et al*, 1993; Mas *et al*, 1994 and García Milá and Marimon, 1999.[178]

This research attempts to highlight the matter of the existence and persistence of development differences among regions in developed countries, but through a *structural analysis*. That is, studying the relational structures linking selected components of the regional economic systems, instead of analysing the main components of the systems. This has already been done partially in the previous chapter, where only technical links were considered. The deduced *regional production systems* and their main characteristics implied an initial vision of regional differences and allowed for some development explanations. The analysis will continue in this chapter, focusing on the regional development differences attending to structural changes, instead of studying the components mentioned above which are generally considered structural, and instead of analysing the possibility of convergence. This analysis is also regional, while most of the works studying growth and development differences have a national focus,

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[177] According to Florax *et al* (2002, p.1), making a review of the empirical economic growth literature: "the empirics are geared towards determining the significance of institutions, catch-up and convergence, and knowledge accumulation for economic growth differentials".

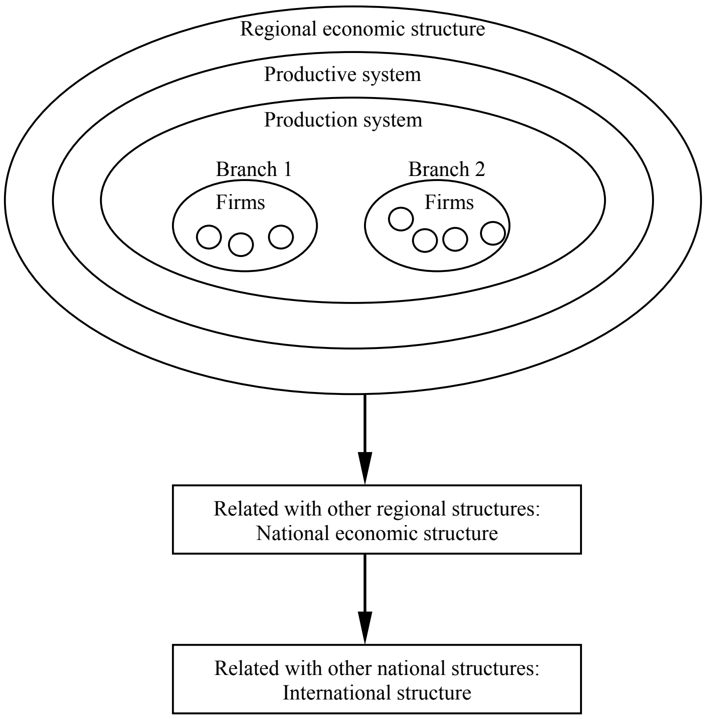
[178] Some other basic references for regional growth and development theory are Hirschman (1958), Arrow (1962), Romer (1994) and Nelson (1995).

forgetting the important differences taking place among regions belonging to the same country (Porter, 2003).

In order to do this a literature review is offered in section 5.2, considering the relevant research studying structural factors affecting efficiency, growth and development. Then, the empirical work focused in Andalusia and the Basque Country will be continued using additional, non-technical, information to transform the *production systems* into *productive systems*, as explained in chapter 2. The study of those, more complex, systems will be helpful for a better understanding of regional development differences. This will be done by presenting a set of hypotheses that will be tested by mechanism causality.

The set of hypotheses to be tested is established at the macro level (production structure and productive systems). Following mechanism causality it will be shown that there is an underlying structure at micro level (firm and institutional), generating the macro situation. Branches, at the same time, are making the production and productive systems at an intermediate level, and these in turn exist in the global complex regional structure of a national and international system, as shown in figure 5.1.

Figure 5.1: Micro and macro levels and structures



Inside relations, that is, considering only the intra-regional links, allows for a deep knowledge of the regional systems according to their specialisation, historical productive characteristics, labour skills and institutions. The study of *productive systems*, considering their relationships and changes, should be focused on technical and also on non-technical relations, regional specialisation and technological progress. Among the non-technical explanations the effect of social capital, understood in a wide sense, is the engine maintaining and embedding the *productive system* in the regional economic structure.

5.2. Review of the relevant literature to study development processes from a structural view: social capital and development

There are several research works explaining, theoretically and also empirically, development processes and development differences following a structural view. Those works focus on the relational aspects of regional and national structures, considering their non-technical aspects and the role of social capital as a whole or the role of its most relevant aspects.

There are books dedicated completely to the contribution of social capital to economic growth and development, with the contribution of several researchers, such as the works edited by the following authors: Evans (1997), Dasgupta and Serageldin (1999), Helliwell (2001) and Ramaswamy *et al* (2002). In all of them one of the analysed subjects is how to measure social capital in order to relate it with economic growth and development. This theme appears recurrently because the social capital concept is very complex and therefore it is very difficult to measure it. Putnam (2002) defines it as social networks and the norms of reciprocity associated with them, and asserts that it varies systematically across time and space. The author also establishes that it can be classified as formal or informal, thick or thin (according to the 'weak tie' concept), inward looking or outward looking (the first tends to promote interests of their own members) and bridging or bonding (depending on whether it brings together people who are like or unlike one another). Therefore, it is very difficult to measure it if all those aspects and its continuous change character have to be considered. Nevertheless, complex indices can be built as in Putnam (2001), where a social capital index made of thirteen different variables related to formal membership, participation in many different forms of informal networks, trust and altruism is proposed.

It can then be deduced that the research should focus on particular areas, and then regional quantitative and qualitative information, surveys and questionnaires should be used to consider several social capital aspects (Putnam, 1995; Hjøllund and Svendsen, 2000 and Norris, 2003). However, there are several research works comparing country values and generally using trust as a social capital proxy, even knowing that this is a partial social capital aspect or considering that it is not a social capital component but a consequence of it (Nielsen, 2000; Woolcock, 2001; Carter and Castillo, 2002). The World Values Survey (WVS) measures trust as the percentage of respondents in each nation replying "most people can be trusted", with a mean value of 35.8 in 1991. Some national data are in table 5.1.[179]

Table 5.1: Trust by countries

Countries	Trust	Countries	Trust
Norway (96)	65.3	Austria (90)	31.8
Sweden (96)	59.7	UK (96)	31.0
Denmark (90)	57.7	Korea (96)	30.3
Netherlands (90)	55.8	Czech Republic (90)	30.3
Canada (90)	52.4	Spain (96)	29.8
Finland (96)	47.6	Mexico (96)	28.1
Ireland (90)	47.4	Hungary (90)	24.6
Japan (96)	46.0	France (90)	22.8
Iceland (90)	43.6	Chile (96)	21.9
Germany (96)	41.8	Portugal (90)	21.4
Switzerland (96)	41.0	Nigeria (96)	19.2
Australia (96)	39.9	South Africa (96)	18.2
India (96)	37.9	Argentina (96)	17.5
US (96)	35.6	Turkey (96)	6.5
Italy (90)	35.3	Brazil (96)	2.8
Belgium (90)	33.2		

Note: Values in brackets refer to the year in which the WVS collected the trust data.
Source: OECD (2001)

[179] The survey also offers some regional data that will be discussed, in the cases of Andalusia and the Basque Country, in the hypotheses testing section.

Table 5.1 shows that Scandinavian countries are on the top of the ranking for trust values. It can be also deduced from the available data that more developed countries usually show higher trust values than less developed countries. In every case the moment in which the data have been collected is crucial, and also the inclusion in table 5.1 of values corresponding to a six years gap should be taken into account, because in that period important socio political changes have taken place. Therefore, there are clear differences when comparing the values at different moments. In this sense, it should be mentioned that from the comparison of the data in table 5.1 with the data offered in Knack and Keefer (1997) corresponding to years 1980 and 1990, depending on the country, there are significant cases to be remarked. The most noteworthy cases increasing their trust levels are Germany (from 29.8 to 41.8), Italy (from 26.3 to 35.3) and Mexico (from 17.7 to 28.1). The remarking cases reducing their trust are South Africa (from 30.5 to 18.2), Australia (from 47.8 to 39.9), USA (from 45.4 to 35.6) and Argentina (from 27.0 to 17.5).

Although it is generally used, the WVS trust measure presents serious methodological problems. First of all, because it attempts to summarise, in a single aggregated value, the social capital of a country: "It is even less clear in the case of social capital than it was in the debate of the two Cambridges about physical capital that we can simply "ad up" all these different forms to produce a single, sensible summary of the social capital in a given community; much less an entire nation…Because social capital is multidimensional, and some of those dimensions themselves are subject to different understandings, we must take care not to frame questions about change solely in terms of more social capital or less social capital. Rather, we must describe the changes in qualitative terms. For example, within a given country one could imagine that the stock of social capital has become more formal but less bridging, more bridging but less intensive, or more intensive but less public-regarding" (Putnam, 2002, pp. 12, 18).

But even more problematic is the use of the question referred in the WVS to measure trust as a social capital proxy. Glaeser *et al* (2000) argues that the WVS question is vague, abstract and hard to interpret and therefore variation in responses might arise for numerous reasons.[180] Casson and Della Giusta (2003), after collecting social capital information in Mexico through interviews, conclude that their data confirmed the need to approach generalised trust measurements with scepticism as they test that context matters when analysing trust. Woolcock (2001) asserts that the application of social capital to economic growth analyses should be done by integrating quantitative and qualitative research strategies into the design of comprehensive new instruments, or at least by taking the central ideas underlying the social capital perspective to apply them in innovative ways, instead of simply using ‘trust’ as a proxy to be entered into macroeconomic growth regressions. Fukuyama (2000) also emphasises the too general character of the WVS question to measure trust, leading respondents to vary their answers depending on the way the question is phrased by the person who is asking; moreover, there is the problem of the absence of consistent data for many countries and periods. The criticism of Carter and Castillo (2002) follows the Fukuyama argument, defending the study of social capital by focusing on small group interactions, mainly because it is not possible to know which aspect of trust is being uncovered with the WVS question. Gibson (2001) analyses social capital in Russia, measuring it directly with interviews and comparing the results with the WVS values, obtaining different results and concluding that they do not rely on that single measure of the social capital concept, and also stressing the necessity of distinguishing among various forms of trust, like between people and institutions.

For this reason there are numerous researchers building their own social capital indices, as it is the case of Grootaert (1999), Krishna and Uphoff (1999), Yli-Renko *et al* (1999), Arrighetti *et al* (2001), and Bjørnskov and Svendsen (2003). Moreover, Ahn and Hemmings (2000) refers to Barro (1991) using political violence frequencies as a

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[180] Among those reasons the authors describe the following: differences in beliefs about the trustworthiness of a common set of people, differences in interpretation of who comprises “most people”, differences in interpretation of what it means to be able to trust someone; differences in the ability to elicit trustworthy behaviour from other people, or even some respondents might be not willing to answer truthfully when asked such a question on a survey.

government social capital variable to correlate it with growth and private investment and Grootaert (1998) enumerates several social capital indicators. Even there are works, like Glaeser *et al* (2000), measuring trust through experiments with volunteers.

Knack and Keefer (1997, p. 1256) use the WVS trust values to relate them with economic growth, but even they assert: "This trust item is somewhat ambiguous with respect to which "people" is general enough that responses should not merely reflect expectations about the behaviour of friends and family". For this reason they decide to use another complementary variable: the strength of norms of civic co-operation.

Knack and Keefer (1997) is among the several works relating social capital and growth using the WVS trust data to find a positive relation between trust and growth. However, while their results are clear for low-income countries, they are not so evident for the analysed OECD countries. In low-income countries trust is assumed to operate as a substitute for formal institutions. "Trust's relationships to growth in our study is specially large in poorer countries, which may be attributable to their less well-developed financial sectors, insecure property rights, and unreliable enforceability of contracts. Interpersonal trust seems to be more important in facilitating economic activity where formal substitutes are unavailable" (Knack and Keefer, 1997, p. 1284). The analysis was made again in Zak and Knack (2001) including more countries (forty one countries), obtaining more robust econometric results and concluding that there is a positive relationship between trust and growth:[181] "Trust is higher in more ethnically, socially, and economically homogeneous societies, and where legal and social mechanisms for constraining opportunism are better developed, with high-trust societies exhibiting higher rates of investment and growth" (Zak and Knack, 2001, p. 297).

Among the research showing a positive link between trust, used as a social capital proxy, and growth, measured as GDP *per capita*, there is Inglehart and Baker (2000), where the application is made for sixty five countries, Moesen *et al* (2000) and Whiteley (2000), for thirty four countries. In this last case the effect works directly and indirectly by interacting in positive terms with human capital, physical investment and

[181] According to Beugelsdijk *et al* (2003) the improvement in robustness is caused by the inclusion of countries with relatively low scores on trust, most notably the Phillipines and Peru.

catch-up. Uslaner (2003) analyses forty one countries to conclude that trust leads to greater prosperity as it is positively related to an open economy index, a foreign policy globalization index, the internet users as share of population, the real growth rate, the education spending per capita, the transfer spending per capita, a polity democracy score and post materialist values, while it is negatively related to the Gini index of income inequality and a corruption index.

Among the few works finding a negative impact of social capital on economic results there are Helliwell (1996) and Beugelsdijk and van Schaik (2001). While the first study mentioned shows a negative relationship between trust and productivity growth in seventeen OECD countries, the second asserts that social capital, in terms of trust, is not related to economic growth for the fifty four analysed European regions, while social capital in terms of active group membership contributes to regional economic growth in Europe. For the authors, the different results obtained compared with Knack and Keefer (1997) are owing to a sample selection bias, however Zack and Keefer (2001) replicated the results with a wider sample and obtaining even more robust conclusions.

In general terms, the results are clear for low-income countries while discrepancies can appear for high-income countries when trying to relate trust and economic growth. The relation between development and trust is evident for the whole set of countries. Knack and Keefer (1997) argue a positive link between trust and civic norms, as social capital proxies, and innovation, human capital and public institutions. They assert that social capital has a clear positive impact on innovation because it helps in the flow of tacit knowledge and embodied technology. The positive link with human capital comes from the tested positive relation between trust and education, measured with the number of people studying at different levels. They also assert that there is a strong negative correlation between trust and economic inequality, measured with the Gini index. For them, another important factor for trust is the country formal institutional structure. They even assert that ethnic and linguistic cohesion are positively related to the social capital measures. Similarly, Helliwell and Putnam (1995) reason that Italian regions with a more developed civic community have experienced higher growth rates in the period 1950-1990. Moreover, Putnam (1993) attributes the economic success and government efficiency of regions in the north of Italy mainly to their richer associative life. For him social capital can influence growth via its impacts on the quality of regional government as well as directly by influencing the performance of firms. The author concludes that this deduction can be generalised to other countries. Even the different chapters in the wide Helliwell (2001) research, La Porta *et al* (1997) and Knack (2001) show the positive link between social capital and education, income equality and investment.

The trust WVS values of seventeen developed countries are also used in Newton and Norris (2000) to test that trust leads to effective social and political institutions. In the analysis of six countries made by Osberg and Sharpe (2000) the impact of social capital is clear on well-being, measured with an index including information about consumption flows, wealth stocks, equality and economic security: "even if social capital had zero impact on per capita GDP, and instead only served to decrease the extent of economic inequality, poverty and insecurity, it would be valuable for economic well-being" (Osberg and Sharpe, 2000, p. 32).

De Clerq (2003) also uses the WVS information to show a positive effect of trust and of associational activity on innovation when applied to a sample of fifty nine countries. In La Porta (2000) the effect of trust on several performance indicators, including GDP *per capita*, GDP growth and inflation, efficiency of the judiciary, corruption, bureaucratic quality, tax compliance, quality and adequacy of infrastructure, is significant and large.

Bjørnskov and Svendsen (2003) use several indicators of social capital (economic freedom,[182] corruption index, generalised trust and civic participation) to show remarkable differences among countries. The authors obtain clusters of countries with different levels of social capital, where the northern European clusters scores about double as much as southern Europe. Among all Switzerland has the highest social capital level, followed by a group made by Netherlands, Denmark, Sweden and Norway, a third group would be made of Finland and Iceland is in a fourth place.

[182] It includes political rights and civil liberties by country.

There are also studies analysing the economic effects of social capital from a micro perspective, in the case of Yli-Renko *et al* (1999) for United Kingdom, in Tsai (2000) for a set of multinationals, in Landry *et al* (2001) for Montreal, in Burt *et al* (2000) for France and USA, in Krishna and Uphoff (1999) for India, in Grootaert (1999) for Indonesia, Evans (1997) analyses India, Mexico, Russia, South Korea and Brazil, Carter and Castillo (2002) for South Africa and Narayan and Pritchett (1998) for Tanzania. All of them show positive economic effects of social capital, in expenditure, livelihood or welfare of households, in development, or in competitive advantages of firms through resources exchanges and learning.

Moreover, Putnam (2001) applies a social capital index including thirteen different social capital aspects to the American States, showing a clear positive effect of the index on education, child welfare, health, tolerance, income equality and civic equality. The analysis also shows clear negative impacts of social capital on TV watching, murder rates, pugnacious behaviour and tax evasion. Therefore, it can be concluded that, for the analysed states, there is a positive effect of social capital on development.

For the authors referred to until now, the relationship between trust and economic growth was clear for low-income countries and quite clear in general. At the same time, the relationship between trust and the country's institutional structure is evident in any case and the relation between groups' membership and economic growth was tested for the European regions. For most of the authors there is also a positive relation between trust, civic norms and group membership, social capital indicators, and education, income equality and investment. Therefore, arguing a positive relationship between social capital and development.[183]

Among the arguments explaining the positive effects of a social capital based on trust relationships is that trust avoids opportunism. At a firm level, Ouchi (1980), Williamson (1983) and Bolton *et al* (1994) explain that opportunistic behaviour, considered a source of market failure, leads to a change from market relationships (outsourcing) to hierarchy or bureaucracy (internalisation). That organisational change attenuates opportunism,

[183] The World Bank also dedicates resources to study social capital in poor countries, trying to enhance it as a development initiative. 'Social capital for development': http://www.worldbank.org/poverty/scapital.

because the new productive parties belong to a common organisation and internal control and auditing are more effective. Trust, as opposed to opportunism, is necessary for a proper functioning of outsourcing (externalisation process), otherwise productive tasks that could be more effectively outsourced, are internalised by the firm, assuming the efficiency costs derived from this decision. The externalisation process, therefore, depends on trust, to a different degree according to the outsourced task.

