
Università degli Studi di Bergamo

# The Diffusion of New Collaborative Approaches in Technology Intensive Contexts: Literature Analysis and Empirical Evidences on Virtual and Extended Enterprise Models

Doctoral Thesis in

Economics and Technology Management

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# EXECUTIVE SUMMARY

## 1. Theoretical background

In today's business environment, companies are faced with dramatic pressures. In general, four interrelated major 'forces' put additional requirements on today's enterprises (Sarli et al., 2007):

- globalisation;
- focus on core competencies through outsourcing;
- customisation;
- impact from the development in technologies.

These four trends are not independent from each other. Globalisation reduces the entrance barriers to the market for competitors leading to a fiercer competition within many industries (Levitt, 83; Sari et al., 2007). Therefore, companies have been prompted to establish alternative management strategies in order to introduce more customised products with high quality, manufactured at the lowest cost and by continually reducing the production times (Prahalad and Ramaswamy, 2000; Gunasekaran, 2008; De la Fuente, 2010). As a consequence, companies are forced to reconsider the aim of their businesses and focus on what they do best (Sari et al., 2007). This means identifying and nurturing their core competencies (Hamel and Prahalad, 1990) and outsourcing non-core activities to external partners with an increasing dependency on a network of suppliers (Cheng and Popov, 2004). While, traditional management theory has focused on the individual firm as the competitive unit in any industry (Contractor and Lorange, 1988; Porter, 1980), given the interdependence of members in the supply chain, the competitive success of a firm is no longer only a function of its individual efforts (Christopher, 1998; Clark and Hammond, 1997). Competitive success, to a large extent, depends on how well the entire supply chain delivers value to its ultimate consumers, relative to its competing supply chains (Christiaanse and Kumar, 2000).

In general, technology improvements and developments within information and communication technology (ICT) can be seen as an enabler of the other three 'forces' (Sari et al., 2007). ICTs have reduced some of the barriers towards

globalisation, for instance, by enabling people to communicate and interchange electronic documents and models online (Chae et al., 2005). The technological developments have also reduced cost and time of goods' transport as well as people from one place to another (Sari et al., 2007; Cash and B. Konsynski, 1985). On the other hand, ICTs transform organisational boundaries as they 'extend' the enterprises leading collaboration and relationships to new and higher levels (Cash and Konsynski, 1985; Konsynski, 1993; Elofson and Konsynski, 1993; Christiaanse and Kumar, 2000).

To summarise, companies to a larger extent have to be global, focus on their core competencies, and partner up with companies that possess competencies that complement their own competences and with whom customised solutions can be made within a competitive 'time to market' (Sarli et al., 2007).

These new requirements put the traditional business models under pressure in more and more industries. As a result, new more collaborative business models have emerged, where different enterprises coordinate the necessary means to accomplish shared activities or reach common goals (Cardoso and Oliveira, 2005) aiming at the sustenance of flexibility and innovation (Pollalis and Dimitru, 2008).

These changing dynamics of business has been the focus of managerial debate in the past few years. Practitioners and scholars extensively talk about alliances, networks, and collaboration among companies (Prahalad and Ramaswamy, 2000).

The concepts of *extended enterprise* (EE) and *virtual enterprise* (VE) arose from these trends with a particular emphasis on the role of ICTs. As asserted by Jagdev and Thoben (2001):

"extended and virtual enterprises are merely new paradigms reflecting the extent to which the information systems of the collaborating enterprises are integrated with one another and the way they actually communicate and collaborate with one another".

Literature on these new collaborative organisational models is still heterogeneous and fragmented. Contributes from different research areas have analysed different features of these concepts through different perspectives.

This research thesis has been conceived in order to partially fill some critical literature gaps on extended and virtual enterprise.

## 2. The research thesis

This dissertation, which takes the form of three essays (figure 1), investigates the diffusion of extended and virtual enterprise models in technology intensive contexts. The three essays are strongly interrelated.

In the first essay I reviewed the literature on these two models in a systematic way considering contributes published on ISI certificated journals. The review allowed understanding of the main literature gaps. In particular, a lack of empirical studies testing the theoretical evidences in potential real cases of virtual and extended enterprise clearly emerged.

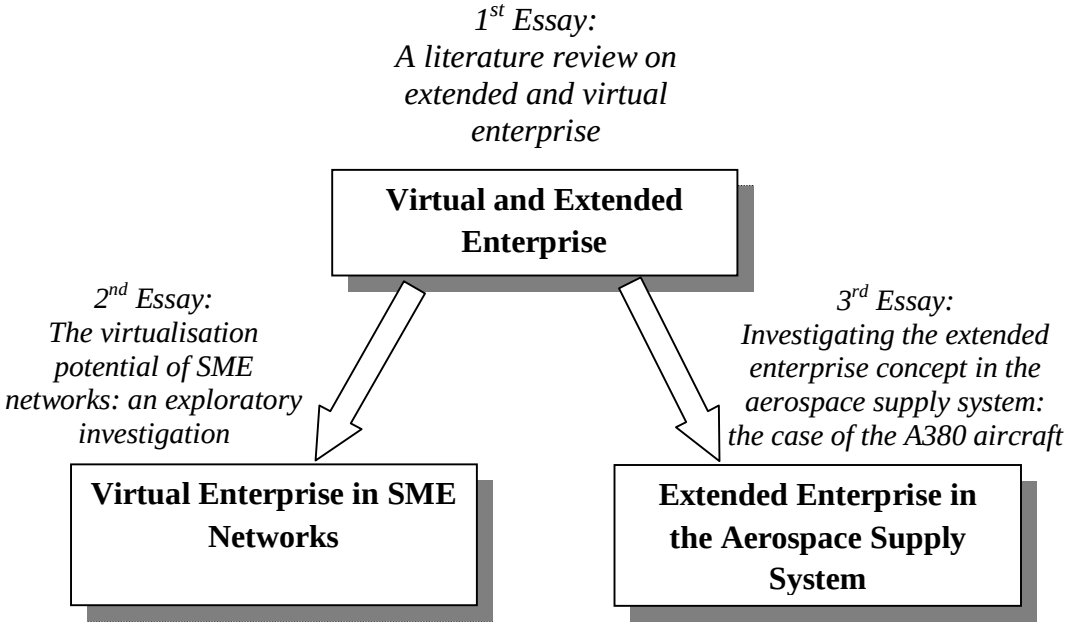


*Figure 1: The structure of the research thesis*

It is to partially fill these gaps that the second and third essays have been conceived. The theoretical background of these two essays directly relates to the review carried out in the first one.

The second essay focuses on a network of SMEs. It aims at analyse the virtualisation potential of this network through a questionnaire survey. This essay

represents the main output of my research thesis as it has been already published on an international book (see reference Esposito et al., 2010).

The third essay investigates the extended enterprise concept in the aerospace supply system. A single case study analysis has been conducted on the Airbus A380 case. This essay should be considered as a work in progress has not all the interviews planned have been conducted yet.

In the following part of this section three extended abstracts of the three essays have been reported.

### *3.1 A literature review on extended and virtual enterprise*

*Objectives*

The specific objectives of this essay are:

- to put in evidence the characteristics of the extended and virtual models shared in literature and the aspects still uncovered;
- to highlight if different virtual and extended enterprise configurations emerge;
- to guide future researches on these topics through the understanding of the main literature gaps.

*Methodological approach*

The essay is based on a bibliometric study involving articles published on ISI certificated journals. I followed a three steps sampling process. After the first query to the entire ISI database, I refined twice the raw sample utilising the ISI subject areas and the relevance of the article as refinement criteria. The sampling process resulted to a number of central articles on the VE and EE topics. These articles have been systematically read in order to highlight the most important characteristics and definitions.

*Findings*

After an overview of most comprehensive definitions, this essay has ascertained that there are a number of shared and non-shared issues in the

definition of the EE and VE. In particular issues on coordination mechanisms and organisational structure have been partially neglected for both models.

A variety of VE models may be considered within a framework. This framework includes two extreme VE forms: the hierarchical and holarchical models. In the case of the hierarchical VE, a leader company assumes the coordination of the network, and generally manages market relationships acting as the product integrator. By contrast, the holarchical model is characterised by a self-organization in which the success of the virtual enterprise strictly depends on all partners co-operating as a single unit. Therefore, the problem seems to be the identification of all the potential configurations that can be assumed between these two extreme models in a "*virtualisation process*".

The literature does not indicate a unique EE organizational model, but in this case only a hierarchical approach clearly emerges, while non-hierarchical EE configurations have still received less attention.

*Research limitations/implications*

The sample consists of articles published in many leading academic journals.

The primary implication of this paper is the emergence of some important gaps that need to be fulfilled. Literature on virtual and extended models is still fragmented and heterogeneous. The two models have been receiving a strong theoretical attention, but there are few empirical works matching theories with real example of VE and EE. Indeed, the relationship between these two new concepts and other widely studied collaborative network models such as industrial districts, clusters and supply networks is unclear.

*Originality/value*

Currently, there are no works that try to review the literature on these two new models. Indeed, the literature review conducted in this essay allows the construction of theoretical frameworks on virtual and extended enterprises that could guide future empirical researches on these topics.

### *3.2 The virtualisation potential of SME networks: an exploratory investigation*

*Objectives*

Two are the main objectives of this essay:

1. to ascertain whether it is possible to identify a unique VE model or a framework that includes a variety of VE models through analysis of the recent literature;
2. to contribute to plug the gap in the empirical research with a field analysis focused on a network of SMEs.

*Methodological approach*

Firstly, the essay reviews the literature on the VE model. Secondly, it analyses a network of small and medium sized firms located in the eastern area of Naples through a questionnaire survey in order to assess whether the network is evolving towards the VE model. Finally survey results have been compared with literature evidences.

*Findings*

On the basis of the literature review, this essay has ascertained that it is not possible to identify a unique VE model. A variety of VE models may be considered within a framework. This framework includes a number of shared issues and other specific issues.

In particular, two extreme VE forms were identified: the hierarchical and holarchical models. In the case of the hierarchical VE, a leader company assumes the coordination of the network, and generally manages market relationships acting as the product integrator. By contrast, the holarchical model is characterised by a self-organization in which the success of the virtual enterprise strictly depends on all partners co-operating as a single unit.