Ouchi (1980) and Bolton *et al* (1994) also assert that relational contracting and clan,[184] as an alternative to markets and bureaucracies, are superior organisational systems. The clan system works under the normative requirements of reciprocity, legitimate authority and common values and beliefs and the informational requirement of traditions. Thus, actors in the clan believe that individual interests can be reached when all of them are embedded into a general interest. Diverse social mechanisms reduce differences between individual and organisational targets, generating a strong community sense. Opportunism is quite unlikely and equity can be reached with relatively low transaction costs. According to the authors, this system is more typical in technologically advanced productive sectors or firms, where team-work is usual, technological change is continuous and individual results are ambiguous. This system avoids opportunism and therefore monitoring and auditing. Moreover, it is helpful for information and innovation diffusion and for the adaptation to continuous market changes. Nevertheless, a particular working tradition and a business culture are necessary for a proper functioning of the system, which are formed through experience over time.

A similar argument is defended in Dasgupta (2003), arguing that horizontal networks allows for better flows, avoids opportunism and encourage reciprocity norms. Also Putnam (1993) stresses that dense networks of interactions reduce incentives for opportunism and malfeasance. The reduction in transaction costs appears as the main explanation for social capital stimulating growth in Skidmore (2000), Bjørnskov and Svendsen (2003) and Uslaner (2003). For them, trust (general and institutional), reciprocity and collective action generate this reduction in the costs. Fukuyama (2000,

[184] Relational contracting is an intermediate form of governance between market and vertical integration. It can be also understood as an inter-firm network (Thorelli, 1986), where outsourcing is common with durable trade relationships among firms based on trust.

p. 4): "The economic function of social capital is to reduce the transaction costs associated with formal coordination mechanisms like contracts, hierarchies, bureaucratic rules, and the like".

Putnam (2002) explains the positive effect of social capital in efficiency, through collective action enhancing trust, through embeddedness avoiding opportunism and with trust facilitating reciprocity. For the author, the main driving forces of social capital are technological innovation and entrepreneur culture. Therefore, an adequate social capital of high quality will have a positive impact on development: "Studies from Tanzania to Sri Lanka have found that economic development under some circumstances can be boosted by adequate stocks of social capital". (Putnam, 2002, p. 6). In that situation, the role of organisations with a particular structure, like clan and relational contracting or horizontal networks, and of particular environments motivating a particular working tradition and a business culture, is crucial for the implied firms, as this will enhance their efficiency and for the whole system.

Therefore, one of the strategies for firms to increase their efficiency is to take advantage of their relationships, at an internal level and also considering their links with other firms and institutions. They look for trust links with all the agents taking part, in all possible forms, in their productive processes. This is the reason why there are business service firms whose product is the identification of their customers' social capital. They claim that a complete knowledge of firms' relationships would have a positive impact in their efficiency and benefits. Some examples of those service firms are Cakehouse, Ecademy, Humax, INWYK, Linkedin, Orgnet, Ryze, Typaldos Consulting and Visiblepath.[185] These mentioned firms emphasize the role of networking and trust for the firm's results and for personal success at work. There are also publications offering wider information about those kinds of firms, such as Network Moves (The Monthly Newsletter for Business Networking & Opportunities).[186]

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[185] Detailed information about those firms can be found in their web pages: www.cakehouse.co.uk, www.ecademy.com, www.humax.net, www.itsnotwhatyouknow.com, www.linkedin.com, www.orgnet.com, www.ryze.com, www.typaldos.com and www.visiblepath.com.

[186] This is an online publication available at www.networkmoves.com.

The positive impact of social capital, trust and co-ordination relationships has also been analysed in particular contexts with study cases. In that sense, there are different analyses focused on regions belonging to different countries, studying their regional productive structures and their relationship with the area development and growth. This is the case of Maillat and Grosjean (1999), analysing the Mittelland area in Switzerland. The authors identified six territorial production systems according to the area specialisation. The main conclusion of this study is that some of the systems, mainly based on machine-tooling, automation, watch-making and micro-technical, had a strong milieu effect attained by outsourcing and long term links with other regional firms,[187] research and training institutions while for other systems this was not the case. For the authors the systems with milieu effects are the ones pushing an endogenous development process in the area. Moreover, the systems encouraged by milieus come about as a result of learning processes changing over time.

Even more evident are the cases of Baden-Württemberg (Germany) and Emilia-Romagna (Italy) where the keys of their regional development, although with obvious differences among both places,[188] are the structure of intimately linked firms, the networks of co-operation and subcontractors and the dense infrastructure of institutions supporting innovation and information transfer, financing, advising and training. Moreover, the long existence of mutual trust relationships has helped for the creation and maintenance of highly efficient networks and institutions. Cooke and Morgan (2000) also compares the situation of Emilia-Romagna with Calabria, a less developed region in the south of Italy that used to be more developed than the 'industrial districts' northern area in the nineteenth century and at the beginning of twentieth century. The main implication is that the existence of a co-operative system, localised learning and trust formation taking place in a particular culture context had clear advantages for

[187] The authors define 'milieu' as "a territorialised entity ruled by norms, rules, values which are so many guidelines for the behaviour of the players and the relations between them" Maillat and Grosjean (1999, p.3). The milieu is based in 'cohesion' and is made of five basic aspects: 1) spatial entity, 2) group of players, 3) specific material elements, 4) organisational logic and 5) learning logic.

[188] Baden-Württemberg economy is based on 'mittelstands' that are groups of SMEs linked to large firms through supply chains and with some degree of lateral networking with other small firms. Emilia-Romagna structure is based on 'industrial districts' made of small firms making networks of co-operation and based on competing subcontractors.

growth and development. There are also other important factors affecting this situation, like the different location of both regions.

Another relevant case study refers to Wales, UK (Cooke and Morgan, 2000), whose dynamism and development are not at the level of Baden-Würtemberg or Emilia-Romagna. Wales' economy, although the embeddedness of its institutions is more evident than in the rest of UK, is based on the public sector with a lack of private institutions supporting businesses. However, while the Welsh Development Agency (WDA) was until recently the only institution offering the services that firms required, it has realised that this was not the most efficient strategy. Now, the agency is playing the role of *animateur*, enhancing the creation of other institutions where trust and reciprocity are the keys for their successful collaboration.

Moreover, instead of small and medium firm networks, large multinationals branch plants dominate the productive system in Wales. Therefore, the regional economic growth is mainly based on Foreign Direct Investment, instead of in endogenous development. Nevertheless, there is a process for the creation of firm networks and of regional institutions that have already shown positive effects in efficiency and productivity. "In contrast to classical British regional policy, the RTP [Regional Technology Plan] is designed to stimulate a collective learning process among the key regional players –the regional state, private firms, public agencies, social partners, and a wide array of intermediary organizations spanning education, training, and technology transfer. Equally important, the RTP exercise is predicated on the notion that the initial impetus for regional renewal must come from within the region and that this turns on the region's networking capacity, that is, the disposition to collaborate to achieve mutually beneficial ends" Morgan (1997, p. 153). Among the development regional strategies are the creation of regional supply chains for the sharing of expertise, the creation of public agencies diffusing innovation and enhancing trust, the creation of horizontal sectoral networks, and the promotion of collaborative training programmes.

When adoption of innovations is considered, the regional system shows its lack of dynamism: "On the SME front, most firms in Wales do not perceive 'innovation' as a strategic priority and, when they do engage in product or process innovation, it is often due to customer pressure. For most SMEs, the main source of innovative ideas is the supply chain, while the biggest barriers to innovation are lack of available finance and inadequate technical expertise" (Henderson, 1995).[189]

Public help generally tries to cover the lack of finance, although this does not mean that through financing there is a positive link, acting as one more factor for regional development. Cappellin and Batey (1993, p. 112), studying the situation of European lagging regions, assert: "However, regional authorities and entrepreneurial organisations are currently undergoing conflictual relationships. The entrepreneurs are often looking for financial support from regional authorities but they refuse to share the management and the follow-up of the cooperation projects".

All the cases mentioned have a clear specialised productive structure, although more concentrated in some cases. The Mittelland area is specialised in machinery, vehicles, metallurgy, electronics, optical engineering and jewellery. Baden-Württemberg focuses its productive structure in automotive, electronic and machine-tool.[190] Emilia-Romagna focuses in knitwear, ceramics and automotive engineering; Wales was historically specialised in coal and steel industries although now most of the firms work for multinational branches, such as for Sony, Ford, Nissan or General Electric.

There are other cases showing that regional development and dynamism depend on endogenous growth, with co-operation and trust links leading to efficient institutions, outsourcing and firms efficiency, although at different levels. Some of those cases, each with a particular situation but all showing the importance of specialisation, social capital and outsourcing, are the following:

- Avey Valley in Portugal (Garofoli, 1992), specialised in textile, clothing and shoes, is a clear example of intense subcontracting relations leading to the introduction of new technologies and high productivity.
- Garofoli (1992) has also studied several Greek regions showing the positive effects of subcontracting: Kastoria, specialised in agriculture, tobacco and cigarette

[189] Taken from Cooke and Morgan (2000, p. 150).

[190] This is an area with big firms as Mercedes-Benz, Bosch, DASA, Daimler and Porsche although generally maintaining the same business culture as the SMEs.

factories; Mesolóngion-Agrinion, focused on fur processing and Nàxos depending on agriculture and tourism. Nevertheless, in those Greek areas social capital is still based on informal low quality links, limiting the path towards a regional productive system that could enhance an endogenous and long-term development process.

- North Doubs (small subcontracting business depending on the Peugeot plant), Besançon (clock industry), Haut-Doubs (wood, farm, food products and micro-technology), Savoy (aluminium, steel, metal work, composite materials, electronics and farm and food products) and Upper Savoy (clock-making and mechanical engineering sub-contractors) in France have been studied in Garofoli, 1992. They are examples of different degree cases showing the positive effects of outsourcing based on trust and long term links, and the necessity of enhancing relationships with customers for the adaptation to technological changes, with training centres and with other firms through collective actions for innovations, technology and knowledge transfers. The systems that appear following that strategy are named 'new production areas' or 'local open systems'. All the measures trying to build 'local open systems' came from public programmes making it possible to develop a technological environment, an atmosphere for business creation, training for skilled labour force and support for small business in high technological sectors.

- Sillicon Valley (USA) is probably the best known case of economic growth based on firms and institutions networks. Although firms in the Valley trade with the whole world, the core of knowledge and production remains local. Among the business institutions acting in the valley are firm incubators. "One way the Valley accomplishes this recombination of knowledge and capital is through spin-offs, which have contributed to the construction of dense social networks of entrepreneurs, inventors, and other institutional actors" Castilla *et al* (2000, p. 223). Networks inside and among firms are based on relationships without social distinctions. They depend on a particular institutional configuration made of financial, commercial and legal institutions and of strong links with the University. According to the authors mentioned, only some regions have the proper institutional infrastructure to support such elaborate networks (Route 128 in Boston, 'third Italy' in Emilia-Romagna) and each have its peculiarities impeding their translation to other places and implying different results: different networks are associated to different kinds of outcomes. “It is our view that these intersectoral flows are what make Silicon Valley unique, and that in the history of the world’s economy, the ability to leverage value by shifting resources among previously separated sectors has always provided a vital edge for regions able to do so”, Castilla *et al* (2000, p. 245).

Other places have been studied to emphasise the importance of their structural links and social capital. This is the case of The Golden Triangle in North Carolina, Silicon Fen in Cambridge, England (Dasgupta, 2003), Route 128 in USA (Saxenian, 1994). Also the positive impact of program funded enhancing social capital in Denamrk, Ireland and Wales has been analysed in Cooke and Wills (1999).

All the information offered in this review section will be used in section 5.4, once the relevant productive systems for the two selected regions have been studied, to propose a set of hypotheses that will be tested with direct observations from Andalusia and the Basque Country and making use of other regional information. Nevertheless, the review made in this section will also serve for a stronger corroboration of the hypotheses.

5.3. Regional productive systems

For the selected regions, Andalusia and the Basque Country, the two systems identified in the previous chapter, agro-food and metal-mechanical are going to be analysed in this section. First, they will be shown graphically considering their main components. In that way the comparison of both regional productive systems is clearer. Nevertheless, the main subcomponents will be also illustrated for a better understanding of each system’s complexity.

5.3.1.- The Basque Country

In the Basque Country the metal-mechanical productive system is wider and more complex than the agro-food system, according to the regional specialisation. Although the systems are similar when considering their main components, once they are decomposed to know their institutions the agro-food system is narrower and simpler than the metal-mechanical system. Nevertheless, in general terms *regional productive systems* in the Basque Country show great density and complexity as there is a significant number of institutions working in its productive structure.

5.3.1.1.- Metal-mechanical productive system

Figure 5.2 schematises the Basque *metal-mechanical productive system*. The main institutional groups in the region linked to the production system are represented. Some of those groups are quite complex and therefore they are also schematised considering their components. The relatively less relevant groups have also been described in annex 5.1.

The sector production system, as deduced in the previous chapter, is at the core of the new system. Then, the main institutional groups related to the firms making the production system are added to it. In that case, eight new components appear and the arrows, with double direction connectivity, show the links that usually take place among the components.

Figure 5.2: Basque metal-mechanical productive system[191]

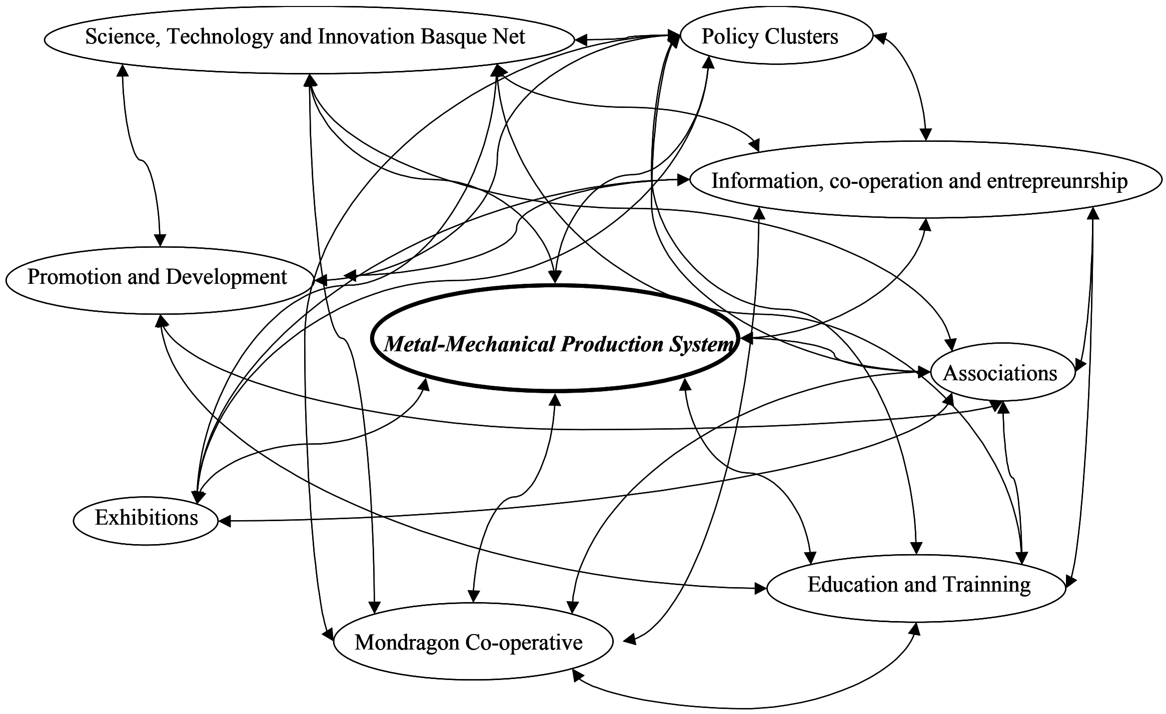

Figure 5.2 and the following figures (corresponding to the selected regional productive systems) represent the underlying relational structure that constitutes the base of the system social capital. As was discussed in chapter 2, section 2.4, social capital corresponds to the relational structure of the network, and therefore to networks and norms that facilitate co-ordination and co-operation for the actors' mutual benefit. The figure above (Basque metal-mechanical productive system) represents a network showing a particular relational structure, which includes a set of norms and values and facilitates co-ordination and co-operation. Moreover, tacit knowledge, skills and organisational culture are among the most important factors that flow, in a different form, in the two analysed regions. In the particular case of the Basque Country, the structure of its productive system, shaping its social capital, generally facilitates those flows in an efficient way. All this will be discussed in detail in the hypotheses testing section.

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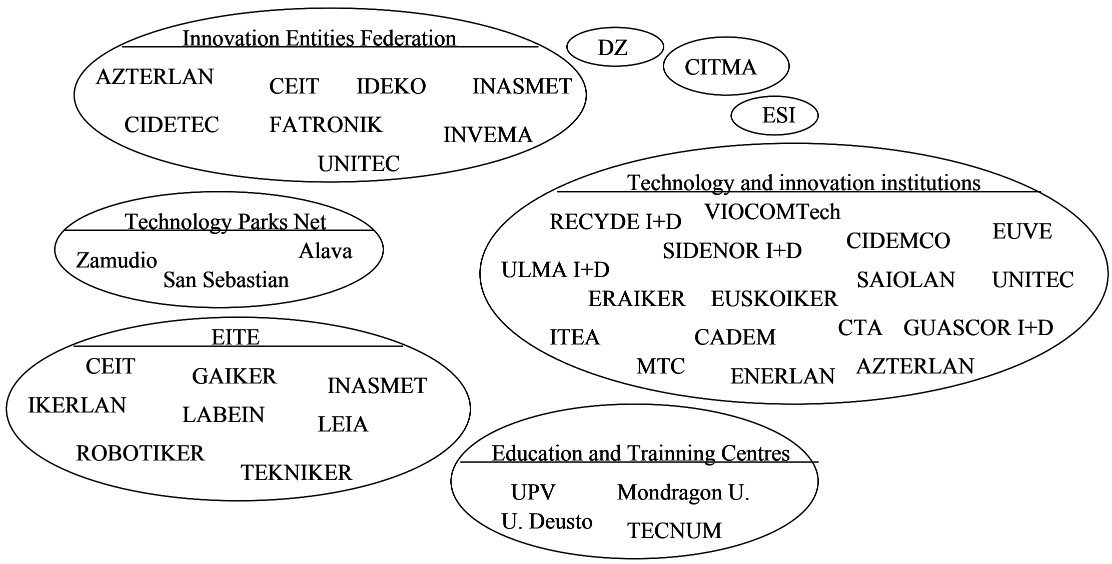
[191] The source of this and the following figures is own elaboration based on fieldwork.

The most important component in the system is the 'science, technology and innovation Basque net' (SARETEK), including most of the institutions with a relevant role in the regional innovation creation and diffusion. It is a private association without lucrative objectives created in 1997 by the Basque regional government. Its main objective was to concentrate all, public and private efforts to enhance science, technology and innovation incorporation. This would lead to an improvement in competitiveness and in the regional economic and social development. According to its president, SARETEK represents the scientific, technological and innovator Basque institutions, enhances its associates relationships, facilitates the links among its members and the public science and technology policy representatives and integrates the science-technology-firm-society system in the Basque Country. The structure of SARETEK is shown in figure 5.3.

***Figure 5.3: Science, technology and innovation Basque net (SARETEK)*[192]**



One of the main components in SARETEK, and also in the Basque productive system, is the Technology Parks Net linking three technology parks, one in each province, with a common general director. Most of the innovation and technology institutions, consitituting a significant number of participant institutions in the regional productive

[192] The meaning of the institutions acronyms is shown in annex 5.5

structure, are located in the parks, some of them are specialised in particular sectors, mainly related with machines and tools. Most of the relevant centres in the region are associated, as it is the case of EITE (Basque association of technology innovation centres), to increase their co-ordination and take advantage of it.

Another key component in the Basque productive system is the Mondragon co-operative corporation, founded in 1956. It has been widely studied (Kasmir, 1996; Lutz, 1997) as it is a unique case in Europe made of a large number of firms (150 firms and 60,558 workers at present), a significant number of them working in a co-operative regime, being part, with training and research centres, of a co-operative group.

This is a characteristic instituion in the Basque Country, showing in practical terms some of the peculiarities of Basque entrepreneurs and Basque firm's culture. Its structure, including training, research centres and firm groups is represented in figure 5.4.

Figure 5.4: Mondragon co-operative corporation

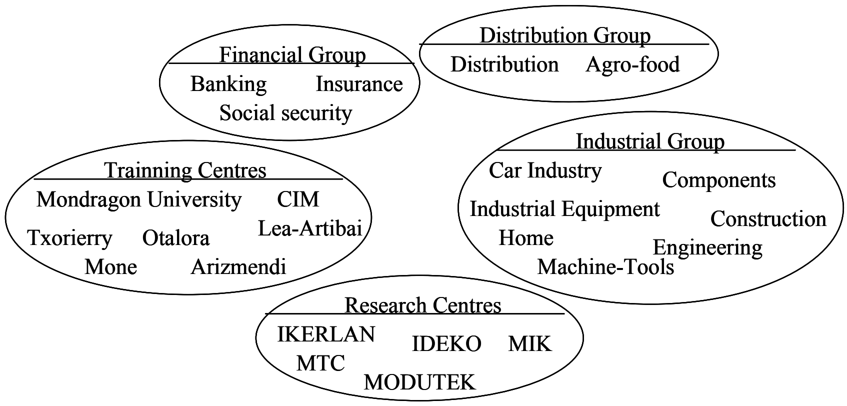
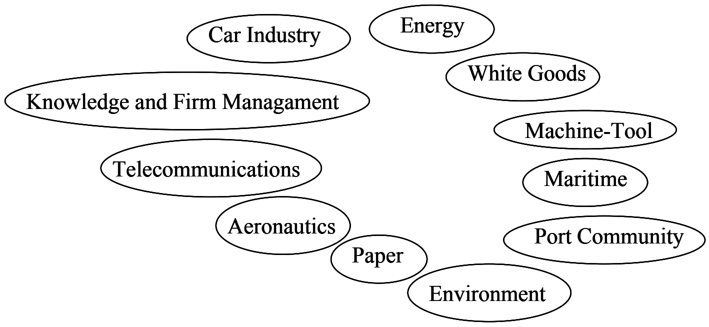


Figure 5.5 shows, graphically, a policy instrument created by the Basque government in 1993 to push the growth and development regional process. The intention was to create sector clusters made of firms, technology, innovation and training specific centres, associations and all the main institutions related to each selected sector, that could help its efficiency and growth. The eleven clusters, all of them directly related with the branches making the metal-mechanical production system, are represented in figure 5.5.

Figure 5.5: Basque policy clusters

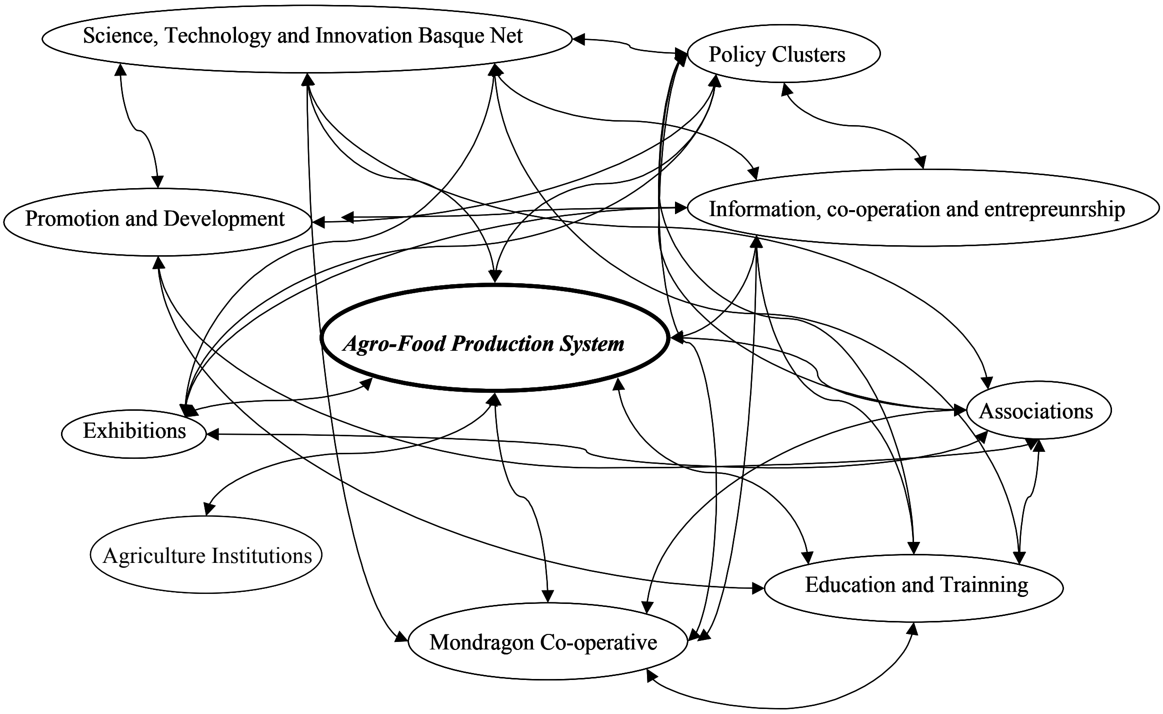


The main characteristics of the *Basque metal-mechanical productive system* have been shown in the above graphs and explanations. Nevertheless, they will be analysed again, later in the chapter, when compared with the agro-food system and the systems in Andalusia. The next part of this section focuses on the study of the structure and components of the *Basque agro-food productive system*.

5.3.1.2.- Agro-food productive system

The *Basque agro-food productive system* has a quite similar structure to the metal-mechanical system. However, the institutions making its main components are less numerous, and therefore they make a less complex and less dense system. The explanation for this difference is the regional productive specialisation, focused in metal-mechanical productions. Figure 5.6 shows the Basque agro-food productive system.

Figure 5.6: Basque agro-food productive system



All the institutions making the nine components around the Basque agro-food production system are listed in annex 5.2. As a consequence of specialisation, innovation and training institutions are less numerous in the agro-food than in the metal-mechanical system. However, there are specific agriculture institutions working in the region to enhance information and innovation flows and firms' training and experience. This is the case of innovation institutions like AZTI and NEIKER, or foundations like AZARO, ELIKA and KALIKATEA. There are also other agro-food institutions with an important role in the system, although they are not regional specific as they can be found in other regions. This is the case of 'wholesale markets' and the 'origin denomination regulating councils'. Nevertheless, their regional involvement and efficiency is different in each place as will be shown in the hypotheses testing section.

Both selected systems are also schematised and discussed for the case of Andalusia. They will be compared, between them and with the Basque systems, to get conclusions about the regional relational productive structures and their relation with regional development and dynamism.

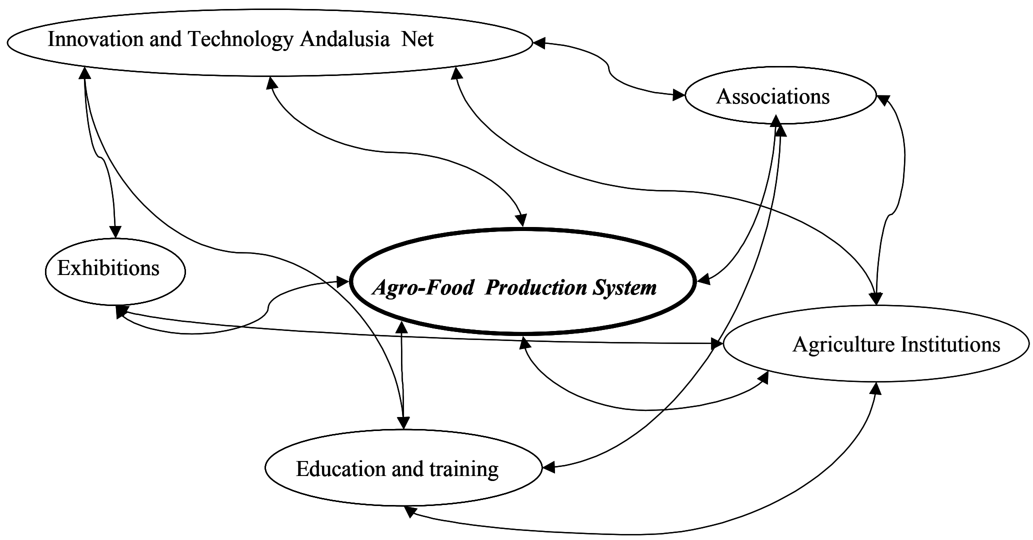
5.3.2.- Andalusia

In the case of Andalusia, the agro-food system is more complex than the metal-mechanical. That second system had important consequences in the regional productive structure in the past, but at present it does not show an involvement in the region. However, it is studied in this part of the research to compare it with the Basque system.

5.3.2.1.- Agro-food productive system

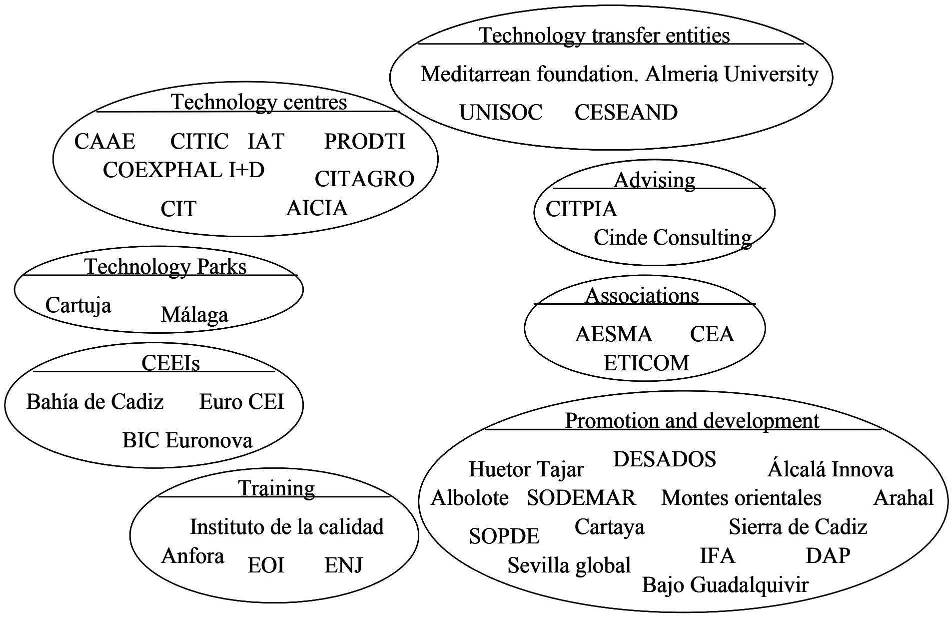
The main productive sectors in Andalusia are agriculture production and transformation. Although there is a big diversity of agriculture related products, there is a growing specialisation in production and export of olive oil. The main links in the systems are inside the production system (among primary producers, transformation industry and distribution sector) and the region has not developed a sector of machinery not even for agro-food production and instead machinery is generally imported. Other important links are maintained among the production system, innovation and training centres, associations and, in the case of the agro-food system, specific agriculture institutions like wholesale markets and origin denomination regulating councils.

Figure 5.7: Andalusia agro-food productive system



The regional government has pushed the creation of an 'innovation and technology net' (RAITEC), similar to SARETEK in the Basque Country. This public institution was created in 2001, as a part of the General Plan for Innovation and Technological Development in Andalusia 2001-2003, by the Employment and Technological Development Regional Council. The objective was to generate a tool to articulate the links among technological agents, service suppliers, service customers and the regional productive fabric. More particularly, it intended to facilitate knowledge and information access to firms in Andalusia. This is the most complex component in the system, which institutions are shown in figure 5.8.

Figure 5.8: Innovation and technology Andalusia net (RAITEC)[193]



Only the institutions focused in agro-food production processes, or directly linked to them, have been included in figure 5.8. Although there are several innovation and technology institutions in the region, most of them are concentrated in ICT and rarely offering agro-food specific services. Therefore, in general terms there is a lack of links among those institutions and the basic regional productive structure.

In Andalusia there are two technology parks working at the moment and several park projects. Some of them are already under construction as is the case of the monographic Olive Oil Technology Park in Jaén. However, there is not a park net or a general co-ordinator instead they have very weak relationships.

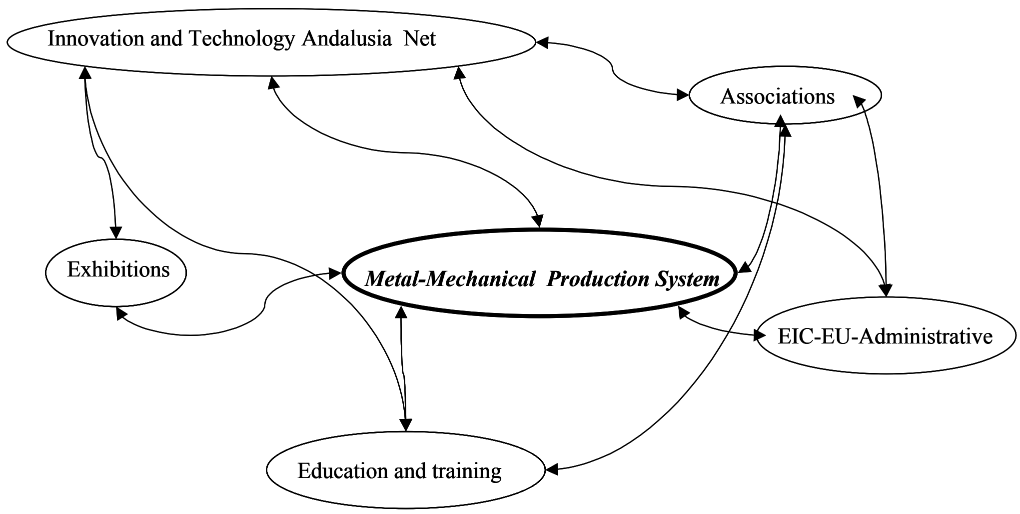
[193] The meaning of the institutions acronyms is shown in annex 5.6.

Relations are difficult among provinces, showing the region locality character, and therefore big differences can be found from one province to another according to institutions and productive development. In fact, most of the innovation institutions are in Seville while at the other extreme there is the province of Huelva with almost none of the institutions belonging to the productive regional net. Even considering these local disparities, the system in figure 5.7 and the metal-mechanical system, represented in figure 5.9, are representative of the whole region.

5.3.2.2.- Metal-mechanical productive system

As with the case of the Basque Country, the two Andalusia systems, in general terms, are very similar. However, when comparing the institutions in the main groups, important differences can be found. In the case of technology centres, only few of them develop activities related to metal or mechanical activities. The main differences in favour of the metal-mechanical system relate to specific associations and a training centre. Figure 5.9 represents the structure of this system in Andalusia.

Figure 5.9: Andalusia metal-mechanical productive system



All the institutions making the system components are shown in annex 5.4. As with the other three cases, the most important component is RAITEC, including several technology centres and an important number of promotion and development institutions, most of them depending on the local councils. There is also an association net (redCESEA) connecting province firms' associations and several specific institutions for the construction sector (CONSTRUCTOR association, CONSTRUSUR and CONSTRUCOR exhibitions).

The information obtained in the previous chapter for the *regional production systems*, and the information of this section for the *regional productive systems* will be used in the next two sections. The objective is to propose and test a set of hypotheses for an explanation of the regional disparities of those systems' structures, and to relate it to the different regional development and dynamism. The information has been complemented with direct firms' interviews and other regional study cases that will be explained in the last section.