The network investigated is characterised by a set of temporary peer relationships oriented to specific projects in which collaborative relationships are continuously formed and re-formed. This suggests that it may be considered a potential *pool of VEs*.

Comparison between the literature review and survey findings establishes that VEs created within the ENES assume a hybrid form between the two extremes originally identified.

*Research limitations/implications*

The exploratory nature of the survey limits the generalisation of the results achieved. Further investigations involving a large number of firms operating in different contexts and industries are needed to validate results and models proposed in this chapter.

*Practical implications*

From the managerial point of view, in order to fully exploit the potential of virtualisation, SMEs need to implement new technological solutions. For this reason, small businesses need to support their virtualisation process through the adoption of technological platforms that allow information and knowledge to be managed and shared more efficiently.

From the policy implications point of view, the SME virtualisation process should be supported through a number of actions developed by universities and local authorities. Universities should develop technological solutions, particularly geared to meet the needs of SMEs. In this context it is crucial to involve SMEs in collaborative projects. On the other hand, the role of local authorities also appears important: such institutions should support SME virtualisation processes through a set of policy measures aimed at facilitating not only the process of innovation but also collaboration among small firms.

*Originality/value*

The essay empirically tests literature evidences on virtual enterprise in a SME network. Therefore it provides to enlarge the understanding on VE thorough empirical evidences. Indeed, the object of the study represents a strength itself, as many industrial systems in developed countries are populated by a large number of small company aggregations, as in the case of Italian industrial districts.

### *3.3 Investigating the extended enterprise concept in the aerospace industry: the A380 aircraft case.*

*Objectives*

The main aim of this paper is to investigate the characteristics of the supply system in a specific aircraft project, the Airbus A380, and to compare them with the evidences emerging from an extensive literature carried out on the EE. The objective is to ascertain the level of alignment between academic thinking and business practice and, what are the main characteristics of the EE model emerging in the A380 project.

*Methodological approach*

The analysis has been organised into three steps. Firstly, a comprehensive literature review on the EE concept has been carried out. The most common and specific features have been identified. In the second stage, the Airbus A380 project has been analysed in details using the single exploratory embedded case study approach. The unit of analysis has been the system of relationships established among the different partners involved in the A380 project. The case study investigation has been conducted collecting information from company documents and archival records and, in a further step, through a set of face-to-face interviews carried out at Italian and UK partner companies involved in the A380 project. Finally, the results of both literature review and case study analysis have been compared.

*Findings*

The literature review on the EE has highlighted a number of shared issues and other specific issues not completely. Considering the issues non-shared by the literature, with particular reference to issues of organizational structures and coordination mechanisms, a hierarchical EE approach clearly emerged.

As emerged by our empirical analysis the extended enterprise concept partially fits with the organisation of the supply system in the A380 project. Referring to the specific characteristics of the extended model established, it appears that the EE configuration is a hierarchy with the leadership located at the top of the

pyramid. The hierarchy assumes a tree shape and it branches into the three subsectors. Each subsector (except the airframe one) has a certain degree of autonomy. The hierarchy has different poles, each pole has a certain degree of autonomy in managing lower suppliers but it partially depends from the superior one. In this sense, the network each pole establishes for a specific part of the aircraft could be seen as a *micro extended enterprise.*

Nevertheless, there are some concerns which emerge in relation to the strong authority and to the outsourcing politics exercised by the Airbus. The outsourcing in the A380 project is increased if compared to previous programs, but it is still limited mainly to non core activities. The Airbus has the total design authority and this limited the horizontal collaboration among the risk sharing partners.

Latest programmes (Boeing 787 and A350) indicate that Boeing and Airbus are changing their business models towards complex configurations more fitting the EE concept.

*Research limitations/implications*

The exploratory nature of this case study analysis, the peculiarities of the industry investigated and the reduced number of interview conducted limit the generalisation of the results achieved. Further investigations about other projects in the aerospace industry or in other industries are needed to validate results and recommendations proposed in this essay.

*Practical implications*

Large aerospace company must recognise the pattern of globalisation, learn to globalise their own supply chain activities and design new business model and strategy. It is also important to learn as to manage cultural differences when finding the best subcontractor all over the world.

As the system integrator and their major suppliers increasingly outsource activities and functions they used to perform internally they must find quality suppliers that can assume such responsibilities.

For the suppliers located at the lowest levels of the productive pyramid, to be considered a “good quality supplier”, it is therefore imperative:

- to be equipped with electronic and communication technologies which can be integrated with the ones of the partners according to a PLM logic;
- to be equipped with higher R&D capabilities;
- to have the ability to assume full supply chain responsibilities (selection of lower tier suppliers, quality insurance etc.);
- to have a strong financial banking to assume more risks.

*Originality/value*

To describe the evolution of the aerospace supply systems, the extended enterprise model has been widely used in literature on the aircraft industry even if in an unstructured way. But most papers adopt a theoretical approach. They don't put in evidence the characteristics of the supply systems to justify this assumption. This essay provides a framework to compare literature on extended enterprise and a real case in the aerospace industry.

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# ESSAY 1 - A LITERATURE REVIEW ON EXTENDED AND VIRTUAL ENTERPRISE

## 1. Introduction

In the past few years the competitive scenario has witnessed dramatic changes. The globalisation and the high level of business competitiveness generated demand for quality products that are manufactured at the lowest cost and by continually reducing the production times (De la Fuente, 2010). To this end, companies have been prompted to establish alternative management strategies and to re-consider the design and manufacturing of new products in order to be responsive to customers' unique and rapidly changing needs (Gunasekaran, 2008). This challenge is resulting to the development of new collaborative organisational models aiming at the sustenance of flexibility and innovation (Pollalis and Dimitru, 2008). Business alliances often turn out to be more powerful and successful than traditionally large enterprises (adversarial or arm's length relationship) (Pollalis and Dimitru, 2008). It is also becoming clear that firms operate in value streams involving many firms in supply chains within a supply network, and that the competitive performance of the entire network depends upon learning and the development of the whole system, not just the leading players (Bessant et al., 2003).

While the concept of supply networks has been well established and there is a wide literature on traditional collaborative organisational models, it is the emergence of information and communication technologies (ICT) and in general the need for managing knowledge assets both at an intra and an inter-organisational level, that has expedited the nature and scope of collaboration to new and higher levels. Formation of *extended enterprise* (EE) and *virtual enterprise* (VE) are such recent developments. As asserted by Jagdev and Thoben (2001): "extended and virtual enterprises are merely new paradigms reflecting the extent to which the information systems of the collaborating enterprises are integrated with one another and the way they actually communicate and collaborate with one another".

Literature on these new collaborative organisational models is still heterogeneous and fragmented. Contributes from different research areas have analysed different features of these concepts through different perspectives. The terms “virtual” and “extended” are common terms used in engineering, computer science and operations management literature. Some shared issues from the different definitions provided emerged as the common foundations of these models, but there are some features which are still completely neglected. Different configurations of both models have been suggested, but not empirically tested. Indeed, the relationship between these two new concepts and other widely studied collaborative network models, such as industrial districts, clusters and supply networks, is unclear.

Currently, there are no works that try to review the literature on these two new models. Therefore, the main aim of this paper is to review the literature on virtual and extended enterprise in a systematic way by considering contributes published on ISI certificated journals. The specific objectives of this review are:

- to put in evidence the characteristics of the models shared in literature and the aspects still uncovered;
- to highlight if different virtual and extended enterprise configurations emerged;
- to guide future researches on these topics through the understanding of the main literature gaps.

The paper is organised as follows. This introduction is followed by the description of the methodological approach adopted. In the section three and four literature on virtual and extended enterprise models respectively is widely analysed. The literature evidences are discussed in the section five while the conclusions and the recommendations for future researches are detailed in the section six.

## 2. Methodological approach

### *2.1 Sampling process*

The sample was taken from the ISI Web of Science database that covers over 8,000 scientific journals, including many high-ranking journals. This choice

doesn't limit our analysis as, in the subject area of interest; journals highly ranked through other classification systems (e.g. ABS) have also an ISI certification. Therefore, to consider only ISI publication doesn't affect the relevance of this literature review.

We followed a three steps sampling process (figure 1). After the first query to the entire ISI database, we refined twice the raw sample utilising the ISI subject areas and the relevance of the article as refinement criteria.

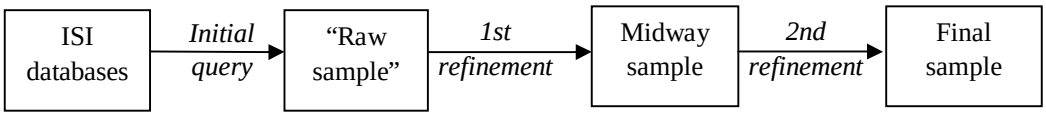


*Figure 1: sampling process*

*Initial query*

I conducted two separated ISI database queries on the subjects of "virtual enterprise" and "extended enterprise". In the queries every publication that contained either of the two phrases in the abstract, title or keywords was first identified. Only articles published between 1990 and 2010 were included in the sample. This does not lead to bias in the results since the earliest publications on extended and virtual enterprises appeared in 1993. After applying these queries we obtained our initial results. On virtual enterprise and extended enterprise there were respectively altogether 317 and 175 citing articles.

*1st refinement*

A first refinement occurred with reference to the subject area. Of these 315 and 175 articles those published in Engineering, Computer Science, Operation Research & Management, Business & Economics, Automation & Control systems and Information Science were included. It is important to note that ISI web of science subject areas relate to the journals not to the single paper and each journal (and therefore each article published in it) could belong to different areas. Therefore through this refinement we aimed at removing articles strongly non -

focused on the areas of interest. This removal resulted in 308 (VE) and 171 (EE) articles.

*2nd refinement*

The second refinement has been made according to the relevance of the VE and EE topics in the articles belonging to the midway sample. After the reading of the abstracts 100 and 71 central articles with a highly significant impact on virtual and extended enterprise literature have been selected. Although it is longer and harder, the criterion of selection based on the relevance of the article for the topic of interest allows avoiding some limitations arising whit other criteria (e.g. the number of citations). After the central articles had been identified they were read systematically.

The detailed sampling process for virtual and extended enterprise is shown in the following figure 2.

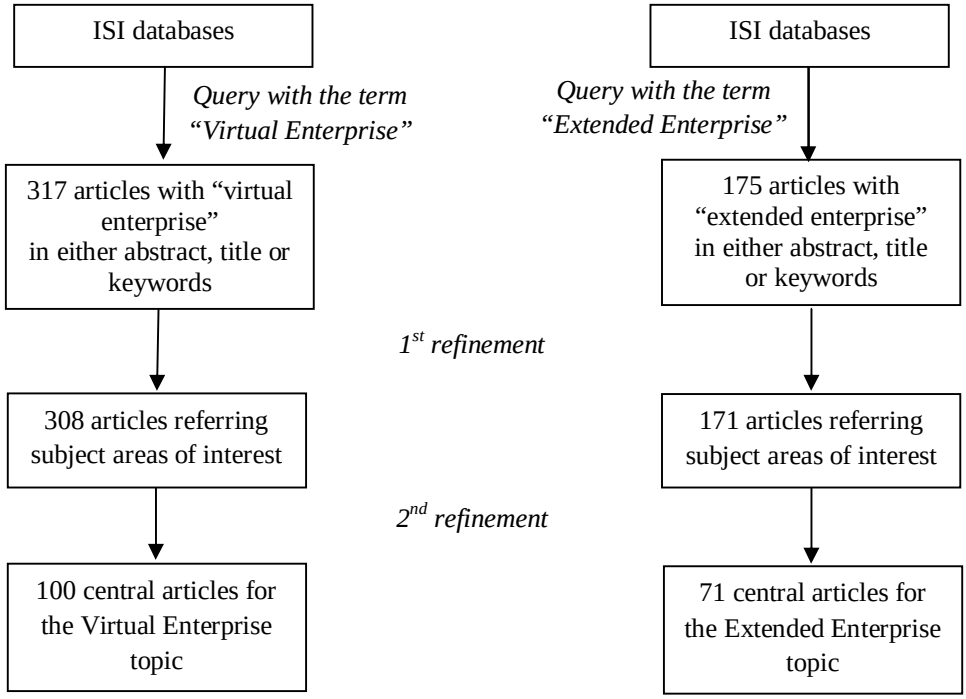


*Figure 2: the sampling process for VE and EE*

### *2.2 Data analysis*

Figures 3 and 4 respectively show the trend of the number of articles published in ISI journals over the years on the VE and EE.

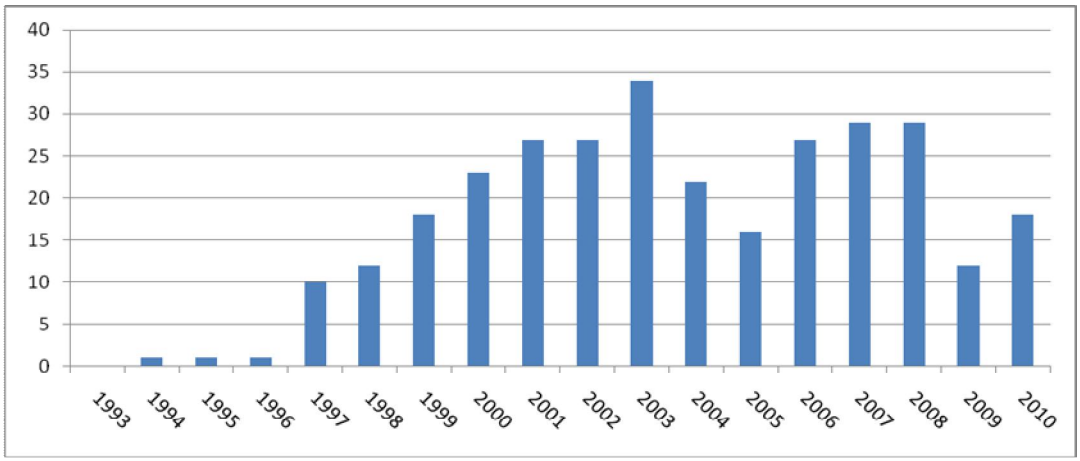


*Figure 3: number of articles in ISI journals on the Virtual Enterprise topic over the years*

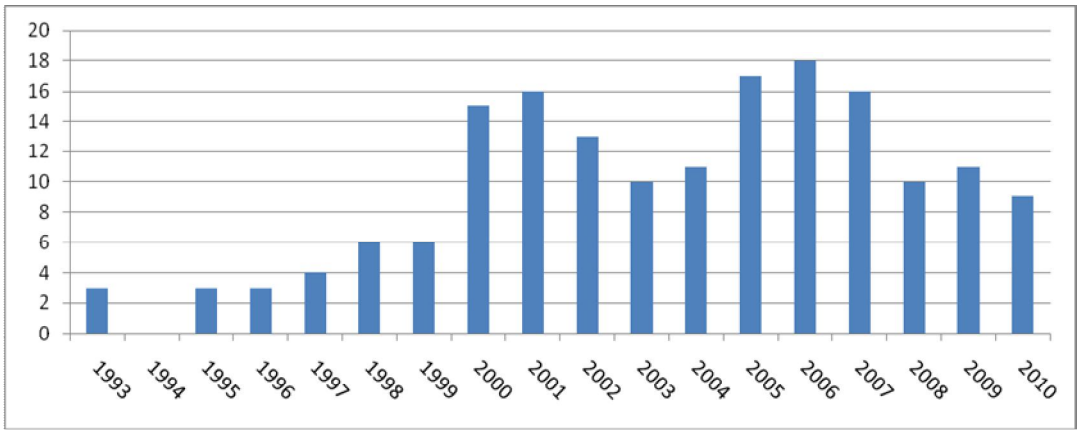


*Figure 4: number of articles in ISI journals on the Extended Enterprise topic over the years*

According to the above figures, the following considerations could be made:

- the general trend over the years is similar for both VE and EE;
- the trend of the articles on EE seems anticipated of a couple of years if compared with VE articles one;
- during the last year the number of articles on the VE topic has increased, while for the EE the number continues to decrease since 2006.

In the figures 5 and 6 the importance of the subject areas selected in the samples on VE and EE respectively is shown.

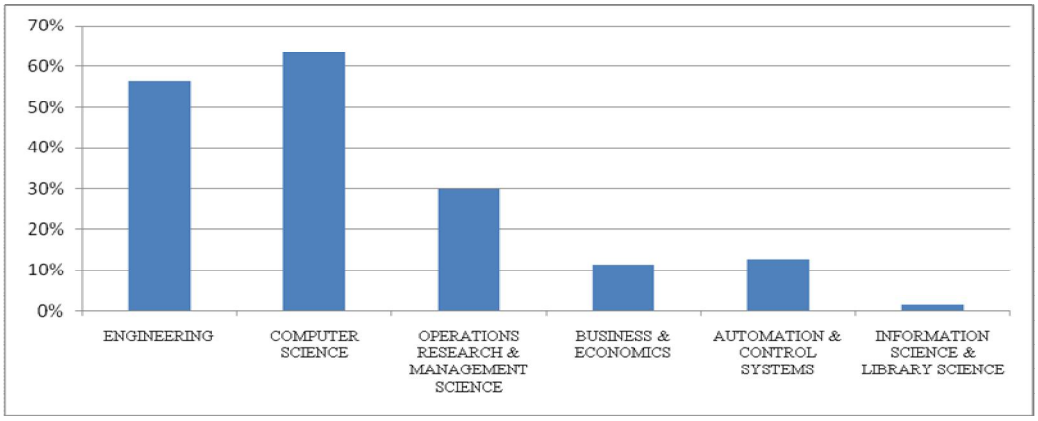


*Figure 5: articles in ISI journals on the Virtual Enterprise and subject areas*

Most of articles refer to engineering, computer science and operational research & management science areas. Nevertheless, in the EE context the influence of the engineering and operations research & management areas is higher. The strongest difference is related to articles published in computer science journals as in such a kind of subject areas the virtual enterprise topic appears more analysed.

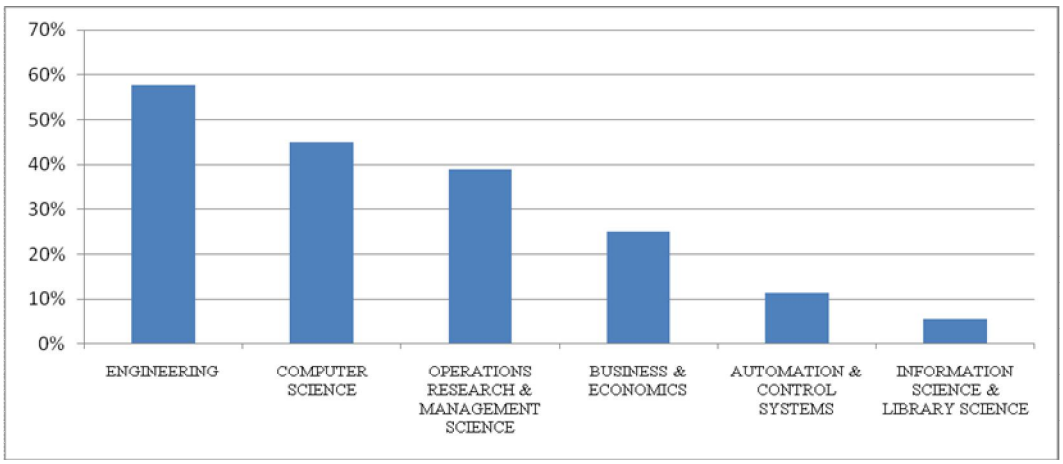


*Figure 6: articles in ISI journals on the Extended Enterprise and subject areas*

In the figures 7 and 8, the trend over the years of the number of articles published in the three most important subject areas (engineering, operations & technology management and computer science) is shown.