5.4. Proposed hypotheses and general mechanisms to study the persistence of regional development differences

As we have already mentioned, among the purposes of this research is the study of structural change patterns in regional productive structures. This analysis will allow for explanations of the persistence of different development levels between more and less dynamic regions, focusing on Andalusia and the Basque Country, through the use of the tools provided by social network analysis, following a network structural methodological view and from the mechanism causality approach.[194] In this framework, the particular set of proposed hypotheses is built in terms of the relationships between development and: the regional productive structures, institutional development and social capital formation.

5.4.1.- Hypotheses proposal

Less developed regions, in an industrialised countries context, enjoy a development stage where the technical side of the regional structure (production system) is experiencing the clearest evolution in their development process. At later stages of economic development technical changes towards diversification and specialisation are continuously taking place. The most developed regions, however, have already

[194] Section 3.3.3.2 explained mechanism causality as one form to test hypotheses. It should not be confused with the more quantitative approach used in econometrics, although the same terminology is used. Table 3.1 shows the different types of causality and table 3.2 shows several examples testing hypotheses with mechanism causality.

experienced most of the technical changes of a diversification process, and focus on specialisation.

Understood in a wide sense, non-technical links making the productive system emerge, more or less slowly and with a more or less clear embeddedness in the regional system depending on the regional institutional dynamism. Among those non-technical links there are the institutional and formal ones, acting in the region with a different efficiency level depending also on the degree of dynamism experienced by the region.[195]

The net of input-output linkages, measuring intermediate transactions and connecting the productive branches according to their trade links, represents the regional production structure. This net changes in time as a result of changes in the number and value of each branch relationship and the position that they occupy in the net, mainly due to technological changes.[196] As a result, variations in the regional system generated by the development process can be observed looking at branches links and positions, a timid and weak emergence of non technical ties, the more efficient participation of formal non technical links and a production territorialisation process. Therefore going from a dense production system to an increasingly complex productive system.

In the system evolution some productive relations emerge while others disappear, following a general path of an increase in the degree of the branches participating in the structure. Some changes will imply that certain branches become more central and other more peripheral while in other cases changes will give rise to branches that act as bridges allowing for the connection between groups inside the network. Therefore, there will be a process affecting the considered key branches according to their degree and their position, as centres or as bridges linking sub-groups, at the same time as the whole net will become denser and more complex.

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[195] Moreover, regional production processes depend on external relations, with other regions in the country and with other countries.

[196] Peeters *et al* (2001, p. 6), mentioning Lundvall (1992), De Bresson *et al* (1994) and Edquist (1997), assert: "economic (supplier-user) linkages between industries –as reflected in the I/O tables (intermediary flows of goods and services between industries) –are the main "carriers" of technology diffusion in an economy; through interactive learning processes".

It is worth remembering that every productive branch is made of firms, and therefore the behaviour of the branches, although representing mainly technical relations, has a micro foundation in the behaviour of individual purposive firms. Those foundations at firm level will be also analysed as the underlying process explained through mechanisms.

The described process towards a more complex and denser productive net (including technical and non-technical links) will be faster in more dynamic regions, making them achieve higher positions according to a regional development ranking. There is, therefore, a process in which regions with more efficient decision taking institutions grow faster.[197] The case studies analysed in this research showed that in those regions innovation is accepted as a key factor, training and education are among the most important objectives and there is a clearer business culture. In general terms, regional institutions are more dynamic. Therefore, there is a process in which this more efficient decision taking is showing its consequences in growth and development. The dynamism effects have even clearer consequences on development than on growth, as growth is usually understood and measured in very strict economic terms, basically with *per capita* GDP.

This differentiated process can be observed when comparing Andalusia and the Basque Country. Some facts indicating it have already been explained. Section two in chapter four showed the main historical characteristics for the two regions, by which Andalusia has moved from being one of the more outstanding regions of Spain up to the nineteenth century to being one of the less developed ones owing to its lack of dynamism.[198] Nevertheless, the region has experienced clear growth rates looking at the main macroeconomic indicators but without converging to the national averages.

Graph 5.1 shows the regional growth process in the period 1955-1998 measured in terms of *per capita* Gross Domestic Product. The Basque Country is in the area with *per capita* GDP above the national average in both compared years, while the situation for

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[197] Those institutions include firms and other private and public institutions.

[198] In some economic aspects such as exports, the region was still considered among the most successful Spanish regions until the beginning of the twentieth century.

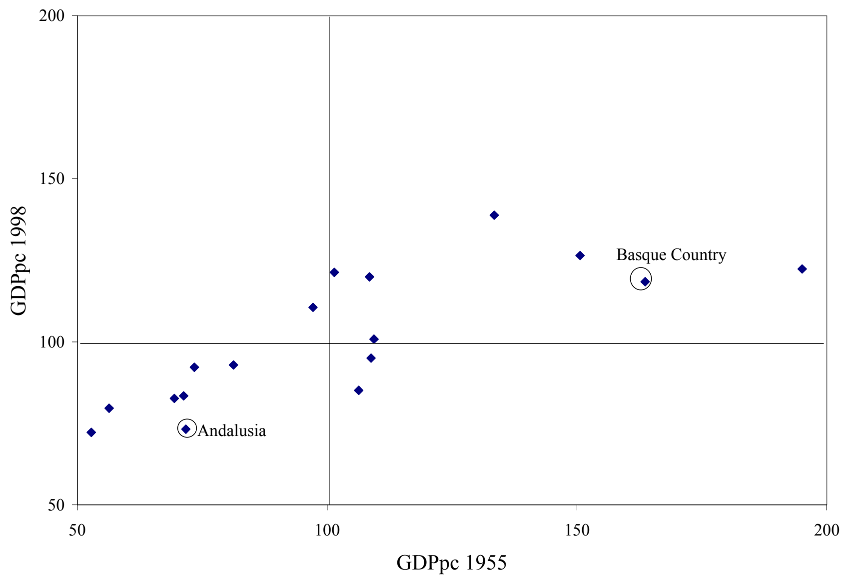
Andalusia is just the opposite. The differentiated historical process explains the opposite regional location. Nevertheless, in 1998 the Basque Country is closer to the national average than in 1955, in accordance with the regional convergence hypothesis explained by the neoclassical growth theory. Graph 5.1 shows the evolution of the Basque economy going down in the national 'league table', according to its GDP *per capita* in the whole period 1955-1998. There are several factors explaining this change, but first of all the analysed period should be separated in two, before and after the year 1975. Until that year the Basque Country maintained its first or second position in the national ranking, considered among the richest regions in Spain. The circumstances changed mainly owing to the following factors: the role of ETA, as explained in the previous chapter and the huge impact of the industrial crisis.

The Basque Country, Asturias and Cantabria were the regions with a more negative impact from the industrial crisis, because they were the regions that specialised more in metal ores and machine-tools. The Basque Country has its economic growth highly focused in that kind of industry and with very low productive diversification. In the period 1975-85 the region even had negative GDP *per capita* variation rates (Domínguez Martín, 2002). From 1986, however, another intense growth period started in the Basque Country, while the other two most affected regions, Cantabria and Asturias, could not recover in the same way from the crisis. For the Basque Country, however, it can be asserted that there is a long term success owing to its dynamism as explained through this chapter, particularly in terms of investment and R+D.

For Andalusia, however, it is not possible to deduce a convergence process, the data set used in graph 5.1 shows that the situation is similar at the beginning and at the end of the period (1955-1998). There are also other works, like Rodero Cosano *et al* (2003) analysing the period 1965-1999 for regional *per capita* income and also showing that Andalusia has maintained its differences with Spain (72% *per capita* income in Andalusia with respect to Spain in 1965, 71% in 1999).

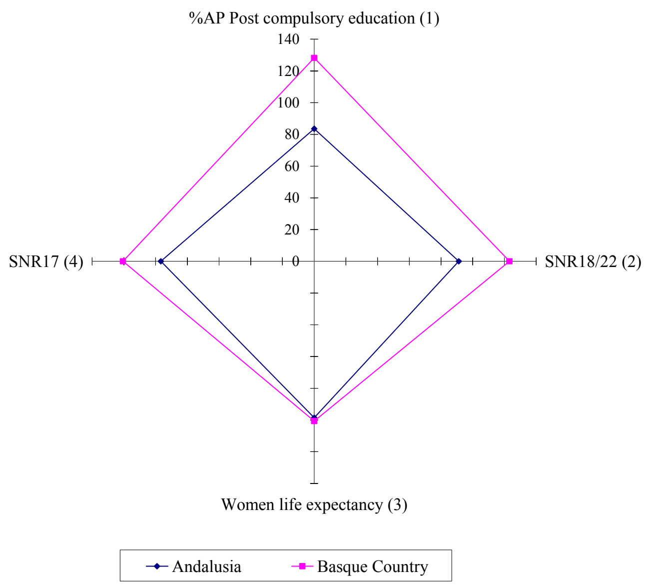
It is even more difficult to accept a convergence process when considering development instead of economic growth and therefore taking into account additional socio-economic variables. In this sense, the Basque Country is still showing big differences with respect to Andalusia. This can be seen by looking at education statistics, mainly for secondary, professional and university studies, life expectancy or public services. Graph 5.2 compares some of those social indicators.

Graph 5.1: Spanish regions GDP_{pc}, 1955-1998, GDP_{pc} in Spain = 100



Data source: *Fundación* BBV (1999).

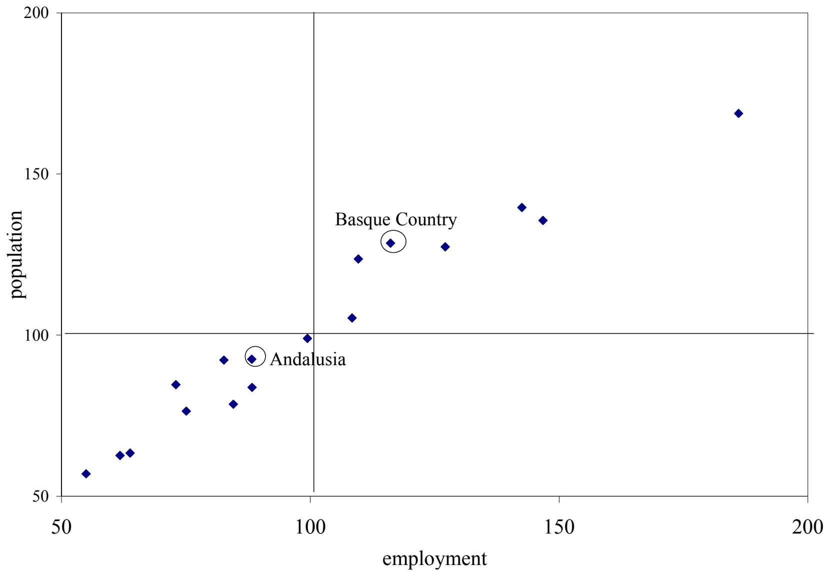
Graph 5.2: Social indicators in Andalusia and the Basque Country, Spain = 100



Data source: *Ministerio de educación* (2002) and INE (2002).
Note: (1) % active population that completed the post-compulsory education, 2000. (2) Net university schooling rate, age population between 18 and 22, 1999-00. (3) Women life expectancy, 1998. (4) Net schooling rate for population with age of 17, 1999-00. In Spain, education is compulsory until the age of 16.

The growth and development differences are explained by historical disparities in the regional dynamism. The historical information offered in the previous chapter and the institutional information of the preceding section give some important details to understand it. Innovation, training and business culture, have played a more crucial role in the Basque Country than in Andalusia. Decision taking in private firms has generally followed an entrepreneurial behaviour in the Basque Country through innovations, co-operation with other firms and institutions, and a tradition in professional education. Andalusia, however, has traditionally shown a lack of this entrepreneur spirit, working at a less well developed stage of innovation and depending on public initiatives. Some of these differences can be observed in the population and employment dynamism and in the R+D evolution, as shown in graphs 5.3 and 5.4.

Graph 5.3: Population and employment relative variation rates, Spanish regions, 1955-1998, Spain = 100.

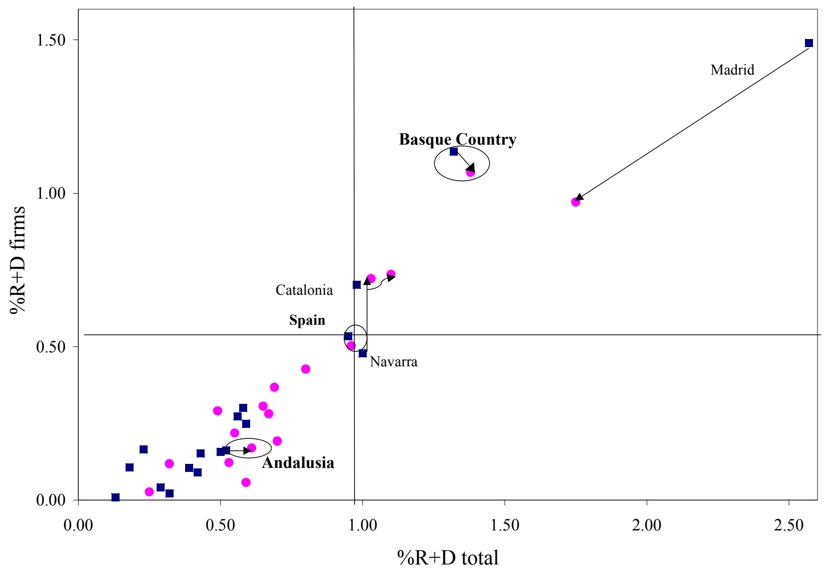


Data source: *Fundación* BBV (1999).

Graph 5.3 shows the total and working population evolution in all the Spanish regions compared to the country average indicators. All the regions with employment variation above the national average (higher than 100) showed also population variations above the country average. Moreover, all regions with relative employment reductions showed a population decrease with respect to the country as a whole.

In the analysed period, 1955-1998, the Basque Country experienced higher variation rates than the national average for both, population (76%) and employment (43%). The situation is quite different for Andalusia, with positive but lower than the average variation in population (27%) and employment (9%). This is a regional dynamism indicator, with Andalusia having the highest unemployment rate in the country, together with Extremadura.

Graph 5.4: Regional R+D, total and private, 1991-2001



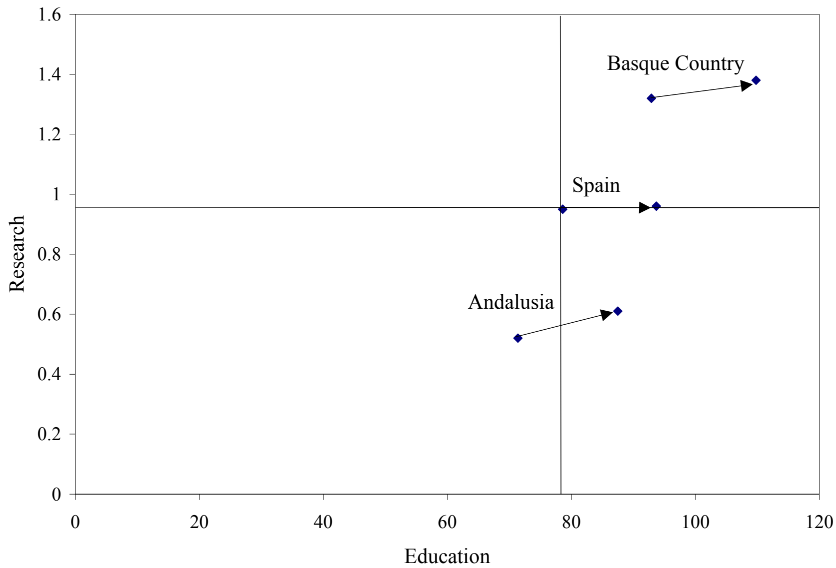
Data source: INE (1994 and 2003).
Note: the horizontal axis shows the percentage of R+D on regional GDP. The vertical axis shows the R+D expenditure made by private firms as a percentage of regional GDP. Squared symbols represent values in 1991 and circles in 2001. The horizontal and vertical lines represent the average values for Spain as a reference.

Graph 5.4 shows that the Basque Country had in the whole period, 1991-2001, R+D expenditures above the national average and even above most of the regions. Madrid is the only exception, but it is the capital of the country where the main public and private research centres are located. This circumstance conditions the results, because the capital receives more public and private resources than the other regions. The only regions with R+D expenditures above the national average, Catalonia and Navarra, have also been indicated in the graph with the corresponding arrows showing their research evolution.

The country as a whole has almost not changed its position between 1991 and 2001 in either of the two research indicators, where firm R+D expenditure has changed from 0.5 to 0.53, representing approximately half of total R+D expenditure. This value (private on total R+D expenditure) is for Andalusia one third and for the Basque Country 86% in 1991 and 77% in 2001, showing the differentiated endogenous effort made by regional firms.

By considering, in a synthetic form, the development and dynamic regional situations, education can be used as a development measure and innovation as a dynamism indicator. Thus, graph 5.5 summarises the evolution of development and dynamism in Andalusia, the Basque Country and Spain.

Graph 5.5: Education and Research in 1991 and 2001



Data source: INE (1994 and 2003).
Note: Education is measured as the percentage of registered students in secondary and professional education on population, with age between 14 and 18. Research is measured as the percentage of total R+D on regional and national GDP. Arrows indicate the movement from 1991 to 2001. The horizontal and vertical comparative lines have been drawn for the country values in 1991.

Graph 5.5 can be a summary of the situation experienced by a more developed and more dynamic region and a less developed and less dynamic region, represented by the regions of Andalusia and the Basque Country. Education and research have been, in the whole period, above the national average in the Basque Country. Andalusia, however, has shown lower development and dynamism. Although the region is experiencing a development process it has not reached the country average position in any of the values.

The above situation, deduced when comparing more or less developed and more or less dynamic regions, can be explained starting behind in the development process. Then, there would be a development process, where technical links and social capital are crucial, that can be expressed in hypothesis form for its testing as presented next.