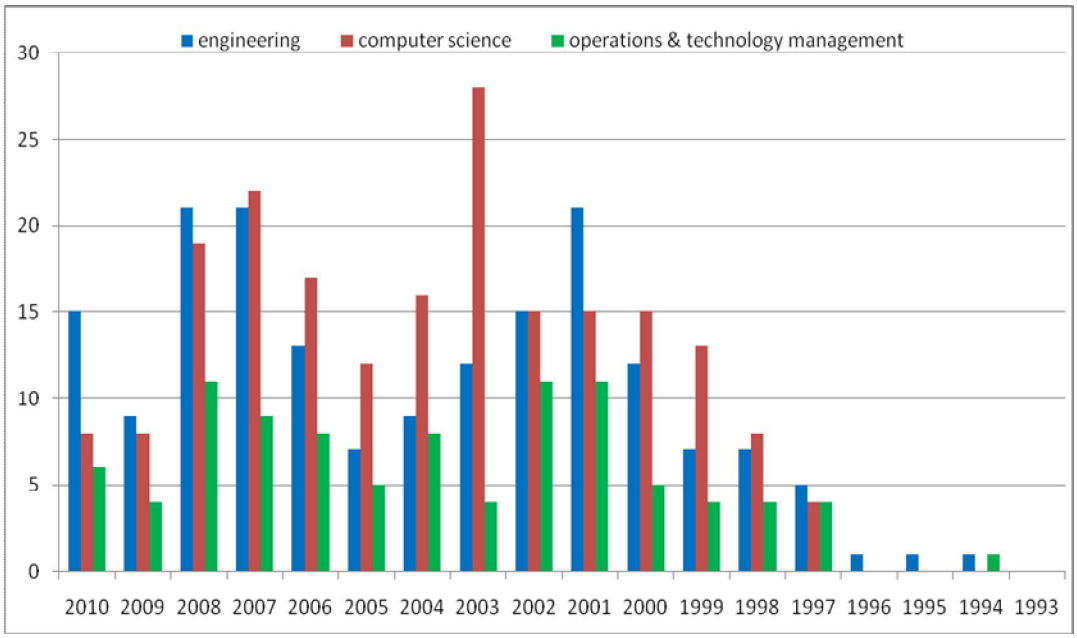


*Figure 7: subject areas over the years (virtual enterprise)*

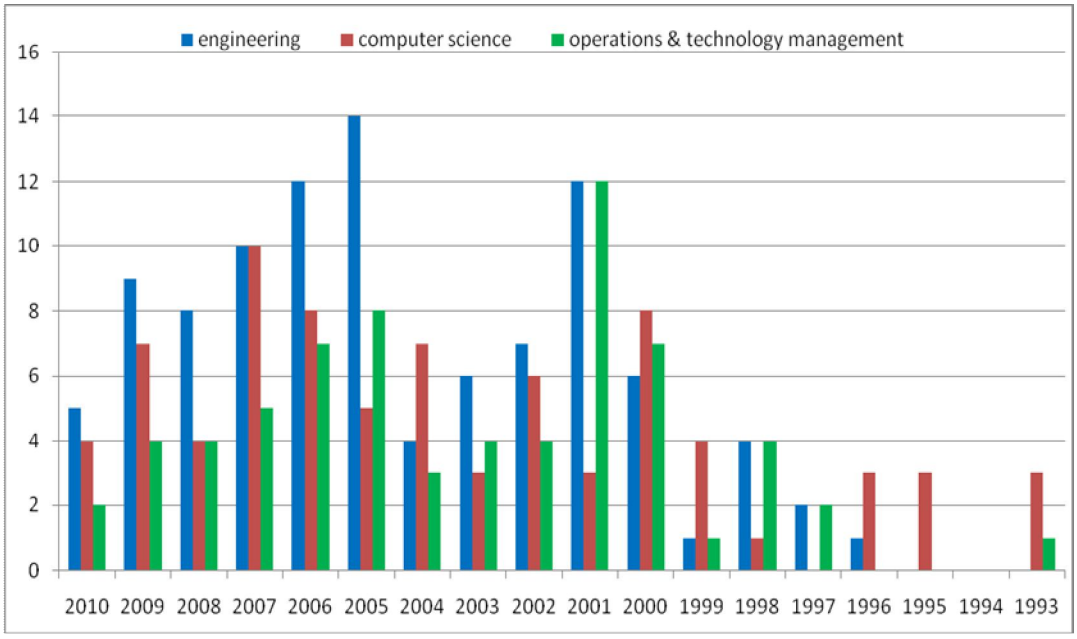


*Figure 8: subject areas over the years (extended enterprise)*

In the VE context, the first articles on the topic were not published in computer science journals. Since the middle ‘90s we can observe an increase in the number of articles published for all the three areas. The three trends are similar in shape (apart from the one relative to 2001): the computer science area is more important than the engineering and the operations ones. During the past three years only the number of articles in engineering journals is larger than computer science ones.

In the EE context the trends appear to be more irregular. The concept has been analysed first in the computer science area but engineering became more important since the 2001. Articles in operations & technology management journals assumed a more critical role if compared with the VE context, especially in 2000 and 2001.

## 3. The virtual enterprise

In this section I firstly review (from the oldest to the newest) the most comprehensive and significant definitions and perspectives on the VE. Secondly I summarise literature evidences by putting in evidence issues shared and issues not completely covered in literature. Finally I tried to outline if different virtual enterprise configurations emerge. To the purpose of this paper, articles strongly computer science based have been neglecting as they don’t provide either a description of the virtual enterprise model or theoretical evidences for the knowledge management practices.

### *3.1 An overview of definitions*

In the late 1980s the term ‘virtual corporation’ first appeared, referring to links between companies supported by ICT. The concept of VE was mainly technology-driven and based on the sharing of information systems. The most important definitions on the virtual enterprise are shown in the table 1.

One of the first definitions of VE was given by Byrne (1993) on *Business Week* who indicated the VE as a network of independent companies managed through information technology and characterised by the temporary nature of

relationships. The main aims of VE relate to sharing skills, costs, and to access to one another's markets.

*Table 1 : definitions of virtual enterprise*

| Year | Definitions | 1st Author |
|---|---|---|
| 1998 | -Virtual enterprises usually operate in niche markets, are project based and tend to have, relative to extended enterprises, a shorter life span. They form and reform based on market needs. Information Technology in virtual enterprises acts as an integrator.<br>- The virtual enterprise is a temporary network of independent companies, even erstwhile rivals, who come together quickly to exploit fast-changing opportunities. The business partners are all linked using information technology.<br>- The independent companies temporarily linked by IT networks share skills, costs and can achieve access to each other' s markets. The virtual enterprise is an organisation which is distributed geographically, and whose work is co-ordinated through electronic communications. | Jagdev, H.S |
| 1999 | - Virtual Enterprise is considered as the most advanced and efficient form of modem networked enterprise organizations, and supported by extensive use of information and communication technologies.<br>- Virtual enterprises are created to address a specific market opportunity, made up from parts of two or more different enterprises, and designed to facilitate gathering productive resources quickly, broadly and concurrently. | Park, K.H |
| | - A virtual enterprise can be defined as a temporary alliance of enterprises that come together to share skills or core competencies and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks. | Camarinha -Matos, L. M |
| 2000 | - A virtual enterprise is a temporary consortium of independent member companies which come together to quickly exploit fast-changing, worldwide product manufacturing opportunities. Within the virtual enterprise, companies share costs, skills, and core competencies, which collectively enable them to access global markets, with world-class solutions that could not be provided individually. | Zhang, Y.P |
| | - The structure of a virtual enterprise can be seen as a holarchy, i.e. it is a temporary, goal-oriented aggregation of several individual enterprises. Each virtual enterprise is created to pursue a specific business objective, and remains in life as long as this objective can be pursued. | Mezgar, I |
| 2001 | - A virtual enterprise can be defined as a network of independent organisations that jointly form an entity committed to provide a product or service. Because, from the customer's perspective, as far as that product/service is concerned, these independent organisations, for all practical and operational purposes, are virtually acting as a single entity/enterprise. | Jagdev, H.S. |
| | - The VE is a form of joint venture but with important differences. It is designed to be a temporary alliance of member companies who join to take advantage of a market opportunity. It is expected that the VE will possess almost no employees or inventoried resources. Each member organisation provides its own core competencies in organisational functional areas such as marketing, engineering and manufacturing. Only a small headquarters staff is required, to deal with the administrative and management details, with the actual work being performed by geographically separated shareholder companies, subcontractors, and partners joined through computerized hardware and software. When the market opportunity has passed, the VE is dissolved. | Presley, A. |
| | - This concept has been used to characterise the global supply chain of a single product in an environment of dynamic networks between companies engaged in many different complex relationships […] It is supported by extensive use of information and communication technology. In a VE, manufacturers no longer produce complete products in isolated facilities. They operate as nodes in a network of suppliers, customers, engineers, and other specialised service functions […]. The main objective of a VE is to allow a number of organizations to rapidly develop a common working environment; hence managing a collection of resources provided by the participating organisations toward the attainment of some common goals. Because each partner brings a strength or core competence to the consortium, the success of the project depends on all co-operating as a single unit. | Martinez , M.T |

| | | |
|---|---|---|
| 2002 | -The VE is an organisation which is distributed geographically, and whose work is co-ordinated through electronic communications. [...]The business partners are all linked in a dynamic network in order to share their skills and to exploit the fast-changing opportunities. | Mikhailov, L. |
| | - The goal of a VE is to share skills or core competencies and resources so that a new product can be developed without additional capital investment for resources. | Wu, N.Q |
| | - Essentially, these are micro-enterprises that have managed to profit by the advantages of the information infrastructure and, in particular, one of its components, the Internet. They have chosen the Internet as their sole instrument for sales, promotion, logistics and distribution, and as the tool for their financial transactions. They are called "virtual" because the end user does not necessarily know where they are located geographically and probably will never need to meet any of their staff members.<br>- Virtual enterprises (also known as "extended enterprises") are also brought to birth by multinationals that are responsible for complex products and also act as product integrators. In its most complex form, a virtual is the (often temporary) grouping of several actors, all operating on the same informational platform and working together while a project lasts or to create a given product. These actors do not generally belong to the same enterprise and are not necessarily on the same continent. | Lefebvre, L.A.; |
| 2003 | - A VE is a dynamic alliance of member companies (tenderee and tenderers), which join to take advantage of a market opportunity. | Ip, W.H |
| | - Virtual enterprise means a nucleus enterprise (or main assembler) joins with a number of collaborating enterprise (supply and distributions enterprises, transporting agents), to manufacture and sell a class of product with the characteristics such as qualitative, agility, and leanness to achieve maximum customer satisfaction. | Davidraju h, R. |
| 2005 | - A virtual enterprise can be defined as a network of independent organisations that jointly form an entity committed to provide a product or service. | Hao, Q |
| | - A VE is a joint venture, which consists of suppliers, manufacturers, distributors, and customers to develop and produce products for fulfilling consumer requirements in the rapidly changing environment of the global manufacturing area | Sha, D.Y. |
| 2006 | - VE can be viewed as headed by a major firm that distributes the manufacturing tasks among a number of manufacturing partners sharing enterprise and resources. | Fenga, D. Z.; |
| | - The virtual enterprise, which is in general the collaborative partnership between business partners in value chains, has become a key factor for survival in the competitive business environment. A VE is a temporary organization which is created according to a business opportunity and is dissolved when the business opportunity no longer exists.<br>- In order to realise the common business goal which is to secure business opportunity, the VE is an active collaborative organisation structure which is temporarily made up of value chains. Each value chain consists of loosely-coupled business processes of distributed business partners who offer the core complementary functionality and resources. | Kim, T.Y |
| 2008 | - VE is based on developing partnerships based on core competencies for achieving agility in a supply chain environment. | Gunasekaran, A |

Successively, Rolstadas (1995) defined the virtual enterprise as a number of collaborative units geographically dispersed but managed as one total unit, although the subunits may be under separate management.

Without providing their own definition, Wright and Burns (1997) described the potential strengths and weaknesses of a virtual enterprise model. In particular the strengths refer to: i) workforce flexibility/innovation closer to the customer, ii) low overheads, iii) IT readily and available cheaply and iv) increases job access; while the weaknesses are: i) system and people difficult to control, ii) cultural/time zone conflicts, iii) loss of social office aspects, iv) protection of IPR.

A similar classification of both strengths and weaknesses has been proposed by Eschenbacher et al., (2001).

Probably, the first comprehensive work on the VE has been carried out by Jagdev and Browne (1998). The two authors identified a number of VE characteristics. Firstly, this organisational form is based on temporary relationships and information technology (IT) act as integrator among the networked firms. Jagdev and Browne assign to IT the role of coordinating communication flows within the network. Secondly, the authors argued that the main aim of a VE is to exploit fast-changing market opportunities sharing skills and costs. The third important element in their view is that VE is typically project based and tend to have a relative shorter life span in comparison with the extended enterprises concept.

At the same time, Gunasekaran (1998) described a similar framework for the VE model, but the author also indicated the virtual enterprise as a key enabler for the agile manufacturing. A related association has been proposed by Bhandarkar and Nagi (2000), Xu et al. (2000); Camarinha Matos et al., (2003); Cao and Dowlatshahi (2005).

Park and Favrel (1999) proposed a similar view of VE that is supported by extensive use of ICT to address specific market opportunities. They stressed the following two other elements: i) a VE may be created from parts of two or more different enterprises; and ii) it may be designed to facilitate gathering productive resources quickly, broadly and concurrently.

Since the late ‘90s, a number of interesting works (Camarinha Matos et al., 1998, 1999; Camarinha Matos, 2001; Camarinha Matos and Lima, 2001; Camarinha Matos et al., 2001; Pereira Klen et al., 2001; Osorio and Barata, 2001; Camarinha Matos et al., 2003) on the virtual enterprise came from researchers working for the PRODNET II project. In this area the paradigm of virtual enterprise emerged as a reaction to fast evolving market trends, shaped by the globalisation of the economy and the formation of large economic blocks, challenging the way industrial manufacturing systems are planned and managed. Therefore, a virtual enterprise can be defined as a temporary alliance of enterprises that come together to share skills or core competencies and resources

in order to better respond to business opportunities, and whose cooperation is supported by computer networks. Two keyword elements in this definition are the *networking* and *cooperation* (Camarinha Matos et al., 1999).

The vast majority of articles on the VE topic has been published during the early 2000s. In this period especially engineering-based journals committed a great interest on the virtual model.

The VE definition provided by Zhang et al. (2000) does not significantly differ from the two detailed above as the authors claimed that the main components of a VE are its temporary the life span and its main objective is quickly exploit fast-changing, worldwide product manufacturing opportunities. Zhang et al. also stressed that in a VE context companies share costs, skills and core competencies.

Mezgar et al. (2000) suggested that a VE may be considered as a *holarchy* considering that it is a temporary and goal-oriented aggregation of several individual enterprises. The authors also underlined that a VE is created to pursue a specific business objective, and it remains in life as long as this objective has been pursued.

Interestingly, according to Zhou et al. (2000) a virtual enterprise is assembled based on cost-effectiveness and production competencies with less regard for organisations, geographic locations, computing environments or technologies deployed. That is to say, it is virtual in organisation, location and technology. As a main activity of an enterprise, production planning and control plays an important role in running a virtual enterprise and has a major potential to improve its performance.

Martinez, et al. (2001) also evidenced how VE concept may be used to characterise the global supply chain of a single product in an environment of dynamic networks between companies engaged in many different complex relationships. The focus of this definition is on manufacturing companies that no longer produce complete products in isolated facilities but they operate as nodes in a network of suppliers, customers, engineers, and other specialised service functions. In their view, the main objective of a VE is to allow organisations to rapidly developing a common working environment and managing a collection of resources provided by the participating organisations toward the attainment of

common goals. Hence, the VE success depends on all co-operating as a single unit.

Jagdev and Thoben (2001) also highlighted that the independent organisations participating in a VE are virtually acting as a single entity/enterprise.

For Presley et al. (2001) the VE is a form of joint venture that is characterised by a number of relevant differences such as: i) it is designed to be a temporary alliance among the member companies for taking advantage of a market opportunity; ii) each member organisation provides its own core competencies in organisational functional areas such as marketing, engineering and manufacturing; iii) a small head quarters staff is required to deal with the administrative and management details; iv) geographically separated shareholder companies, subcontractors, and partners are joined through computerised hardware and software; v) when the market opportunity has passed, the VE is dissolved.

For Mikhailov (2002) a VE is an organisation which is distributed geographically, and whose work is co-ordinated through electronic communications. He also stressed that business partners are all linked in a dynamic network in order to share their skills and to exploit the fast-changing opportunities.

Lefebvre and Lefebvre (2002) pointed out that VE are micro-enterprises that take advantage from the information infrastructure and, in particular, the Internet as the sole instrument for sales, promotion, logistics and distribution, and financial transactions. For the authors, the end user does not necessarily know where the VE participating companies are located geographically. It is interesting to note that in their view VE is also known as “extended enterprises” and it is created by multinationals companies that are responsible for complex products and also act as product integrators. They also stress that a VE is often a temporary group of several actors, all operating on the same informational platform. These actors do not generally belong to the same enterprise and are not necessarily located on the same continent.

Huang et al. (2002) developed a holonic framework for virtual enterprises control.

Wu and Sun (2002) defined a VE as an organisational structure that is aimed at sharing skills or core competencies and resources so that a new product can be developed without additional capital investment for resources.

An interesting view of a potential VE formation has been given by Davidrajuh (2003). The author highlighted that virtual enterprise means a nucleus enterprise (or main assembler) joins with a number of collaborating enterprise (supply and distributions enterprises, transporting agents), to manufacture and sell a class of product with the characteristics such as qualitative, agility, and leanness to achieve maximum customer satisfaction. When market requirements are changed, a new class of products or an improved version of the product should be turned out to meet the new market requirements. In this case the nucleus enterprise may seek for a new combination of collaborating enterprises that are more suitable to manufacture the new class products; thus the main aspect of virtual enterprise is dynamic logic of organisation and reorganisation of collaboration (Davidrajuh, 2003).

Ip et al. (2003) stressed the VE has an alliance of member companies (tenderee and tenderers) with a dynamic nature designed and implemented to take advantage of a market opportunity.

Hao et al. (2005) simply defined a VE as a network of independent organisations that jointly form an entity committed to provide a product or service.

Sha and Che (2005) made and interesting distinction between the concepts of virtual integration (VI) and virtual enterprise. VI is a collaborative production-distribution network that unifies many independent business partners to plan, perform, and control operational interchanges effectively and efficiently, from acquisition of raw materials to delivery of the finished product to the end user/customer. Every collaborative partner (enterprise) collectively interacts by sharing their product information, to transport the right quality and quantity of product at the right time. Under this concept these enterprises constitute a larger organisation, that is, a virtual enterprise. Therefore, a VE is a joint venture, which consists of suppliers, manufacturers, distributors, and customers to develop and produce products for fulfilling consumer requirements in the rapidly changing

environment of the global manufacturing area (Sha and Che, 2005).

For Kim et al. (2006) VE is characterised by a number of features such as: i) collaborative partnership between business partners in value chains; ii) its life span is temporary; iii) it is created according to a business opportunity and is dissolved when the business opportunity no longer exists; and iv) each participating company offers their core complementary functionality and resources.

Fenga and Yamashiro (2006) view a VE as headed by a major firm that distributes the manufacturing tasks among a number of manufacturing partners sharing enterprise and resources.

According to Molina et al., (2007), the concept of virtual enterprise seems to fit the requirements of supply chains management very well. The concept of virtual enterprise responds to the mass customisation demands based on build to order supply chains. The main principle of this operational model is to manufacture on demand products (highly customised, customer driven, non volume restriction, short time response and low cost) using core processes and competences within the firm and subcontract the reminder of production resources from the best available suppliers. However, companies must carefully analyse how to pursue this strategy because it requires capacity to design, configure, co-ordinate and operate dynamic supply chains.

The view proposed by Corvello and Migliarese (2007) pointed out that in a VE arrangement partners are integrated in a productive system which is based on mutual adjustment processes supported by ICT. The authors indicated that, compared with vertically integrated firms, the VE model substitutes hierarchy with incentives, and formal and procedural coordination with complex communication systems.

Even if they provide neither their own definition nor a set of characteristics of the VE model, Sari et al., (2007) tried to answer to the following interesting questions:

- what type of knowledge is needed to realise a VE? (and how could this knowledge be structured?)

- How should one prepare, set up, and operate a VE? (applying the identified types of knowledge)
– How should one test and validate the VE methodology?