Hypothesis 1: *There is a positive relation between the level of development and the density of the production system structure in a later development stage*.

The causation relation in this hypothesis acts in both directions. That is, a higher development situation leads to an increase in the number of links leading to a higher density net, and also a higher density net enhances development. In the process of development, in a context of developed and industrialised EU countries, there are regions enjoying less advanced development situations than others (this is the case of Andalusia when compared with the Basque Country). In those regions there is a positive relationship between the level of development and the density of the production system. This situation will act during sometime, with increasing development and density of production systems. When those regions go on in their development process, they go beyond or get past that situation, then there is a clearer tendency towards specialisation and, moreover, non-technical links are having an increasing importance building complex and dense productive systems.

The explanation of this double causation will be shown in section 5.4.2, where the underlying sequence of events is studied. In general terms, there is a tendency towards increasing degree levels (number of sent and received relationships, labelled technically in chapter 3 as outdegree and indegree) for the trade links among branches, and therefore towards more complex and diversified structures of relations. Moreover, the complexity of the relational net implies also the appearance of more overlapping groups of relations, again positively related with the level of development. At the same time there is the emergence of informal and institutional links, in a second phase consolidation, shaping a regional productive system. The appearance and the efficiency of those informal and institutional links will be higher the more dynamic the region is.

Hypothesis 2: *There is a positive relation between the level of development and the emergence of service branches as bridges through structural holes. That is, there is a significant and positive relation between the level of development and the role of service branches as bridges*.

Like in hypothesis 1 the causation relation acts in both directions: some services branches emerge as bridges linking the selected production systems with the rest of the regional production structure as a cause and consequence of the development process. In general terms, the development process always moves from a productive structure focused on industrialisation to a structure based on services. Then, there is an increase in the intensity of the service trade relationships that can be observed by the application of different threshold values to the trade values under analysis. Moreover, services have a key role in the evolution of the productive net, acting as bridges and therefore increasing the number of links in the network. This is shown in the specialisation and, at the same time, the outsourcing processes of production units, with more positive effects in a more dynamic environment.

The general implication of hypotheses 1 and 2 is that, for less developed regions, in an industrialised countries context, at the macro system level there is a positive relationship between development and the number and type of technical relations that branches maintain among them. This can be observed through the change between 1980 and 1995 in the intermediate relations of the production systems. Changes in the technical relations among productive branches are caused by variations in production organisation. Changes in the productive processes coming from technical change or from outsourcing decisions are reflected in transformations in the firms' production organisations. This, instead, affects the technical relations established among branches. Interactions and dynamic behaviour of the firms forming the system explain the process, caused by events occurring at the micro level and described later in section 5.4.2 in terms of events and mechanisms.

Those macro changes entail an increase in the number and volume of intermediate relations and also higher complexity and relations density, with new branches appearing as centres (receiving and sending a high number of links) and a clear regional specialisation. The intensity of this process changes with the level of development of the particular geographic area, and it is observed dynamically according to a development and growth process. Regional diversification and specialisation are observed, and the system density will evolve through non-technical links and a focus on specialisation. This procedure was observed in the previous chapter and will be analysed in the hypotheses testing section. Moreover, more advanced areas benefit from an endogenous development, reached by the territorialisation of their production processes (Garofoli, 1992).

Then, there is a stage of higher development positively related to the creation of dense and complex territorial productive systems, own to the regional endogenous development and social capital. The level of development is higher, more permanent and self-sustained when it is based on local factors. A model of endogenous development, as opposed to exogenous, is focused in a territorialisation process through regional complete production chain values, regional production exchanges and the use of regional resources and intermediate inputs. In this case, the economy will be able to reach autonomous and self-sustained growth processes, avoiding dependency relationships and enhancing the regional society and economy. Territorialisation also enhances the positive effects of social capital in regional productiveness.

The positive link between development and social capital can be split in two separated hypotheses from the following more general assertion (hypothesis 3).

Hypothesis 3: Formal and informal social capital are economically relevant, and the latter helps in the building up and use of the former. In less developed regions the quality and quantity of informal social capital, when compared with formal social capital, has a greater effect on economic performance than in more developed ones.

When economies enjoy a low development level, their most intense social capital is based on informal links and trust. However, more dynamic regions (*ceteris paribus*) attain faster higher development levels with the emergence of a social capital focused on formal links with other firms and institutions. The first type of social capital can be considered as 'more primitive' and the second, or the combination of both, as more sophisticated and with clearer effects in economic efficiency and regional development.

Less developed areas focus their social capital on personal links and trust, while when a significant development stage is attained the focus is substituted towards formal institutional links. That second type has more positive economic effects. There are several cases; some will be discussed in this chapter, showing that the combination of both kinds of social capital has led to clear efficiency improvements. A better quality of informal relationships helps in the creation and maintenance of better quality formal links.

Hypothesis 3a: *The social capital having greater effects on economic performance in less developed regions, when compared with more developed regions, is based on the set of tacit norms, informal links and informal nets that facilitate collective action. More dynamic regions (ceteris paribus) enjoy high quality of this social capital with positive effects for their development and growth.*

The general mechanisms, and therefore the general explanation, of hypothesis 3a is that there is an important role of trust among entrepreneurs and other institutions for the maintenance of *social capital* and of permanent trade relations (Krackhardt, 1992; Gulati, 1995; Whiteley, 2000). Increasing relations generate trust and this in turn raises the level of relations and the *social capital*. The regional development is intensified and reinforced through relationships and trust as there are clear externalities derived from high *social capital*. Even if firms just compete, there are continuous information flows among them generating *social capital*. Moreover, when firms have a relationship of competition and co-operation, revealed as a more efficient situation, the *social capital* is even higher allowing for a net structure of dense inter-relationships with clear benefits for the whole regional community.[199] Even more, when relations are maintained not only among firms but also between firms and institutions, the *social capital* increases and the regional growth and development rise. The conclusion is that more developed regions show a denser and more solid productive system, owing to its social capital component. This social capital is being built faster and more effectively in more dynamic regions, *ceteris paribus*.

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[199] Brandenburger and Nalebuff (1997) use the term co-opetition referred to a firm strategy based, at the same time, on co-operation and competition.

This effect will be tested with the specific literature and through case studies of selected firms in each region. The interviews should offer information about formal and informal relationships of the firms belonging to the regional system. Relationships referred to would be trade, projects, co-operation, training, information and innovation.

Hypotesis 3b: *There is a positive relation, in both causality directions, between the level of development and the quantity and quality of relationships with formal institutions*.

Those institutions are mainly technology parks, universities, innovation, knowledge and training centres. In more dynamic regions, *ceteris paribus*, the most important productive systems evolve by adding and intensifying the links among the branches and the mentioned regional institutions. As an effect of this process, the nets representing the systems should be denser and more complex at periods of time and places with a higher development level. The institutional thickness is part of the regional environmental characteristics explaining its economic development. A large number and variety of institutions with a presence in the regional productive systems, through high levels of interaction, implies a higher development level as complexity in local institutional nets is considered a positive indicator of dynamism and collective initiative and they express the characteristics of informal institutions (hypothesis 3a).

A correct functioning of informal relationships is helpful for an efficient operation of formal relationships. However, less developed regions depend more on localised informal links and this situation is reinforced when there is a lack of dynamism, *ceteris paribus*.

5.4.2.- Underlying structure of firms' sequence of events

In the analysis of the underlying structure of the productive branches taking place at firm level (micro level), the focus is placed on the idea that firms adapt to continuous market changes trying to follow a path towards higher efficiency. In the relation between more efficient firms and the three proposed hypotheses there are important factors to consider: the role of innovation, the process of co-ordination and the path towards higher specialisation. All those factors play a more effective role when they act territorially focused, where the productive system is embedded in the regional socio-economic system.

Innovation, considered in a broad sense, includes mainly process and product innovation, new types of industrial organisation, opening to new markets, identification of new sources of raw materials, and training and more skilled workers. Even co-ordination can be considered innovation as it implies a change in the organisation of the firm, that can co-ordinate with researchers and scientific experts, households, retailers and other producers.[200] Both, innovation and co-ordination allows for a process towards higher specialisation as they facilitate the firm concentrating in the productive task where it has an advantage.

Every productive branch is made of some firms with entrepreneurs that are able to judge and take decisions to adapt to the continuous changing economic situation. Therefore, there are highly efficient firms adopting innovations, externalising the productive tasks that can be obtained cheaper and more specialised from other firms, and intensifying co-ordination with other institutions. At the same time, there are less efficient firms failing to adjust as they should, without adopting innovations, maintaining the whole productive process and disliking co-ordination. As a result, there is a continuous process in which dynamic firms co-exist with less efficient firms. Moreover, as the more dynamic firms generate changes in the productive links, new relations appear in the whole net of intermediate links while the old relations are also maintained, and there is a delayed development stage showing an increase in the number of links maintained among productive branches (hypothesis 1).[201] This stage can be observed in the case of Andalusia. The specialisation process followed by the more dynamic firms is intensified with the outsourcing of the service side of the productive processes (hypothesis 2).

The continuous search for higher efficiency is strengthened with links that firms maintain with other institutions. A large number of institutions working properly and highly related with regional firms, will allow for several benefits of positive externalities (hypothesis 3b). Those externalities come from the flows of information, innovations and training, the transfer of tacit knowledge, the initiative of joint projects

[200] "A co-ordination plan that is novel in some respect qualifies as an innovation", Casson (1997, p. 73).

[201] Considering a dynamic process instead of as comparative static where the situation should show the substitution, and not the co-existence, of relations.

(and therefore firm co-ordination), and the permanence of a high credibility and trust in the regional system (hypothesis 3a).

Therefore, there is a positive relation between development and the number and type of relationships the firm keeps with other firms, government and other institutions. This can be inferred when observing the following sequence of events: firms, in their adaptation process, search for higher efficiency levels, more information (cheaper and better quality) and lower costs, tending to implement strategies that are directed to innovate and to increase their specialisation and co-ordination. The more dynamic firms will *incorporate innovations* (like product, process and intra-firm organisation), *externalise tasks* (mainly services) and *co-ordinate with other firms* (mainly at local level through trust), giving rise to an *increase in the number and type of their relationships with other institutions* (technology parks, universities, innovation and training centres) in the process. Moreover, firms with that behaviour will look for the most efficient supplier for their productive process. This will push a selection procedure distinguishing the supplier firms that also innovate, externalise and co-ordinate, reinforcing the efficiency progression and the links increase.

Then, in a superior stage in the development process, there would be an increase in the number of relations among firms and with other institutions. At the same time, service firms become key branches as specific services are the generally externalised tasks, and therefore they increase their relations in number and volume with firms. When the analysis is focused at local or regional level, higher development is positively related to co-ordination through trust and co-operation. Moreover, the outsourcing process for services also implies a change in the firm productive structure moving from a vertical to a horizontal organisation. This vertical disintegration process is favoured by trust relationships that firms start establishing with other productive units. A relational structure, made of formal and informal links, of high quality, as it is the case of more dynamic regions, facilitates the mentioned organisational change and the path towards higher efficiency and development. At the same time, the development process itself facilitates and enhances the organisational changes and the relationship structure leading to more efficient productive systems.

Therefore, the intensity of this process will be higher the more developed and dynamic the geographic region is where it takes place, and it is observed dynamically for every place according to a development and growth process.

The observed sequence of events needed, to get general conclusions, will be obtained from interviews made at regional firms, case studies and the existing literature in this respect. Table 5.2 offers a summary of the firm mechanism and its effects.

Table 5.2: Mechanism at firm level

Firm objective	Firm actions	Effects
Efficiency	• Innovation • Specialisation ⇒ Outsourcing • Co-operation and trust among firms • Relationships with institutions	• Increase of relationships with firms and other institutions. • Services as key branches ⇒ Increase in their number and volume of relationships.

5.5.- Hypotheses testing

The three proposed hypotheses are tested by using the structural analysis made in chapter four, the information about institutions and their relationships used to build the productive systems in section 5.3, personal interviews made at firms in Andalusia and the Basque Country, additional case studies obtained through questionnaires and publications,[202] and other regional information.

For the personal interviews and the filling in of the questionnaires, several sources have been used to select firms and other institutions in both regions. In the case of Andalusia, the potential firms and institutions to consider in the analysis have been found in two relevant directories: the directory of firms and centres working in the technology park of Málaga, and the directory of firms in the Agricultural Origin Denomination Regulating councils. In the case of the Basque Country, the information on which we have based our selection of firms and institutions has been taken from the following sources: the directory of firms and centres in the technology park of Zamudio, the directory of firms

[202] Other Basque and Andalusia study cases reinforcing the hypotheses are based in the following firms: Asle, Copreci, Fagor, Gasnalsa, AYD, IMH, ITP, Microdeco, TVA, Batz, Bultzaki, Gamesa, Goizper, Ibermática, Orkli, Grupo Ulma, Neionnova, Aucore, Plaza and Björm, Actividades Químicas Andaluzas, Mercaempresas S.A., Permasa, NSN Sistemas SAL, Placinor SL, Wide World Geographic Services SL, PRLSfot, HIS Weiglling SL and Infobasa Agencia de Comunicación SL.

in the Mondragon Co-operative Corporation and the directory of metal-mechanical firms in the regional Chambers of Commerce.

For the selection of firms and other institutions a criteria of 'accessibility'[203] has been followed, since they consisted of recorded semi-structured interviews held with the General Manager of the institution (or a person with a similar position/job title) and with a duration of no less than three hours. The main details about the fifteen interviewed firms and institutions are provided in annex 5.7. The outline followed in the interviews is included in annex 5.8.

The objective of the interviews has been to collect qualitative information in order to analyse particular case studies. Therefore, firms belonging to the sectors in which each region has focused its productive specialisation have been looked for. In addition, to confirm the main conclusions obtained from the interviews, one hundred questionnaires have been emailed to randomly selected firms from the already mentioned directories. The detailed questionnaire is provided in annex 5.8. This allowed us to add twenty-eight more reports and enhance the reliability of the qualitative information used in the analysis.

Making use of the commented information, this section will examine and test each proposed hypothesis in turn, although sometimes explanations will refer to more than one hypothesis. The hypotheses will be tested through mechanism causality, after having observed a sequence of events, to obtain general conclusions. This method of testing hypotheses, which is a common procedure, mainly in other social sciences, was discussed in section 3.3.3.2 where also some examples were shown it (table 3.2).

From the information obtained in the empirical analysis made in chapters four and five it is established that, while in 1995 in Andalusia the production structure is denser than in the Basque Country, its productive systems are less dense than in the Basque Country.

[203] For a definition and justification of the use of this criterion, see Kvale (1996) and Judd *et al* (1991).

In the previous chapter, densities increased in the 1980-1995 period in the case of Andalusia while they decreased for the Basque Country (table 4.18). Moreover, the net cohesion analysis (table 4.19) also explained this situation where in Andalusia there is a tendency towards diversification with an increasing number of links and of directly reachable branches, while this is not the case for the Basque Country. The empirical analysis made in chapter four confirms the more patent tendency in Andalusia towards a more complex and diversified production structure.

While this is happening at production system level, in the present chapter it has been shown that, once formal institutional links are added to the system, the productive structure in the Basque Country is clearly denser than in Andalusia (figures 5.2, 5.6, 5.7 and 5.9). The Basque productive net is made of a higher number of formal institutions than in Andalusia, maintaining solid links with regional firms. Although in both cases an innovation and technology net has been built from the public initiative, the Basque net is more efficient than the one in Andalusia. It is not only made of a higher number of institutions, but they are also more sturdily linked to regional firms, and more importantly, to firms working in the sector in which the region is clearly specialised. These assertions were also confirmed by the interviewed firms and institutions in both regions, as will be shown later. Then, hypothesis 1 is corroborated, explained by the fact that the Basque Country is a more developed region, as has been discussed in section 5.4.1.

Going on with the underlying sequence of events explaining the hypotheses at firm level, interviews offered some rich information making the confirmation of the first hypothesis more evident and for the verification of hypothesis 2. In section 5.4.2 it is asserted that at later stages of economic development there are new relationships appearing while at the same time the old relationships are maintained. The main consequence is an increase in the number of links among productive branches. According to the information used, in Andalusia the firm's links sustaining a traditional organisational system are definitely more present than in the Basque Country. When interviewing the olive oil co-operatives in Baena (Córdoba) some of their representatives said that they decided to internalise some tasks that they externalised some time ago, as is the case of transport, while other co-operatives decided to go on with the externalisation. In general terms, after having interviewed some experts, such as the marketing executive officer in the Malaga technology park and the province co-ordinator of DAP, which is the most important public agricultural services firm in the region, they agreed that the externalisation process is being very slow and only accepted by a section of the firms. In the Basque Country, however, the service externalisation process is widely accepted as necessary for the firm's efficiency, even from small firms (CEDEMI assistant executive officer) and it has been applied for some considerable time. Nevertheless, there are exceptions proved with the interview with LARON, a highly specialised firm maintaining lasting links with the University and training centres, but developing the whole production process at home.

Those results are in accordance with Ouchi (1980), Williamson (1983) and Bolton *et al* (1994) arguing that the externalisation process depends on trust, in a different degree according to the outsourced task. And, as it has been stated in hypothesis 3 and confirmed by the related literature (Putnam, 1993; Helliwell and Putnam, 1995; Knack and Keefer, 1997; Zak and Knack, 2001), trust is positively related to higher development and dynamism. Therefore, externalisation is also a positive function of those two aspects. According to this, externalisation would be more probable in regions such as the Basque Country than in regions such as Andalusia.