Only in the 2008, we started to find some comprehensive articles that started to study the problems of knowledge management in the VE not only through a strongly computer science perspective but also through a theoretical and modelling perspective. It is the case of Tsung-Yi Chen (2008) who provided a knowledge access control model that supports the management of knowledge access authorisation for VE workers when performing their tasks; and Pollalis and Dimitrou (2008) who have examined the approaches through which enterprises can obtain a competitive advantage based on the knowledge that they contain, taking part in new organisational structures such as the virtual enterprise.

Finally, the last important picture of the VE has been given by Gunasekaran et al. (2008). The authors argued that a VE is based on developing partnerships based on core competencies for achieving agility in a supply chain environment. They showed that virtual enterprises are highly dynamic and have several strategic objectives: i) to maximise flexibility and adaptability to environmental changes, ii) develop a pool of competencies and resources, iii) reach a critical size to be in accordance with market constraints, and iv) optimise the global supply chain.

### *3.2 Literature evidences*

What emerges from the literature review is that: a) there are a number of shared issues related to the VE concept; b) there are also important issues that are not fully addressed by the literature. An overview of the issues shared is outlined in Table 2.

The first shared issue identified relates to the main aims of VE that mainly focus on exploiting fast-changing market opportunities. The main objectives of partnership between VE participating companies are the sharing of risks, costs and competencies. The virtual enterprise appears as a dynamic and flexible network and relationships involve independent companies. Such relationships are typically

temporary and based on a collaborative approach. Finally, the coordination and communication tools used are based on ICT. These five issues may be considered the common foundations of the theoretical concept of the VE model.

*Tab. 2: literature evidences on VE, shared issues*

| Issues | Literature evidence |
|---|---|
| Main aims | - Exploit fast-changing opportunities<br>*(Jagdev and Browne, 1998; Park and Favrel, 1999; Mezgar et al., 2000; Presley et al., 2001; Jagdev and Thoben 2001; Mikhailov, 2002; Wu and Sun 2002; Lefebvre and Lefebvre, 2002; Kim et al., 2006; Corvello and Migliarese, 2007, Molina et al., 2007)* |
| Partnership objectives | - Share costs, skills, and core competencies<br>*(Jagdev and Browne, 1998, Park and Favrel, 1999; Camarinha-Matos et al., 2001; Martinez et al., 2001; Presley et al.. 2001; Weisenfeld et al., 2001; Mikhailov, 2002; Wu and Sun 2002; Fenga and Yamashiro, 2006; Corvello and Migliarese, 2007; Molina et al., 2007, Gunasekaran et al., 2008)* |
| Organisation stability | - Flexible, rapid, dynamic and reactive network<br>*(Park and Favrel, 1999; Mezgar et al., 2000; Camarinha-Matos et al., 2001; Martinez et al., 2001; Lefebvre and Lefebvre, 2002; Kim et al., 2006; Corvello and Migliarese, 2007; Molina et al., 2007, Gunasekaran et al., 2008)* |
| Partnership characteristics | - Temporary relationships<br>*(Jagdev and Browne, 1998; Camarinha-Matos et al., 2001; Jagdev and Thoben 2001; Wu and Sun 2002; Lefebvre and Lefebvre, 2002; Mikhailov, 2002; Fenga and Yamashiro, 2006; Kim et al., 2006; Corvello and Migliarese, 2007; Gunasekaran et al., 2008;)*<br><br>- Collaborative; co-operative<br>*(Rolstadas, 1995; Jagdev and Browne, 1998; Jagdev and Thoben 2001;Mikhailov, 2002; Fenga and Yamashiro, 2006; Kim et al., 2006; Gunasekaran et al., 2008)*<br><br>- Independent companies<br>*(Jagdev and Browne, 1998; Jagdev and Thoben 2001; Lefebvre and Lefebvre, 2002; Mezgar et al., 2000; Mikhailov, 2002; Corvello and Migliarese, 2007)* |
| Coordination and communication tools | - Extensive use of ICT and computer networks<br>*(Jagdev and Browne, 1998; Park and Favrel, 1999; Camarinha-Matos et al., 2001; Mezgar et al., 2000; Jagdev and Thoben 2001; Weisenfeld et al., 2001; Mikhailov, 2002; Wu and Sun 2002; Lefebvre and Lefebvre, 2002; Martinez et al., 2001; Corvello and Migliarese, 2007; Gunasekaran et al., 2008)* |

Issues not shared by the literature are shown in the table 3.

*Tab. 3: literature evidences on VE, non-shared issues*

| Issues | Literature evidences |
|---|---|
| Coordination unit | - Coordination agent may be both internal and external to VE *(Jagdev and Browne, 1998)* |
| | - Small headquarters staff dealing with administrative and management details *(Presley et al., 2001)* |
| | - The product integrator distributes the manufacturing tasks and manages in parallel the product's physical and virtual value chains *(Lefebvre and Lefebvre, 2002; Fenga and Yamashiro, 2006 )* |
| Firm size | - VE model bridges the gap between large and small firms *(Park and Favrel, 1999)* |
| | - VE is especially suitable for small and medium-size enterprises *(Wu and Sun 2002)* |
| | - the virtual enterprise represents an appropriate cooperation alternative and competitive advantage for small and medium enterprises *(Bremer et al. 2001)* |
| Knowledge management | - KM critical resource to achieve competitive advantage in VE *(Pollalis and Dimitriou, 2008;Tsung-Yi Chen, 2008)* |
| Organisational structure | - VE members self-organise their activities *(Mezgar et al., 2000)* |
| | - The relationship in a VE is mostly non-hierarchical in nature *(Jagdev and Thoben, 2001)* |
| | - VE organisational structure is mostly hierarchical *(Fenga and Yamashiro, 2006)* |
| | - A VE substitutes hierarchy with incentives and formal and procedural coordination with communication systems *(Corvello and Migliarese, 2007)* |
| Market relationships | - Customer deals directly with the product integrator during product design or may interface with it through business platforms *(Lefebvre and Lefebvre, 2002)* |
| | - The manufacturer manages the relationships with customers *(Jagdev and Browne, 1998)* |

The most relevant non-shared issues relate to the organizational model and coordination mechanisms. The literature does not indicate a prevalent VE organisational model. Two different views emerged in terms of hierarchical or non-hierarchical structures. On the one hand, in the hierarchical approach the VE is created by large firms which act as a coordination unit of the network. On the

other hand, an alternative approach proposes the self-organisation of VE members based on the substitution of hierarchy with incentives and formal/procedural coordination with communication systems.

The role of firm size in the VE context is generally underestimated. Few works indicate that virtualisation is particularly suitable for SMEs. As asserted by Mallidi et al. (1999), while significant effort has been spent to demonstrate the benefits of the new production paradigm on large companies, SMEs are still missing a proper approach to co-operative manufacturing. This seems a gap that needs to be addressed as many industrial systems in developed countries are populated by a large number of small company aggregations, as in the case of Italian industrial districts.

Moreover, the literature seldom refers to the increasingly important role of knowledge and knowledge management systems in the context of VE.

Finally, it is not clear which specific participating company manages the relation with the final user of the product/service. These five non-shared issues may be considered the specific characteristics of VE models.

### *3.3 A taxonomy of virtual enterprise models*

The literature review presented above identifies a number of common and specific issues that contribute to provide a comprehensive picture of the theoretical concept underlying the VE model. Considering the issues non-shared by the literature, with particular reference to issues of organisational structures and coordination mechanisms, it is possible to identify at least two extreme VE models: the hierarchical and holarchical models (see Figure 9).

In the case of the hierarchical VE model, a leader company (generally a large firm) allocates the manufacturing tasks among partners sharing resources and costs (Fenga and Yamashiro, 2006). The leader company assumes the task of coordinating the entire network of firms (Lefebvre and Lefebvre, 2002) and manages the knowledge and information flows. This company also acts as product integrator, as it is responsible for the final product/service and relationship with the customer.

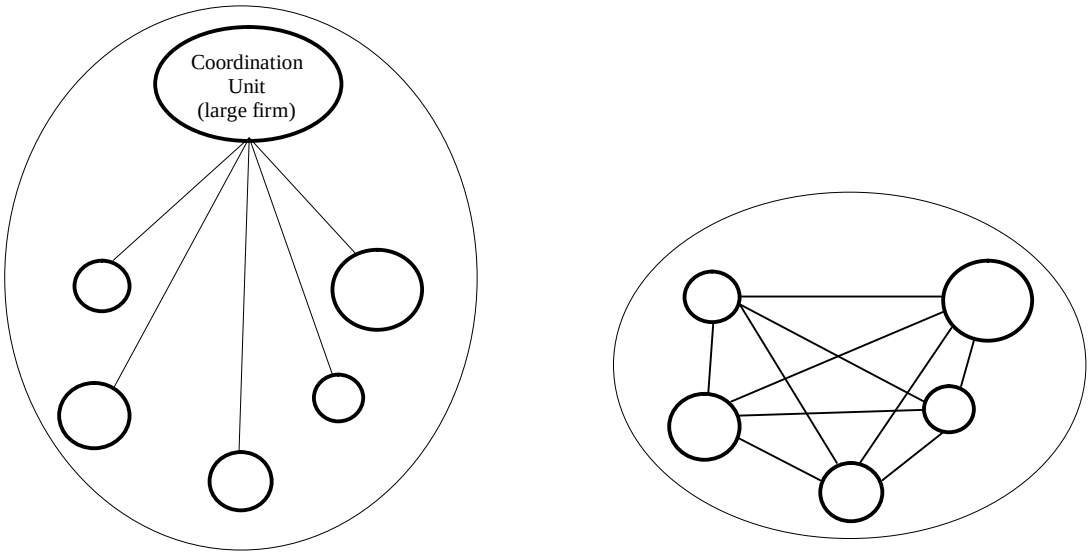


*Figure 9: comparison between hierarchical and holarchical VE*

The holarchical VE model has no hierarchical coordination unit. The self-organisation approach is the main coordination mechanism (Mezgar et al., 2000) which is based on mutual adjustment processes (Corvello and Migliarese, 2007). The holarchical model appears particularly suitable for SMEs but knowledge and information flows need to be integrated as there are differences in information systems used. Finally, due to the lack of a leader firm, the success of this type of model strictly depends on all partners co-operating as a single unit (Park and Favrel, 1999).

## 4. The extended enterprise

This section has been organised as the previous one. Firstly we review (from the oldest to the newest) the most comprehensive and significant definitions and perspectives on the VE. Secondly we summarise literature evidences by putting in evidence issues shared and issues not completely covered in literature. Finally we tried to outline if different virtual enterprise configurations emerge. Also in this case, articles strongly computer science based have been neglecting as they don't

provide either a description of the extended enterprise model or theoretical evidences for the knowledge management practices.

### *4.1 An overview of definitions*

Extended enterprise is a relatively novel concept and thus has no generally agreed upon definition (Lethinen and Ahola, 2010).

In this paragraph we reported the most important definitions (table 4) of the Extended Enterprise concept in the attempt to outline the common characteristics of the model and also the issues that have received less attention in literature.

The term extended enterprise appeared in the first '90s in the computer science literature thanks to Konsynsky (1993) and Elofson and Konsynsky (1993). Although these articles did provide neither a definition nor a picture of the management issues in the EE model, they put in evidence the key enabling role of information and communication technologies. Emerging ICTs change the limits of what is possible in the leverage of strategic control through transformation of boundaries, relations, and markets (Konsynsky, 1993).

Because of massive changes in the competitive environment and marketplaces, in the middle of '90s the EE model rapidly started to be analysed in the engineering manufacturing and operations research literature.

Browne et al. (1995) provided a comprehensive description of the context that was pushing firms to participate in extended enterprise forms of networking. According to the authors manufacturing systems are subject to tremendous pressures from the need to match global competition entering previously local markets, to develop environmentally benign products and production processes and to develop new forms of business organisation. Along with these pressures, five major trends have been identified, namely: i) the fact of *reduced product life cycles* and the consequences in terms of flexibility in the manufacturing capability; ii) the issue of *time-based competition* and the associated need to reduce the time to market for new products; iii) the necessity of taking *a total product life cycle view* due to the heightened awareness of environmental

problems; iv) the challenge of *creating organisations* and systems which attract *high-quality people* and make full use of their capabilities ands the problem for the individual manufacturer of developing a m*anufacturing strategy* which is appropriate to the business environment and which takes account of the position of the manufacturing facility in the value chain. Given these pressures and trends, it is no longer feasible to look in isolation at the manufacturing system.

*Table 4 : Definitions of extended enterprise*

| Year | Definitions | 1st Author |
|---|---|---|
| 1995 | - […] where core product functionalities are provided separately by different companies who come together for the purpose of providing a customer-defined product/ service.<br>-In the Extended Enterprise the bringing together of core competencies from many different organisations to provide a short manufactured life product means regular enterprise business process restructuring. | Browne, J |
| 1997 | - A group of strategically aligned companies focused on specific market opportunities.<br>- The advantage of the extended enterprise derives from a firm's ability to quickly exploit not only its internal resources, but also the collective resources of the entire extended network of suppliers, vendors, buyers, and customers.<br>- An extended enterprise might include manufacturers, suppliers, and logistics providers in a confederation that differs from a traditional strategic alliance or joint venture in the fluidity of its underlying nature and a tacit acknowledgment of its transient existence. | Greis, N. P. |
| 1998 | -The extended enterprise is a conceptual business unit or system that consists of a purchasing company and suppliers who collaborate closely in such a way as to maximise the returns to each partner.<br>- The extended enterprise does not necessarily comprise the entire supply chain, but a group of companies within it. | Childe, S. J. |
| | - The formation of closer co - ordination in the design, development , costing and the co - ordination of the respective manufacturing schedules of co - operating independent manufacturing enterprises and related suppliers.<br>-This form of collaboration is represented by the formation of mutually beneficial and formal (electronic) links in terms of co-ordination in the design, development and costing between the co-operating and independent manufacturing enterprises.<br>- Extensive use of IT within the respective enterprises and electronic communications among the enterprises is an additional feature of the extended enterprises. | Jagdev, H.S |
| 2000 | - A network of interconnected facilities through which an enterprise procures, produces, distributes, and delivers products and services to its customers. | Lin, G |
| | - An extended enterprise comprises an OEM, its supply chain, subsidiaries, consultants, and partners affiliated with the life cycle of a particular family of products. By integrating the various components of an extended enterprise into the development process, OEMs can dramatically reduce the cycle time and cost, while improving quality and product variety. | Rezayat, M. |
| | - This extended enterprise may be consonant with a single multinational organisation or, as is increasingly the case, a set of strategically aligned companies which partner to capture specific market opportunities. | Stock, G. N. |
| 2001 | - Extended and virtual enterprises are merely new paradigms reflecting the extent to which the information systems of the collaborating enterprises are integrated with one another and the way they actually communicate and collaborate with one another.<br>- The extended enterprise is a term frequently used in today' s business literature to reflect the high level of cooperation between organizations.<br>- It is this seamless exchange of relevant operational information on top of existing long term (and successful) relationship that distinguishes the extended enterprise form other forms of long-term collaboration such as a supply chain. | Jagdev, H.S. |

| | | |
|---|---|---|
| 2001 | - EEs span company boundaries and include complex relationships between a company, its partners, customers, suppliers and market.<br>- The organisational aspects of an extended enterprise can be summarise as globalisation of exchanges, subcontracting and partnership.<br>- Companies in an extended enterprise must co-ordinate its internal systems (intra-organisational activities) with other systems in the supply chain and further must be flexible and prepared for adapting to change | Martinez, M.T. |
| | - The Extended enterprise' concept covers industrial situations where functional entities belonging to independent enterprises come together to market (co-design, co-produce, etc.) particular products or services. | Vallespir, B |
| 2002 | - Extended enterprises unite project- and opportunity-based businesses that must react quickly to changes in the market or the available technology. The collaborating partners must reach general agreement on a project framework, and one enterprise (usually the most powerful) must lead the network. This leader — often described simply as an enterprise whose expanded boundaries incorporate its business partners — must provide specific resources for operating the extended enterprise.<br>- Extended enterprises can be established only within a coherent business space. | Furst, K |
| 2003 | -The concept *extended enterprise* is used here in preference to networked organisation precisely because the former term better captures this purposiveness (the other reason is to avoid confusion with ICT-linked organisations).<br>- The concept extended enterprise synthesises neatly with theories of knowledge interdependency, competence and technology-centred theories of the firm and the view of the innovative firm as a learning organisation. Firms gather and exploit knowledge using processes of its transfer, cumulation, generation and socialisation<br>-The extended enterprise making up supply networks, must invest in the absorptive capacity necessary to learn from and contribute to the networks in which they participate—to gain advantage from networking the extended enterprise must itself be a learning organisation | Kinder, T.. |
| 2005 | - Extended enterprise is a kind of organisation comprised of interconnected enterprises. Based on cosharing knowledge and manufacturing resources, the enterprises team with one another so that their competitive advantage could be improved. While providing comprehensive products or service for customers jointly, each enterprise could achieve its individual objective. Extended enterprise is an enormous system with a world of complexity in the organisation and its operation | Hongzhao, H. |
| 2006 | - The Extended Enterprise can then be defined as "*a collection of* legal entities ($N \geq 2$) that pursue repeated, enduring exchange relations with one another".<br>- Although an Extended Enterprise is usually not a real enterprise from a legal (financial) point of view, it is noticeable that an Extended Enterprise conceptually forms a new enterprise (the constituting organisations share and redesign processes, data, etcetera). This new enterprise has a starting point and an endpoint (in time). | Goethals, F. G. |
| | - Extended enterprise concept in parallel with the concurrent enterprising looks for how to add value to the product by incorporating to it knowledge and expertise coming from all participants on the product value chain<br>- This new paradigm implies a quite new scenario: knowledge capturing and sharing, new forms of interrelationship between companies and persons, etc. Companies need to be able to extend their own enterprises, (by removing barriers of geographic location and human resource problems) to encompass the customer's operations where the supplied industrial products are being used. | Sorli, M. |
| 2008 | -The entire network of collaborating enterprises, from supplier to end-use customers, which have a long term agreement<br>- The purpose of this integration is to achieve a competitive advantage by maintaining a distributed cooperation across the entire organisation.<br>- In the age of the Extended Enterprise, the swift expansion of the Internet provides the infrastructure by which information can be made simultaneously available to all those involved in planning manufacturing processes<br>- […] Extended Enterprise scenario where exists one enterprise, that requires to assign manufacturing contracts to those geographically distributed enterprises capable to satisfy quality, costs and delivery requirements<br>- In the case of Extended Enterprise different tier suppliers collaborate within the common communication infrastructure provided by the Original Equipment Manufacturer (OEM) | Siller, H. L. |

The manufacturing system must be seen in the context of the total business and the linkages of the business back through the supplier chain and forward into the customer chain. This concept of inter-enterprise networking is called the extended enterprise. The authors also highlighted as the Extended Enterprise, where core product functionalities are provided separately by different companies who come together for the purpose of providing a customer-defined product/ service is made possible and viable through information and communication technologies such as EDI supporting the networking among different members. Similarly, Gunn (2000) identified four clusters of drivers enabling the EE adoption: political, economic, social and technological drivers; and three levels of barriers: human, business and technological barriers.

In their discussion of the new role of logistics in the information era, Greis and Kasarda (1997) provided an exhaustive view of the EE model. According to these authors, an extended enterprise might include manufacturers, suppliers, and logistics providers in a confederation that differs from a traditional strategic alliance or joint venture in the fluidity of its underlying nature and a tacit acknowledgment of its transient existence. The notion of the extended enterprise is in direct contrast to the hierarchically controlled organisations that have dominated American manufacturing for more than one hundred years. Each extended enterprise member contributes to the collective enterprise by sharing facilities, resources, technology and know-how. In theory, and in practice, as market opportunities change, the extended enterprise can be reconfigured to assemble the right complement of resources more quickly than a single company can acquire or develop those resources internally. Transactions within the extended enterprise represent a balance between markets and hierarchies. Indeed, the collaborative and longer-term relationships among customers and suppliers in the collective enterprise is accompanied by a level of information-sharing that is deeper than that traditionally associated with the simple exchange of faxes or electronic mail to transact an order, transmit a technical drawing, or tally a bill. It is through the creation of new information exchange channels and the depth of information sharing that the extended enterprise sets itself apart from both markets and hierarchies (Greis and Kasarda, 1997).