Also following Ouchi (1980) and Bolton *et al* (1994) innovation is positively related to the most efficient co-ordinated organisational system and to regional development and dynamism.[204] Co-operatives in Baena, although big firms with a high export level and in an expansion process did not develop innovation themselves. When asked about the incorporation of innovation they asserted that innovations were embodied in the inputs, mainly capital goods, they acquired from their suppliers when suppliers decided to include some kind of change in their products. They were applying product innovation, mainly in the form of new containers, information to customers and labelling, but always through public institutions like DAP and the Origin Denomination Regulating Council. Nevertheless, there is an increasing settling down of small firms in the area

[204] The most efficient organisational systems are, for the mentioned authors, Clan and relational contracting.

offering technical advise and machine repairing, once they have learned enough about the capital components the local firms usually buy, from other regions or countries, for their olive oil productive processes. This situation can be compared to Wales (Cooke and Morgan, 2000) where the firms' attitude for innovation is comparable to cooperatives in Baena.

In the Basque Country, where firms innovate more than in most of the other Spanish regions, relationships with innovation centres, technology parks and universities is admitted as very useful and most of the studied firms use them for their innovations and information flows. Thus, continuous information exchange and technology transfers are routine central aspects of institutional relationships. Under this situation, relational contracting is the superior alternative organisational arrangement with the more positive effect on efficiency (Teece, 1981; Williamson, 1983; Bolton *et al* 1994). In the relational contracting, although organisation outsourcing is a common process, it is more evident for services.

The links maintained with different institutions is crucial for the flow of information and innovation, making use of 'weak ties'. However, less developed areas generally show a lack of weak ties limiting their access to key resources. This is the situation analysed by Dasgupta (2003) in the case of rural areas in poor countries where there is a lack of weak ties and instead relationships are mostly intense, narrowing the economic possibilities. Following with the same argument; Fukuyama (2000) analyses the development difficulties of the Chinese parts of East Asia and of much of Latin America, where social capital resides largely in families and in rather narrow circles of friends. "Traditional social groups are also afflicted with an absence of what Mark Granovetter calls "weak ties", that is, heterodox individuals at the periphery of the society's various social networks who are able to move between groups and thereby become bearers of new ideas and information. Traditional societies are often segmentary, that is, they are composed of a large number of identical, self-contained social units like villages or tribes. Modern societies, by contrast, consist of a large number of overlapping social groups that permit multiple membership and identities. Traditional societies have fewer opportunities for weak ties among the segments that make it up, and therefore pass on information, innovation, and human resources less easily" (Fukuyama, 2000, p. 3).

According to the increasing importance of services, one general conclusion obtained from the empirical analysis made in chapter four was that a post-industrialisation process was taking place in both regions, with service branches showing the maximum links intensity and substituting the manufacturing productive presence. This was also proved from the interviews in both regions. Basque and Andalusian firms increasingly use services: in the first region following a faster outsourcing process, in the second using very intensively public services. Although the situation is not the same, hypothesis 2 is clearly corroborated. Differences mainly come from the view that in the Basque Country the situation is dominated by high quality trust in a more dynamic region, and in Andalusia public funding is a key factor for the regional economy. This could have different effects but not for the terms in which hypotheses 2 has been proposed.

From the results of Cooke and Morgan (2000) studying Wales, this region can be compared to Andalusia because of the link between the regional productive structure and the role of public institutions. However, Wales is experiencing an institutional evolution that Andalusia has not reached yet. While in Andalusia public institutions are still acting, generally, in a paternalistic way for regional firms, WDA in Wales has already realised that this is not the most efficient strategy. "States can have serious negative impact on social capital when they start to undertake activities that are better left to the private sector or to civil society. The ability to cooperate is based on habit and practice: if the state gets into the business of organizing everything, people will become dependent on it and lose their spontaneous ability to work with one another", Fukuyama (2000, p. 11). As Skidmore (2000, p. 7) asserts "strong states need strong societies, particularly at later stages of economic development"; the efficacy of public interventions can be increased by high quality social networks because states are limited in their ability to effect economic transformations and to spread information and innovation to society through vertical ties.

The role of public institutions is more important in Andalusia while private and semi-public institutions are more embedded in the Basque regional system. According to Rodero Cosano *et al* (2003) the stock of public capital in Andalusia is higher than in the rest of the country. However, *per capita* income in Andalusia has not approached the national average values in the period analysed in their work (1965-1999). The authors ask for a reflection about the effectiveness of public investment policies trying to reduce regional disparities. Moreover, *Cámaras de Comercio* (2003) offers some illustrative data to understand the distinct regional public role and the dissimilar firm's behaviour towards efficiency. According to this publication, total R+D workers on regional employment relative to Spain was 83.32% in Andalusia and 128% in the Basque Country. However, when considering only R+D workers in private firms the percentages are 35.16% in Andalusia and 244.51% in the Basque Country.[205] Another illustrative data are the number of patents in the region relative to Spain, that for Andalusia is 45.86% and for the Basque Country 153.45%.[206]

Nevertheless, in both regions a net of institutional links works, building the regional social capital and shaping the regional productive structure, although having in mind the mentioned differences. In the Basque Country system, institutions related with the production system spread in an equilibrated form in the territory. An illustrative example is the Basque Technology Parks Net linking the three parks (Zamudio, San Sebastián and Álava), one in each of the three provinces, and with a common general director. In Andalusia, however, there are big differences depending on the area. Most of the institutions are concentrated in one province (Seville), while in others (Huelva is the most extreme case) they are almost non-existent. Andalusia has only two technology parks, Seville and Málaga, in a region with eight provinces, although there are projects to build new ones in Córdoba, Jaén and Granada. The two existing parks are not linked and they even have some kind of rivalry. Another illustrative example could be the case of one of the parks under project: the Olive Oil Technology Park (Jaén), almost working at the moment. The most important provinces producing olive oil in Andalusia, and also

[205] That is, in relative terms, in the Basque Country the number of R+D workers multiplies by 2.4 the national average R+D workers.

[206] The mentioned R+D workers and patents data refer to year 1999.

in Spain, are Jaén and Córdoba, however none of the interviewed firms in Baena (Córdoba) knew anything about the new park, nor they could imagine any benefit from being linked to it. Those are evidences of different regional public policy decisions with diverse effects. Garofoli (1992. p. 192), studying the case of Andalusia, refers to the limitations of policy decision taking for the region: "The strong administrative dependency of these promotion offices on both the Regional Government and the Local Council Economic Budget, makes them not very flexible in their operations. On the other hand, their location has been following political rather than economic and spatial criteria (…). Despite the fact that in their objectives, these policies claim to pursue the territorial articulation through reducing development gaps within the region, the concrete policies do not still follow any spatial strategy discussed previously. So far, they have been implemented on the basis of political reasons".

Firms in Baena have very close personal relationships among themselves while they do not relate at all with firms in the same sector in Jaén. When asked about this situation they remarked the 'closed' character of firms in Jaén. The locality aspect can be considered a characteristic of the social capital in Andalusia, working in highly localised terms without being extended to more remote areas in the same region, showing a lack of weak ties as mentioned before. This situation is what Uslaner (2003) identifies as an economy based on particularised trust instead of on generalised trust. It is also expressed in Buchan *et al* (2002) as trust behaviour based on direct exchanges while trust is lower for the indirect exchange conditions. This type of local social capital can be assimilated to the notion of 'bounded social capital', while a most efficient open situation will be focused on 'bridging social capital'.[207] For Carter and Castillo (2002) the 'bounded social capital' is the type of connections existing in rural areas, meaning highly localised ties based on family and other close relationships. According to Trigilia (2001), this situation, typical of backward areas, offers potential development possibilities by activating their strong and concentrated ties towards the production of an extended social capital favourable to development.

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[207] Those terms have been defined in section 5.2.

The reality of technology parks and the locality aspects of firms are evidence in favour of hypothesis 3b. For the marketing executive officer of Málaga Technology Park (Andalusia) the main reason why firms have decided to be in the park was to have a good image in the market. In the Park of Zamudio (the Basque Country), however, its director was pretty sure that the main reasons were the innovation benefits obtained through the links created with the innovation centres in the park, and the positive externalities for being close to bigger and more efficient firms working in the same sector.

The links structure maintained with technology and training centres is also in accordance with hypothesis 3b. As it has already been said, those centres in the Basque Country have a key role; all the interviewed firms were related in some form to them. This did not happen at all for the interviewed firms in Baena. Firms applying any kind of innovation, advising, or training, obtained them from the regional government through a strong personal link with its local representative. For firms in the Málaga Technology Park there were relationships with the park innovation centres and the University, but this did not happen for agribusiness firms. In the park there are only two firms with activities related to agribusiness, in a region where this is the main sector. Generally, firms in the sector are not applying the benefits of information and technology flows that could be acquired in the park context. The director of the park said that there were some hectares in the park that had been reserved for agriculture activities for some time, but no one was interested in them. Most of the organisations in the park are software firms that could offer their services for the agriculture automatisation processes and management, as this will be one of the objectives in the Olive Oil Park in Jaén.

In spite of the situation discussed for Andalusia, relationships with institutions were working at the same time as close links among firms. Those relationships are crucial in any development process but they take place in a different way in each region, implying clear differences when comparing them. Evans (1997) and Newton and Norris (2000) discuss this subject in general terms by asserting that an appropriate social trust will lead to efficient political and civic institutions and therefore the key is to be able to 'scaling up' the personal and community ties to form developmentally efficient institutions. According to Gibson (2001) more advanced societies do not need to focus on personal trust as people can relay upon institutions. Therefore high quality informal social capital enhances the creation and maintenance of formal social capital.

In the two studied regions several examples were obtained from the interviews that constitute proof for stronger confirmation of hypothesis 3, and in particular for 3a. When studying co-operation and co-ordination inside the firms, the regional situation is rather different between both places. One of the interviewed firms in the Basque Country was Irizar, a well-known firm in Europe because of its efficient productive system in building luxury coaches, but also because of its peculiar organisation system.[208] Its internal organisation is totally based on co-operation and trust; hierarchy does not exist at all in the firm while hierarchical organisation used to be the firm system until ten years ago. This organisational change led to an impressive increase in its productivity and efficiency. When asked about its research and innovation department, the managing director asserted that all workers in the firm are researchers and all of them generate innovation as information and ideas flow very easily thanks to the horizontal system and the trusting environment.

Irizar is among the numerous firms working in the Basque Country with a co-operative system. The best known case is Mondragon Co-operative Corporation. Attempts in other countries have been made to copy its system because of its great economic results. Conversely, the co-operatives interviewed in Baeza were not happy at all with their organisation system. Information flows and decision taking are big problems for those firms, even one of the co-operative presidents asserted that, according to his experience, cooperative assemblies are ‘a nest of ignorance’.

Mondragon Co-operative Corporation is also a good proof of co-ordination links among firms producing in the same or similar sector as a characteristic of the Basque Country business culture. Firms belonging to the corporation clearly co-operate and have strong trust links. Some of the group norms showing it are: if one of the firms has financial

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[208] Some researches that have analysed the Irizar case are: *Fundación Vasca para la Calidad* (2001) and Casadeus-Masanell and Khanna (2003). The high firm efficiency has also been commented in The Economist Intelligence Unit (2000).

problems and it needs to make some, or all, workers redundant, they are hired in other firms in the group working in the same or similar sector; more advanced firms send their more qualified workers to other firms in the group, working in the same or similar sector, to train and advice their workers. However, the situation in Baena was that there were strong trust relationships among the olive oil firms working in the area; they do not consider each other as competitors. Nevertheless, those strong trust links disappeared outside Baena and still within the same region.

This indicates the existence of a localised informal social capital in Andalusia while the analysed firms in the Basque Country make use of a more spread high quality informal social capital. Moreover, formal social capital is more used from an efficiency and economic perspective in the Basque Country, as seen in the mentioned situation for the Technology Parks, the territorial distribution of formal institutions and the structure of the productive systems nets.

Mondragon Co-operative Corporation and firms working on it, with Irizar and Eroski as very clear illustrations, are examples of Ouchi's theory asserting that the most efficient organisational system is based on socialisation, trust and co-ordination. Opportunism is reduced and monitoring and auditing costs are avoided. Firms also adapt to continuous market changes making an efficient use of the innovation and information diffusion enhanced by their organisational system. The necessary working tradition and business culture are also embedded in the Basque socio-economic system. The 'World Values Survey', reveals that Basques are more egalitarian, less competitive workers and more reluctant to accept hierarchies (Elzo *et al*, 1992) when compared with other Spanish regions and also with regions in the other European countries. This implies a basic distinctive aspect of the Basque socio-economic system because, as Putnam (2002) argues, the flow of technological innovation and the social and political entrepreneur basis are the driving forces of social capital in development processes. Therefore, the cultural factors of social capital should be seen as productive of wealth (Fukuyama, 2001).

Relationships with customers were completely different when both regions were compared. In Baena, trust links were not developed at all but reputation was very important. Even in some cases insurance contracts were asked to be signed by the client, just in case they would not carry out the agreed conditions. An opposite example was Irizar, in the Basque Country, where reputation is also very important but is attained through personal contacts with the client.

Relations with suppliers in Baeza were maintained with personal contacts through the visits made by providers offering their products. In the Basque Country, however, there are several cases showing the personal involvement of both, the buying firm and its supplier. Irizar is a clear case, where relationships with their providers is so continuous and personal that its managing director asserted that in some case the supplier firm had to change its organisation system to adapt it to the Irizar one, becoming more similar to it. As an example, any worker in Irizar could phone a supplier asking for any needed information, while usually firms have just one person in charge of provider relationships. Even in the case of Laron, his chief executive officer admitted that trust and personal links with providers were key factors for them. They continuously collaborate in the elaboration of the acquired products. Caja Laboral marketing executive officer also admitted that trust links make them maintain the same providers without looking for substitutes. This trust generalisation avoided opportunism and favoured efficiency.

Trust data are also offered by the WVS at regional level, the last value offered for Andalusia is 31.8 and for the Basque Country it is 33.6, corresponding to the surveys made in the period 1995-1996.[209] Although they are quite similar, they are indicators of the existence of higher trust for the more developed Basque region than for Andalusia. However, those data seem more similar than expected.[210] On the other hand, from the fieldwork made in both regions it can be inferred that trust in productive systems works more effectively in the Basque Country than in Andalusia. This apparent contradiction

[209] Those regional data have been obtained from Moesen *et al* (2000).

[210] The country average value, corresponding to the year 1996, shown in table 5.1 is 29.8.

can be explained by the methodological problems appearing from the way in which trust is measured in the survey and commented in section 5.2.[211]

When asked, in general terms, about formal and informal links, co-operation and co-ordination, social capital in fact, Basque managers had the following opinion: the assistant executive officer in CEDEMI said that it is the 'culture broth' for regional development; Irizar managing director was very surprised when asked about it as for him it was pretty clear that it is the most important factor in looking for productivity and efficiency; Caja Laboral and Eroski are co-operatives and both belong to the Mondragon group, for them the social capital benefits are quite obvious as it takes part of their organisation culture; the director in the Zamudio Technology Park admitted that one of his main tasks is to promote co-ordination and personal links inside the park.

In the case of Andalusia they did not have an opinion about it, neither cooperatives in Baena, nor the marketing executive officer in Malaga technology park, nor the DAP province co-ordinator had opinions. However, they admitted that personal and trust links worked perfectly among closely located firms and with representatives of public institutions.

This social capital comparison between Andalusia and the Basque Country can be seen as similar to the comparison made by Cooke and Morgan (2000) between Emilia-Romagna and Calabria. Those Italian regions have changed their development situation owing to the co-operative system, the localised learning and the trust formation taking place in the northern region while those factors do not work in the south. According to the authors, those differences are explaining the development process experienced in Emilia-Romagna and the backward state of Calabria, when the situation used to be the opposite. Nevertheless, their different geographic location should also be considered among the important factors explaining the disparities experienced in both places.

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[211] It should be remembered that trust data have been obtained from the answers to the following question: "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?"

As has already been said, the access to flows of knowledge, information and innovation is a key in any development process. But the access to the mentioned flows has to be complemented with an entrepreneurial culture being able to take advantage of them. And this implies one of the main differences in the development processes of both analysed regions when compared. Wolfe (2000, p. 9) express this fact in the following form: “Learning depends on the presence of two key factors: a certain degree of business intelligence that serves as the demand trigger for new knowledge and the access to, or availability of that knowledge”. The entrepreneur culture is considered in Feldman and Assaf (1999) as the micro aspect of social capital that can be labelled as “ethnic entrepreneurship”. The needed environment in any development process is represented in Casadesus-Masanell and Khanna (2003) in the cases of Mondragon Corporation Co-operative and of Irizar. In general terms, as Evans (1997) establishes, main differences are observed in the existence of synergies combining *complementarity* and *embeddedness* taking advantage of the externalities obtained from the interaction among institutions in general and in state-society synergies in particular.

The existence of higher trust and higher social capital in the Basque Country when compared to Andalusia can be assimilated to the situation in Scandinavian countries.[212] Table 5.1 shows that the highest trust values correspond to Scandinavian countries and,[213] according to several aspects Scandinavian and Basque attitudes are very similar (Johannisson, 2002). Similarities appear in the trust behaviour, according to the fieldwork made in the Basque Country, to the attitudes toward hierarchies, to the co-operation actions among firms and also with the income equality data and thoughts (Osberg, 2003).[214] Case studies have shown that in Scandinavian countries their economically successful strategies depend on institutional regimes encouraging participation and association (Bærenholdt and Aarsæther, 2000). Norris (2003)

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[212] The Scandinavian countries group includes Norway, Denmark, Sweden, Finland and Iceland.

[213] Zak and Knack (2001) shows some anecdotes comparing the high trust level in Scandinavian cities with the low trust of New York. Uslaner (2003) remarks as the most trusting countries the Nordic nations and the Netherlands while in the opposite side there are Brazil, the Philippines, Peru, Colombia and Turkey.

[214] The Gini indices are for the period 1973/74 in Andalusia 0.3235 and in the Basque Country 0.2856, in 1990/91 Andalusia 0.2919 and Basque Country 0.2565. (Goerlich and Mas, 1999).

measures associational activism and social trust concluding that Norway and Sweden are among the countries showing clear high levels for both factors. This situation is also tested again in the countries clusters obtained in Bjørnskov and Svendsen (2003), where the countries with the highest social capital among the thirty one analysed countries, by applying several social capital indicators, are Switzerland, Netherlands, Denmark, Sweden, Norway, Finland and Iceland.

All arguments expressed in section 5.2 relating trust and development can be applied to the comparison between the two selected regions. The specific explanations should be found by looking at the particular character of the regional business culture, institutional relations and region specialisation, among other aspects, as has been done in this research. Particularly, the Basque region has evidently higher schooling and investment rates,[215] more innovation adoptions and lower Gini indices (more income equality).

All the arguments found in the fieldwork, in the regional data, and also in the literature review are in accordance with the hypotheses in this research. In general, social capital is more focused in trust for low-income areas, while high quality informal social capital enhances formal social capital and both are positively related to development. At regional level, to have strong trusting relationships with a wide range of institutions is economically very helpful as compared with the situation where strong trusting relationships are confined to a very limited group of local people.

Trust has been used in several studies as a social capital proxy because it is one of its main aspects, also specific and more complex social capital indices have been built and applied in several cases. For any of the social capital measures, the social capital positive effect on development has been found for developed countries, mainly through its decisive impact in investment (Knack, 2001), education (La Porta et al, 1997) and transaction costs (Fukuyama, 2000). One aspect of trust, and of social capital, is the outsourcing process, mainly followed for the service side of the production processes. Services, then, act as bridges through structural holes in the whole net stand by the regional social capital. All this process of increasing social capital quantity and quality

[215] Schooling rates after the compulsory period.

and increasing development is intensified after a first stage in which technical links and diversification are the focus for regional growth and development. The described process has been found in the comparison between Andalusia and the Basque Country by using diverse information that corroborates the proposed hypotheses.

Annex 5.1: Components of groups in the Basque Country metal-mechanical productive system

Information, co-operation and entrepreneurship

- EICs
  - Basque Country EU-Administrative
  - Camaranet
- ZAINTEK
- Seed Capital Bizkaia
- CEEIs
  - BEAZ
  - CEIA
  - BIC-BERRILAN
- EUSKALIT
- LANKIDETZA

Associations

- ASCENE
  - ARAEX
  - AUXIN
  - FASTENEX
  - MEXIM
  - COFIEX
  - PRODESO
  - BAPCO
  - INASHMAC
  - URRKASTING
  - INCEMIN
  - COINAMOBEL
  - DOSYMA
  - COMTEC
  - SISCOMP
  - BEEX

- CONFESBAK
  - ADEGI
  - CEBEK
  - SEA
- ASLE
- CSCE
- ADIDME

Promotion and development

- GARAPEN
  - UGASSA
  - Active Bidasoa
  - Alava development agency
- SPRILUR
- SPRI
- CEDEMI

Education and training

- HOBETZU
- HETEL
- IKASLAN
- ZABALNET
- DEUSTO U.

Exhibitions

- CINTEX
- FERROFORMA
- SINAVAL
- SUBCONTRATACIÓN
- International machinery and technology exhibition

Annex 5.2: Components of groups in the Basque Country agro-food productive system

Science, technology and innovation Basque Net (SARETEK)

- Innovation entities federation
  - AZTI
- Technology parks net
  - Zamudio
  - San Sebastian
  - Álava
- EITE
  - GAIKER
  - INASMET
  - LEIA
- Education and training centres
  - UPV
  - Mondragón U.
- Technology and innovation institutions
  - NEIKER
- AZARO Foundation
- CITMA

Associations

- ASCENE
  - ARAEX
  - PRODESO
- CONFESBAK
  - ADEGI
  - SEA
  - CEBEK
- ASLE
- ASCARVE

Information, co-operation and entreprenurship

- EICs
  - Basque Country EU-Administrative
  - CAMARANET
- ZAINTEK
- Seed Kapital Bizkaia
- CEEIs
  - BEAZ
  - CEIA
  - BIC-BERRILAN
- LANKIDETZA

Policy clusters

- Knowledge and firm management

Promotion and development

- GARAPEN
  - Alava development agency
- SPRILUR
- SPRI
- CEDEMI

Mondragon co-operative corporation

- Training centres
  - Mondragon University
  - Otalora
  - Lea-Artibai
  - Mone
- Research centres
  - IKERLAN
  - MIK
- Distribution group
  - Distribution
  - Agro-food

Education and training

- IKASLAN
- HOBETZU

Exhibitions

- EUROALIMENTACIÓN
- EUROHOSTELERÍA

Agriculture institutions

- Foundations
  - ELIKA
  - KALIKATEA
- NEKANET
- Origin denomination regulating councils
  - Idiazabal
  - Bizkaiko Txakolina
  - Getariako Txakolina
- Wholesale markets
  - Mercabilbao

Annex 5.3: Components of groups in Andalusia agro-food productive system

Associations

- FAECA
- Artesanos de la mar
- AFACA
- Fundación Oliva

Education and training

- U. Almería
- U. Cádiz
- U. Córdoba
- U. Sevilla
- U. Jaén
- U. Huelva
- U. Granada

Exhibitions

- AGROGANT
- Expoliva
- Feria cinegética

Agriculture institutions

- Origin denomination regulating councils
    - Baena
    - Sierra de Segura
    - Jerez y Manzanilla
    - Brandy Jerez
    - Jamón de Huelva
    - Málaga
    - Montilla-Moriles
- Wholesale markets
    - Mercagranada
    - Mercasevilla
    - Mercajerez
    - Mercamálaga
    - Mercacórdoba

Annex 5.4: Components of groups in Andalusia metal-mechanical productive system

Innovation and technology Andalusia net (RAITEC)

- Technology centres
  - AICIA
  - IAT
  - CITIC
  - CIT
- Technology parks
  - Cartuja
  - Málaga
- CEEIs
  - Bahía de Cádiz
  - Euro CEI
  - BIC Euronova
- Training
  - Instituto de la calidad
  - FUECA
  - EOI
  - ENJ
- Promotion and development
  - DESADOS
  - Huetor Tajar
  - Alcalá innova
  - Montes orientales
  - Arahal
  - SODEMAR
  - IFA
  - SOPDE
  - Jun
  - Sevilla global
  - Bajo Guadalquivir

- Associations
  - AEPNA
  - CEMER
  - CEA
  - ETICOM
- Advising
  - CITPIA
  - Cinde consulting
- Technology transfer entities
  - Mediterranean foundation. Almería University
  - UNISOC
  - CESEAND
  - COGESUR

Associations

- RedCESEA
  - CEJ
  - CGE
  - CEM
  - CEC
  - CECO
  - ASEMPAL
  - FOE
  - CES
- CONSTRUCTOR

Education and training

- U. Cádiz
- U. Córdoba
- U. Sevilla
- U. Huelva
- U. Granada

Exhibitions

- FERICOR
- MADEXPO
- CONSTRUCTOR
- CONSTRUSUR

Annex 5.5: Basque Country institutions acronyms

Bidasoa Activa: Bidasoa development agency.

ADEGI: Guipuzcoa employers association.

ADIMDE: Basque maritime industries association.

ARAEX: Rioja Alavesa exports group.

ASCARVE: Dealers, cold-storage plants and cattle quartering plants association.

ASCENE: Export consortia association.

ASLE: Association of worker-owned companies of the Basque Country.

AUXIN: Common export department metallic products.

AZTERLAN: Metallurgy research centre.

BAPCO: Basque paper consortium.

BEAZ: Vizcaya innovation and firms centre.

BEEX: Bureau of environmental expert.

BIC-BERRILAN: Innovation and firms centre.

CADEM: Energy development and saving centre.

CAMARANET: Vizcaya Internet accesses services.

CEDEMI: Left bank business development centre.

CEBEK: Bizcaya business confederation.

CEEI: Firm and innovation European centres.

CEIA: Alava innovation and firms centre.

CEIT: Guipuzcoa technical research and studies centre.

CIDEMCO: Technology research centre.

CIDETEC: Electro-chemical technology research centre.

CINTEX: Construction exhibition.

CITMA: Environment technological innovation foundation.

COFIEX: Office furniture export group.

COINAMOBEL: Furniture auxiliary industries corporation.

CONFESBAK: Basque business confederation.

COMTEC: Industrial representatives society.

CSCE: Euskadi co-operatives superior council.

CTA: Aeronautic technology centre.

Deusto U.: Deusto University.

DOSYMA: Door systems manufacturers.

DZ: Design centre.

EIC: Advising, orientation and information European centres.

EITE: Technology innovation centres Basque association.

ELIKA: Basque foundation for food safety.

ENERLAN: Energy technologies development centre.

ERAIKER: Master builders centre.

ESI: European Software Institute.

EUSKALIT: Quality Basque foundation.

EUSKOIKER: University-firm research foundation.

EUVE: Virtual engineering technology centre.

FASTENEX: Screw export group.

FATRONIK: Machinery technology centre.

FERROFORMA: Ironmongery international exhibition.

GAIKER: Innovation technology centre.

GARAPEN: Basque association development agencies.

GUASCOR I+D: Research and development centre Guascor group.

HETEL: Association of vocational training centres of the Basque Country.

HOBETUZ: Basque foundation for continuous professional training.

IDEKO: Machine-tool technology centre.

IKASLAN: Association of professional technical training institutes.

IKERLAN: Technology centre.

IKT: Engineering and agriculture consulting.

INASHMAC: Construction machinery consortium.

INASMET: Technology foundation.

INCEMIN: Santa Barabara's crushing components.

INVEMA: Machine-tool research foundation.

ITEA: Steen structure Basque institute.

KALIKATEA: Foundation for the enhancement, promotion and development of quality Basque food products.

LABEIN: Technology centre.

LANKIDETZA: Firm co-operation.

LEIA: Firm technology transformation and environment improvement foundation.

MENDIKOI: Rural training, promotion and development.

MEXIM: Engineering export group.

Mondragon U.: Mondragon University.

MTC: Maier technology centre.

NEIKER: Agriculture research and development Basque institute.

NEKANET: Basque rural areas information service.

PRODESO: Cumulated knowledge transfer entity.

ROBOTIKER: Information and communication technology centre.

SAIOLAN: Mondragon innovation and firms centre.

SEA: Alava businessmen.

Seed capital Bizkaia: Venture capital fund.

SINAVAL: International naval exhibition.

SISCOMP: Subcontracting companies export organisation.

SPRI: Industrial restructuring and promotion society.

SPRILUR: Industrial infrastructures, land and buildings public corporation.

SUBCONTRATACIÓN: International subcontracting and firm co-operation exhibition.

TECNUM: Navarra University technological campus in San Sebastian.

TEKNIKER: Research, development and innovation technology centre.

UGGASA: Urola Garaia development agency.

UNITEC: Technological innovation spreading, development and management association.

UPV: Basque Country University.

URRKASTING: Specialised workshops subcontracting exports.

VICOMTech: Centre for visual interaction and communication technology.

ZABALNET: Virtual professional training centre.

ZAINTEK: Competitive intelligence and technology invigilation service.

Annex 5.6: Andalusia institutions acronyms

AEPNA: Andalusia natural stone business association.

AFACA: Association for animal feeding production firms.

AGROGANT: Agriculture and hunting exhibition, Malaga.

Arahal: Economic and social development in Arahal.

AESMA: Andalusia environment firms association.

AICIA: Association of research and industrial co-operation of Andalusia.

CAAE: Organic agriculture and livestock.

CEA: Andalusia firms confederation.

CEMER: Andalusia wood consortia.

CESEAND: Link centre for innovation in the south of Europe.

CIT: Innovation and Technology Forosur Centre.

CITAGRO: Agro-food innovation and technology centre.

CITIC: Technology centre.

CITPIA: Centre for technology information and industrial property of Andalusia.

COEXPHAL I+D: Innovation and technology centre in Andalusia federation of agriculture co-operative firms.

COGESUR: South Geo-technical centre.

CONSTRUCOR: Córdoba construction firms association.

CONSTRUSUR: Construction exhibition.

DAP: Public firm for agricultural and fishing development in Andalusia.

DESADOS: Dos Hermanas local economic development society.

ENJ: Jerez management school.

EOI: Industrial organisation school.

ETICOM: Information and communication technologies firms association.

FAECA: Andalusia federation for agrarian co-operatives.

FERICOR: Cork and cork tree exhibition.

FUECA: Cadiz University-Firm Foundation.

IAT: Andalusia technology institute.

IFA: Andalusia Foment Institute.

Instituto de la calidad: Institute for quality.

MADEXPO: Wood exhibition.

PRODTI: Foundation for research promotion and industrial technological development.

SODEMAR: Society for Marchena development.

SOPDE: Planning and development society, Malaga.

UNISOC: University-society foundation. University Pablo de Olavide. Sevilla.

U. Cádiz: University of Cádiz.

U. Córdoba: University of Córdoba.

U. Granada: University of Granada.

U. Huelva: University of Huelva.

U. Sevilla: University of Sevilla.

Annex 5.7 Firms interviewed

Basque Country

Irizar S. Coop.

Ormaiztegi, Guipuzcoa, Basque Country.

Founded in 1889.

Main activity: Luxury buses production.

Number of workers: 630.

Interviewed person job title: Managing director.

Eroski Coop.

Elorrio, Vizcaya, Basque Country.

Founded in 1969.

Main activity: Commercial distribution.

Number of workers: 29,013

Interviewed person job title: Communication chief executive officer.

Caja Laboral Popular Coop. de Crédito

Arrasate-Mondragon, Guipuzcoa, Basque Country.

Founded in 1959.

Main activity: Financial markets.

Number of workers: 1,550.

Interviewed person job title: Marketing executive officer.

Larón, S.A.

Lemona, Vizcaya, Basque Country.

Founded in 1973.

Main activity: Stone crushing machines.

Number of workers: 49.

Interviewed person job title: Chief executive officer.

CEDEMI, S.A.

Barakaldo, Vizcaya, Basque Country.

Founded in 1997.

Main activity: Business development centre.

Number of firms: 27.

Interviewed person job title: Assistant executive officer.

Zamudio Technology Park

Zamudio, Vizcaya, Basque Country.

Founded in 1985.

Number of firms: 120.

Number of workers: 5,260.

Interviewed person job title: Director.

Andalusia

DAP, S. A.

Seville, Andalusia.

Founded in 1999.

Main activity: Public firm for the agricultural and fishing development of Andalusia.

Number of workers: 838.

Interviewed person job title: Province co-ordinator.

Andalusia Technology Park

Malaga, Andalusia.

Founded in 1992.

Number of firms: 101.

Number of workers: 1,701.

Interviewed person job title: Marketing executive officer.

Consejo Regulador de la Denominación de Origen Baena

Baena, Córdoba, Andalusia.

Founded in 1978.

Main activity: Regulating council for the Baena olive oil origin denomination.

Number of firms: 29.

Interviewed person job title: General secretary.

S. C. A. O. San Isidro

Baena, Córdoba, Andalucía.

Founded in 1944

Main activity: Olive oil milling plant.

Number of associated members: 830

Interviewed person job title: President.

S. C. A. O. Nuestra Señora de la Consolación

Baena, Córdoba, Andalucía.

Founded in 1961

Main activity: Extra virgin olive oil sales.

Number of associated members: 862

Interviewed person job title: President.

S. C. A. O. Germán Baena

Baena, Córdoba, Andalusia.

Founded in 1972

Main activity: Extra virgin olive oil commercialisation.

Number of associated members: 725

Interviewed person job title: Chief executive officer.

S. C. A. O. Nuestra Señora de Guadalupe

Baena, Córdoba, Andalucía.

Founded in 1944

Main activity: Olive oil milling plant and extra virgin olive oil sales.

Number of associated members: 900

Interviewed person job title: President.

S. C. A. O. Nuestra Señora del Rosario.

Baena, Córdoba, Andalucía.

Founded in 1944

Main activity: Olive oil milling plant.

Number of associated members: 1,509

Interviewed person job title: President.

Murcia

Duralmond, S. L.

Lorquí, Murcia.

Founded in 1998.

Main activity: Furniture and roof and wall covers.

Number of workers: 14

Interviewed person job title: Marketing executive officer.

Annex 5.8: Interview outline and questionnaire format

INTERVIEWS

Firms and interviewee data

Institution title/Location/Year of foundation/Main activity/Number of workers-firms

Interviewed person job title/Number of years of the interviewee in the firm

Interview outline

Territorialisation

- Situation
    - Benefits derived from the firms' present location.
    - Intermediate consumptions acquisition at local or regional level.
    - Capital resources acquisition at local or regional level.
    - Technology acquisition at local or regional level.
    - Intermediate output sales to local or regional firm's customers.
    - Final product sales to final demand at local/regional/national/international level.
    - Business services acquisition from local firms.
    - Local infrastructure use.
- Evolution
    - Increasing/same/decreasing.
- Results
    - Higher specialisation.
    - Higher efficiency.
    - Lower costs.
    - More and better information.
    - Higher profits.

Innovation

- Situation
    - Elaboration/adoption/incorporation of innovation.
    - Types of innovations being developed:
        - Process
        - Product
        - Organisation
        - Opening to new markets
        - New raw materials resources identification
        - Workers training
        - Exhibitions participation
- Evolution
    - Increasing/same/decreasing
- Results
    - Higher specialisation.
    - Higher efficiency.
    - Lower costs.
    - More and better information.
    - Higher profits.

Co-ordination

- Situation
    - Co-ordination with other local/regional/national/international firms by making use of trust.
    - Confident or suspicious about co-ordination with other firms.
    - Co-ordination tasks with:
        - Customers
            - Other firms as customers through market impersonal relationships.
            - Final demand through market impersonal relationships.
            - Retail sellers through market impersonal relationships.
            - Obtaining relevant information from the customer through personal relationships, when compared to a pure market relation.

- Sales through Internet.
- Access to new customers allowed by the relationships with existing customers.

- Suppliers
  - Formal or informal relationships.
  - Collaboration in the development process of the acquired product.
  - Trying to avoid behaviours that could damage each other or take advantage of the other part/fulfilment of promises/sharing the same objectives/accepting and understanding the other part objectives.
- Competitors
  - Type of relationship with them.
  - Formal or informal relationships.
  - Pure impersonal competition.
  - Collaboration in marketing/R+D.
  - Outsourcing.
  - Importance of personal relationships for the firm's success.
  - Learning from each other/copying ideas from each other.
  - Sharing or facilitating the local business services hiring.
  - Sharing technical information.
  - Taking advantage/sharing/preparing local training courses.
  - Creating/taking advantage of opportunities for co-operative sales or purchases.
  - Creating opportunities for co-operative marketing.
  - Relying on the competitors for problems solving.
- Scientific experts from outside the firm (like University)
  - Collaboration in the design of innovations.
- Researchers from outside the firm
  - Joint participation with the research centre.

- Evolution
  - Increasing/same/decreasing

- Results
    - Higher specialisation.
    - Higher efficiency.
    - Lower costs.
    - More and better information.
    - Higher profits.

Outsourcing

- Situation
    - Outsourcing of productive tasks that could be obtained cheaper and more specialised, or developing the whole productive process at home.
        - Services.
        - Some parts of the whole previous productive process.
    - Changing towards a concentration in specific tasks of a particular part of the productive process where the firm has competitive advantages.
    - New relationships or maintaining the same links after the outsourcing.
- Evolution
    - Increasing/same/decreasing
- Results
    - Higher specialisation.
    - Higher efficiency.
    - Lower costs.
    - More and better information.
    - Higher profits.

Relationships with regional institutions

- Situation
    - Relationships with other institutions:
        - Technological parks
        - Universities
        - Innovation centres.
        - Advising centres and industry organisations.
    - Membership in any association: firms/exporters/sector cluster.

  - Increasing exploitation of information flows thanks to institutional links.
  - Access to more innovations.
  - Participation in training activities.
  - Participation in joint projects with other firms.
  - Increasing the firm's credibility and trust with other institutions/firms in the regional productive system.
- Evolution
  - Increasing/same/decreasing
- Results
  - Higher specialisation.
  - Higher efficiency.
  - Lower costs.
  - More and better information.
  - Higher profits.

Suppliers

- Are they innovative?
- Do they outsource?
- Are they specialised?
- Substituting suppliers and looking for the most innovative, outsourcers, and specialised.
- Co-ordination.

Social capital

- Using contacts to hire new workers.
- Using contacts to get strategic information.
- Relationships inside the firm: helping in the knowledge creation and diffusion.
- Informal relationships and particular environment inside the firm.
- Events allowing for socialisation inside the firm.
- General feeling about trust with suppliers/customers/competitors.
- Evolution, within the last few years, of the trust relationships maintained with suppliers/customers/competitors/other institutions.

- Unpleasant and conflictive or pleasant and without problems relationships with customers/suppliers/competitors.
- Explicit consideration of the importance of social capital for the firm. Specific or strategic activities in the firm to maintain it and increase it.

Technological parks specific questions

- Relative number of research/training/technology/advising centres. Evolution of this number.
- What firms in the park look for and find.
- Park working properly and evolution.
- Relative number of firms relating with the centres on the park, evolution and satisfaction.
- Importance of informal and trust relationships.
- Effects for the efficiency of the firms, effects from a positive externalities view.
- Evaluation of the effect of belonging to the park for the firms and area success.

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QUESTIONNAIRE

Name of the firm:
Main activity:
Job title for the person filling in the questionnaire:

Questions 1 to 7 refer to the firm's location and to the geographical scope of its commercial relationships

1. Most of your intermediate consumptions and capital resources are acquired at the following level:

Local ☐ Regional ☐ National ☐ International ☐

2. How has the acquisition of intermediate consumptions and capital resources evolved, in every of the following levels? (1 decreasing, 2 same, 3 increasing)

Local	1 ☐	2 ☐	3 ☐
Regional	1 ☐	2 ☐	3 ☐
National	1 ☐	2 ☐	3 ☐
International	1 ☐	2 ☐	3 ☐

3. Your customers are mainly located at the following level:

Local ☐ Regional ☐ National ☐ International ☐

4. The geographical location of your customers (market) has been evolving in every level: (1 decreasing, 2 same, 3 increasing)

Local	1 ☐	2 ☐	3 ☐
Regional	1 ☐	2 ☐	3 ☐
National	1 ☐	2 ☐	3 ☐
International	1 ☐	2 ☐	3 ☐

5. The business services that you hire are mainly acquired at the following level:

Local ☐ Regional ☐ National ☐ International ☐

6. How has the acquisition of business services for your firm evolved? (1 decreasing, 2 same, 3 increasing)

Local	1 ☐	2 ☐	3 ☐
Regional	1 ☐	2 ☐	3 ☐
National	1 ☐	2 ☐	3 ☐
International	1 ☐	2 ☐	3 ☐

7. Give a value to the positive consequences of your present location for the efficiency of your firm: (0 none - 4 high)

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Question 8 refers to innovation activities made by your firm

8. Does your firm undertake any of the following types of innovation? (0 never, 1 decreasing, 2 same, 3 increasing)

Process	0 ☐	1 ☐	2 ☐	3 ☐
Product	0 ☐	1 ☐	2 ☐	3 ☐
Organization	0 ☐	1 ☐	2 ☐	3 ☐
Opening to new markets	0 ☐	1 ☐	2 ☐	3 ☐
Identification of new resources	0 ☐	1 ☐	2 ☐	3 ☐
Workers training	0 ☐	1 ☐	2 ☐	3 ☐
Exhibitions participation	0 ☐	1 ☐	2 ☐	3 ☐

Questions 9 to 24 refer to the co-ordination in the firm, competitors, customers and suppliers

9. Which is the dominant structure of your firm?

Hierarchical ☐ Horizontal Co-ordination ☐

10. Give a value to the weight of relationships inside of your firm based on trust: (0 inexistent – 4 high)

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

11. Does your firm co-ordinate with other firms in the same sector by using trust? (0 never, 1 decreasing, 2 same, 3 increasing)

0 ☐ 1 ☐ 2 ☐ 3 ☐

12. Give a value to the weight of relationships maintained with other firms of the same sector based on trust: (0 inexistent – 4 high)

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

13. Which type of relationship do you have with the other firms working in the same productive sector as yours?

Formal personal relationships ☐ Informal personal ☐ Impersonal competition ☐

14. Does your firm collaborate, through joint projects, with firms working in the same productive sector, in any of the following aspects?

Marketing ☐ R+D ☐ Publicity ☐ Subcontracting ☐ None ☐

15. Give a value to the importance of personal relationships for the success of your firm: (0 none – 4 high)

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

16. According to the relationships that your firm has with other firms working in the same productive sector, to what degree do the following apply? (0 none, 1 decreasing, 2 same, 3 increasing)

You learn from each other	0 □	1 □	2 □	3 □
You copy ideas from each other	0 □	1 □	2 □	3 □
The hiring of local business services is more efficient	0 □	1 □	2 □	3 □
You share technical information	0 □	1 □	2 □	3 □
You collaborate in the elaboration and participation of training courses	0 □	1 □	2 □	3 □
Opportunities for co-operative sales or purchases are created or used	0 □	1 □	2 □	3 □
Opportunities for co-operative marketing are created	0 □	1 □	2 □	3 □

17. If you have to face a new problem, can you rely on any other firm of the same productive sector to help you in solving it?

Yes □ No □

18. Which type of relationship do you have with your customers?

We co-ordinate in the product development process □ Market impersonal relationships □

19. Do you get relevant information from the direct relationship that you maintain with your customers?

Yes □ No □

20. Have the relationships you have with your existing customers allowed you to access new customers?

Yes □ No □

21. Give a value to the weight of relationships with your customers based on <u>trust</u>: (0 none – 4 high)

0 □ 1 □ 2 □ 3 □ 4 □

22. Which type of relationship do you have with your suppliers?

Formal □ Informal □ Both □

23. Do you participate, in any form, in the development of the products that you acquire from your suppliers?

Yes □ No □

24. Give a value to the weight of relationships with your suppliers based on <u>trust</u>: (0 inexistent – 4 high)

0 □ 1 □ 2 □ 3 □ 4 □

<u>Questions 25 to 27 refer to the outsourcing process in your firm</u>

25. Do you hire other firms for productive tasks that your firm used to make itself?

Service tasks □ Some parts of the productive process tasks □ No □

26. If you have outsourced productive tasks, you have done it with firms which of the following best describes:

That already had a trade link with my firm ☐ New firms ☐ Both ☐

27. ¿Has the outsourcing had a positive effect for the efficiency and the profits of your firm?

Yes ☐ No ☐ Do not know ☐

Questions 28 to 32 refer to the institutional relationships maintained by your firm

28. Does your firm maintain any relationship with any of the following institutions?

Technology parks ☐ Universities ☐ Innovation Centres ☐ Advising Centres ☐

29. Are you a member of any association? (Industry organisations, exporters, sector policy cluster):

Yes ☐ No ☐

30. Institutional relationships and association have allowed you to:

Improve the information flows exploitation ☐
Increase the access to innovations ☐
Increase the participation in training activities ☐
Develop joint projects with other firms: ☐

31. Has the use of those institutional relationships been increasing?

Yes ☐ No ☐

32. Have your institutional relationships had a positive effect on the efficiency and profits of your firm?

Yes ☐ No ☐ Do not know ☐

6. CONCLUSIONS

This work has analysed productive systems from a structural relational perspective. This has been done theoretically and also empirically, discussing the adoption of the network perspective and relating the structure and evolution of productive systems with economic growth and development.

In the two first core chapters (two and three), the network perspective has been discussed as being the most appropriate approach to analyse economic systems, and therefore to analyse groups of interrelated firms and institutions at a micro level and productive branches at a more macro level. The distinctive character of this methodology is in its structural and relational nature, focused on the relationships maintained among the actors under study.

Economic organisations, acting as purposive actors, are embedded in wider social structures and therefore the approach and concepts offered by the network perspective are available for their study. In fact, there is a part of the network analysis which focuses on the study of economic organisations and proposes exchange theories. However, the works in this respect are very limited and they have been mainly applied to study the internal structure of firms where information is being exchanged and, in some cases, their links with other firms are also considered.

The application of the network perspective to analyse socio-economic systems has been examined, to study the whole set of actors constituting them. In that form, relationships, instead of attributes, and purposive relational actors, instead of independent agents are considered. Moreover, the application of this perspective benefits from the contributions of economics and sociology, recovering the social character of economics and the importance of the historical and geographical context. Therefore, this is an interdisciplinary analysis.

When studying economic systems, there appear several concepts in the relevant literature to define them. All the definitions refer to sets of exchanging firms and some of them include other institutions. Of all of them the productive system concept considers the widest collection of institutions including formal and informal relationships, therefore reflecting the system's structure in a more realistic form. The productive system concept has been related to a particular geographical context so as to account for the area's specificities explaining its structure and evolution. Therefore, regional productive systems have been selected to analyse them in the empirical part of the research.

Regional productive systems and their relationship with differentiated development paths have been studied from a network perspective. The data used in the empirical part are at a regional level and correspond to input-output links, institutional information, economic history, interviews made at selected firms, and other quantitative and qualitative information. The main methods that have been applied to those data for the study of regional productive systems, according to the adopted methodological perspective, is social network analysis focused on the structure of relational systems. The most important measures and concepts have been explained in chapter three, dedicated to the data and methods explanation. Input-output indices have been also discussed in the chapter as they have been applied in a complementary form. Those indices have been usually used to study trade relationships among productive branches. However, in this research the proposition that an alternative method is necessary to study transacting actors from a relational structural view is defended. Therefore, social network analysis is the main method and input-output indices have been used complementarily.

To test proposed hypotheses in the empirical part mechanism causality has been the adopted perspective, because the micro units making productive systems are firms and institutions. Therefore, it is necessary to explain the behaviour at system level in the sequence of events taking place at firm and therefore more micro, level. For this reason, direct observations have been obtained from interviews made at a set of selected firms.

The methodological discussion offered in the two first core chapters has been applied in a second empirical part, made of the two following chapters, to analyse the relationship taking place between productive system's structures and evolution and development at a regional level. Therefore, before establishing and contrasting those relations, regional productive systems have been identified. Two Spanish regions have been selected for this purpose, Andalusia and the Basque Country. The first is a very extensive region in the south of Spain and it is considered to be among the less developed regions in the country. The second is a small northern region, included among the most developed and dynamic Spanish regions.

The first step in the study of regional productive systems has been the identification of their technical part: regional production systems. With the use of historical information, descriptive statistics, social network analysis, input-output indices and a specific algorithm two regional production system, made of input-output branches, have been selected in each region: the agro-food production system and the metal-mechanical production system. Attending to a regional historical context the agro-food system has always been a key in the socio-economic fabric of Andalusia. The metal-mechanical branches also had a relevant role for the region in the past, although at present they are not clearly inserted in the economic structure of the region. Both systems have nevertheless been studied for comparative purposes. In the case of the Basque Country its economy is clearly focused, historically and also at present, in branches belonging to the metal-mechanical system. Nevertheless, an agro-food system can also be identified and therefore compared to the system in Andalusia, although its importance for the regional economy is clearly less evident.

The structures of the identified agro-food system in Andalusia and of the metal-mechanical system in the Basque Country are essential for the regions' development and growth, owing to their high productive specialisation. The characterisation of the systems shown that the agro-food system in Andalusia has a very cohesive structure, but when considering its embedding in the whole productive net it is not solidly inserted on it, because of its weak and sparse links with other branches and systems. The metal-mechanical system in the Basque Country, however, shows a clear cohesion with the whole regional productive structure. Those conclusions are of great importance because they have consequences for the differentiated regional development processes. Nevertheless, additional relevant implications appear once institutional information and links are added to constitute regional productive systems.

There are institutions in both regions maintaining constant links with the firms forming the branches included in the two selected production systems. Some of those institutions have a public character while others are private. However, the Basque systems are denser and more complex than the systems in Andalusia. The main differences appear from the quantity of innovation and training institutions linked to the productive branches in which the regions are specialised. Another important difference emerges from the co-operative and associative culture of the Basque Country that has led to the creation of a co-operative corporation, innovation centres groups, or a technology parks net.

Once the productive systems have been built, a set of hypotheses has been proposed for testing through mechanism causality. The hypotheses refer to the systems structure and evolution in regions belonging to developed countries but with different dynamism and development. They are tested with observations from Andalusia, a less developed and less dynamic region, and the Basque Country, a more developed and more dynamic region. The different development and dynamism has been proved with indicators referred to GDP *per capita* variations, employment and population evolution, post-compulsory education rates, life expectancy and total and private R+D expenditures.

After the hypotheses testing it can be asserted that, in the development process, regions in a less advanced development stage focus their economic growth in the diversification of their production structure. Therefore, there is an increase in the complexity and density of their production structures. The development process focuses on technological links, with innovations embodied in the productive processes. As regions go on in their development process, attaining more advanced development stages, the increasing quantity and quality of non-technical links augment the complexity of their regional systems, through institutional relationships. Therefore, more developed and dynamic regions, with higher specialisation, have denser and more complex productive systems. At the same time, service branches appear as strategic branches constituting bridges through structural holes in the whole structure enhancing a post-industrial economy. The main firm’s behaviour increasing the number of links with services is the outsourcing of the services’ tasks from their productive processes.

The set of relationships constituting the regional productive systems, sustained by the regional social capital, has a different impact on the regional economic performance depending on its formal and informal aspects. In less developed regions, when compared with more developed regions, the social capital having a greater impact on their economy is its informal institutional links side, but the situation changes with regional progress and dynamism, in the sense that high quality informal social capital enhances high quality formal social capital. More dynamic regions, *ceteris paribus*, attain high quality informal social capital that enhances the creation of formal social capital. At the same time, more developed regions, *ceteris paribus*, enjoy higher levels of social capital, with its formal part having greater effects on economic performance than in less developed regions. Causality goes in both directions; higher development implies more high quality social capital and the reverse.

The most developed regions show an economy affected more by the social capital side made of formal institutional links, when compared with less developed regions. Therefore, in less advanced stages the main aspect of social capital working in the region is tacit norms, informal co-operation and trust. The development process makes that trust and durable relationships push the creation of stable links with formal institutions.

This is the situation observed when comparing Andalusia and the Basque Country. There is a development process in which at the beginning productive systems are focused on diversification and technical links, as observed in Andalusia, maintaining the productive specialisation of the region. Then, the specialisation is more intense with service branches occupying strategic positions linking different subsystems, the most efficient firms facilitates this part of the processes by outsourcing services like most of the analysed firms have been doing in the Basque Country. As development goes on non-technical links appear with more importance, constituting increasingly solid productive systems. The non-technical links having a greater impact on the region's economy are first informal links based on trust, but they enhance the creation of formal links with institutions.

In Andalusia, formal institutional relationships are mainly maintained with public institutions having a very important presence in the regional economic structure. Co-operation and trust links work, but with a marked local character where reputation is also very important. In the Basque Country, trust informal links has led to the creation and maintenance of formal institutional relationships, where co-operation is very important for efficient productive processes. In the search for this efficiency, firms are highly specialised, outsourcing most of the service tasks, and establishing solid links with regional institutions like technology parks, innovation and training centres. The co-operative organisational system is also much extended according to the regional business culture. Therefore, co-operation through formal and informal relationships is present in the efficiency path.

After the fieldwork, the study of other significant case studies and the relevant literature review, it can be deduced that there is a positive relationship between the density of the regional production structure and development in less advanced development stages and also with the appearance of services as key branches. There is also a positive relationship between development and social capital that, in less developed regions depends more on its informal side, and in regions where a higher development has been attained those informal links, if they are of high quality, enhance the creation of formal institutional links. More dynamic regions, *ceteris paribus*, facilitate the transformation of informal social capital into formal social capital, enhancing the region's development.

Regions showing institutional networks based on co-operation, with a solid high quality social capital, will help for the flow of information, tacit knowledge, disembodied technology, and for the maintenance of reputation and long term trade links. Those regions will enjoy endogenous development, where the territory has a crucial role. Those regions will experience a development path allowing them to attain more sustained, durable and successful development and growth.

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