Also the paper of Childe (1998) is widely cited in the EE literature. The author defined the extended enterprise as a conceptual business unit or system that consists of a purchasing company and suppliers who collaborate closely in such a way as to maximise the returns to each partner. The extended enterprise does not necessarily comprise the entire supply chain, but a group of companies within it. The author provided a clear description of a hierarchical extended enterprise form of cooperation. He assessed that it appears that the initiative for all these examples comes from the final company at the high-value, big name end of the supply chain, the point where the money flows in. It may be difficult for the struggling manufacturer of castings or machined parts to initiate a supply chain strategy from a position many stages removed from the final customer. Indeed, according to Childe (1998), the concept of the extended enterprise is very close to what Christopher (1992) terms `Co-makership', a partnership in which a company develops *a long- term relationship with a limited number of suppliers on the basis of mutual confidence*. A similar hierarchical view is described by Furst (2002) who assessed that the collaborating partners must reach general agreement on a project framework, and one enterprise (usually the most powerful) must lead the network. This leader — often described simply as an enterprise whose expanded boundaries incorporate its business partners — must provide specific resources for operating the extended enterprise. As a matter of course, any of the partners can be involved in multiple extended enterprises — for example, two enterprises might simultaneously cooperate in one business segment and compete in another.
However the empirical evidences provided by other authors (Bititci et al., 2005; Vila et al., 2005) also shown as it is possible the existence of different extended enterprises configurations (even for the same company).

In the same period Jagdev and Browne (1998) defined the extended enterprise as the formation of closer co - ordination in the design, development , costing and the co - ordination of the respective manufacturing schedules of co - operating independent manufacturing enterprises and related suppliers. Extensive use of IT within the respective enterprises and electronic communications among the enterprises is an additional feature of the extended enterprises. The co-ord ination of the relationships between member companies and the communication among

them are other critical issues for the extended enterprise. The following are the major characteristics of the extended enterprise arising from JAgdev and Browne (1998):

- the manufacturing enterprise focuses on core business activities, and outsources non-core business activities to outside suppliers and other service providers.
- The manufacturer of the manufacturing-centred extended enterprise develops loyal and long-term relationships with key customers and suppliers, and treats them as his most important business partners.
- The extended enterprise has methods and technologies to support business activities that cross boundaries in order to support supplier- customer integration through the interchange of commercial and technical information.

Probably the work of Jagdev and Thoben (2001) represents the most comprehensive (and one of the most cited) study of the Extended Enterprise topic. The authors put this model within a continuum of industrial cooperations. On the one end of the continuum is the market. Here, only single-market transactions are made between two distinct companies. No further mutual obligations are expected from each other. On the other extreme of the continuum is the hierarchy, where every cooperation is dealt within one single integrated company. In between these two extremes are many types of bilateral relationships. Jagdev and Thoben (2001) mention three types: supply chain, extended enterprise and virtual enterprise. These types of industrial cooperation vary in the degree of integration between the partners and related to this the level of cooperative confidence. According to the authors “extended and virtual enterprises are merely new paradigms reflecting the extent to which the information systems of the collaborating enterprises are integrated with one another and the way they actually communicate and collaborate with one another. In other words, extended and virtual enterprises are different (more sophisticated!) manifestations of the supply chains”. It is the exchange of relevant operational information on top of existing long term (and successful) relationship that distinguishes the extended enterprise from other

forms of long-term collaboration such as a supply chain. It should also be noted that ICT are enabler technologies and a necessary (though not sufficient) condition for an extended enterprise to exist. The following are some of the main characteristics of the EE model put in evidence by Jagdev and Thoben (2001):

- the partners in the extended enterprises are willing to form long-term relationships and treat each other as business partners;
- Within the scope of collaboration, partners share vision and work towards shared goal;
- The decisions are jointly arrived at by making best use of the competencies among the partners;
- It is, therefore, important to have available advanced ICT tools to support the extended enterprise communication and sharing of information;
- The efficiency of the extended enterprise is greatly determined by the speed and efficiency with which information can be exchanged and managed among business partners
- Extended enterprise can occur between any two enterprises across the value chain of any product or service;
- Technology permitting, extended enterprise can take the form of a complex enterprise network where each enterprise can be seen as a node;
- The relationship between a set of nodes in an extended enterprise can be hierarchical or nonhierarchical

Goethals et al., 2006 defined the Extended Enterprise as "*a collection of* legal entities ($N \geq 2$) that pursue repeated, enduring exchange relations with one another". Although an Extended Enterprise is usually not a real enterprise from a legal (financial) point of view, it is noticeable that an Extended Enterprise conceptually forms a new enterprise (the constituting organisations share and redesign processes, data, etcetera). This new enterprise has a starting point and an endpoint (in time). Generally, the Extended Enterprise will be created while its (individual) constituting enterprises are in operation. Of course, setting up an Extended Enterprise may result in new requirements for the individual enterprises, bringing these into the requirements phase. Naturally it is desirable to keep the

individual enterprise operational while redesigning the enterprise to fulfill the new requirements. Therefore individual enterprises will be involved in two types of activities at the same time (e.g., the requirements phase and the operational phase) (Goethals et al., 2006).

At the end of '90s the interest of scholars shifted to the knowledge management issues arising in the extended enterprise context putting in evidence the knowledge-based nature of the extended model.

The concept extended enterprise synthesises neatly with theories of knowledge interdependency, competence and technology-centred theories of the firm and the view of the innovative firm as a learning organisation. Firms gather and exploit knowledge using processes of its transfer, cumulation, generation and socialisation (Kinder, 2003).

Also in the definition provided by Bititci et al., (2005) the focus is on knowledge. The authors after reviewing the literature on the EE topic defined the extended enterprise as a knowledge-based organisation which uses the distributed capabilities, competencies and intellectual strengths of its members to gain competitive advantage to maximise the performance of the overall extended enterprise.

Indeed, according to Sorli et al., (2006), manufacturers need to benefit from 'extended enterprise' techniques by involving all people from throughout the product life cycle (suppliers, customers, design, production and servicing) to provide their product knowledge to enhance product development and support. This knowledge needs to be saved and managed. Loss of this knowledge results in increased costs, longer time-to-market, reduced quality of products and services. Therefore manufacturing companies need to shift towards the use of extended enterprise technologies and knowledge management for customer/product support. This new paradigm implies a quite new scenario: knowledge capturing and sharing, new forms of interrelationship between companies and persons, etc. (Sorli et al., 2006).

Similarly, Kuczynski et al., (2006) assessed that the efficient information/knowledge exchange among the collaboration network's partners is a

key issue. The generation and usage of innovations can be improved by methodologies and means to efficiently analyse, store and share innovation knowledge within the EE collaboration network. Therefore the authors present a set of new methods and IT tools to support efficient and smooth exchange of innovation knowledge in extended and networked enterprises.

Although they do not directly provide a description of the extended model, in the same stream the works of Lopez-Ortega and Hernandez, (2007) (proposal of a formal framework of the information system facilitating data sharing in the Extended Enterprise), Neaga and Harding (2005) (defining a common knowledge enterprise model applied to extended enterprise) and Raymond and Blili, (2000) (constructing an organisational learning model for the extended enterprise) can be located.

The last theoretical work on the EE topic is probably the paper by Siller et al., (2008). According to these authors the extended enterprise can be defined as the entire network of collaborating enterprises, from supplier to end-use customers, which have a long term agreement, the purpose of this integration is to achieve a competitive advantage by maintaining a distributed cooperation across the entire organisation. In the age of the Extended Enterprise, the swift expansion of the Internet provides the infrastructure by which information can be made simultaneously available to all those involved in planning manufacturing processes, that is to say, designers, planners, production managers, shop floor workers and so forth. In fact in a geographically dispersed manufacturing environment such as the extended enterprise, it is needed both a web-based tool for collaboration and a framework that enables the integration and coordination of product development activities and the exchange of information between entities (expert applications or individuals). The authors also described a hierarchical extended enterprise scenario where exists one enterprise, that requires to assign manufacturing contracts to those geographically distributed enterprises capable to satisfy quality, costs and delivery requirements. Different tier suppliers collaborate within the common communication infrastructure provided by the Original Equipment Manufacturer (OEM) (Siller et al., 2008).

### *4.2 Literature evidences*

Following the same process of the previous section on the VE, literature evidences show that there a number of common issues related to the EE concept and other important issues that are not fully addressed by the literature. An overview of shared issues is outlined in Table 5.

*Table 5: literature evidences on EE, shared issues*

| Issues | Literature evidences |
|---|---|
| Main aims | -to provide a customer-defined product/ service *(Jagdev and Browne, 1998; Jagdev and Thoben 2001; Hongzhao et al., 2005; Kuczynski et al., 2006; Sorli et al., 2006; Post et al., 2002; Prahalad, and Ramaswamy, 2000; Kanter, 1999)*<br><br>-to reduce the time to market of new products *(Browne et al.,1995; Jagdev and Browne, 1998; Rezayat, 2000; Stock et al., 2000; Greis and Kasarda, 1997; Martinez et al., 2001)*<br><br>-product lifecycle must be managed as a whole (*Browne et al.,1995; Jagdev and Browne, 1998; Bititci et al. 2005; Kuczynski et al., 2006; Sorli et al., 2006; Cao et al., 2009)* |
| Partnership objectives | -Reduced costs *(Browne et al.,1995; Rezayat, 2000; Jagdev and Browne, 1998; Bititci et al., 2005)*<br><br>- Risk sharing *(Browne et al.,1995; Kuczynski et al., 2006; Boardman and Clegg, 200; Bititci et al., 20051)*<br><br>- Share and focus on core competencies *(Browne et al.,1995; Jagdev and Browne, 1998; Goethals et al., 2006; Frederix, 2001; Lakhal et al., 2001; Kanter, 1999; Greis and Kasarda, 1997; Childe 1998; Jagdev and Browne, 1998)*<br><br>- Knowledge-based organisation incorporating knowledge and expertise coming from all participants *(Mendikoa et el.,2008; Jiang et al., 2007; Kuczynski et al., 2006; Sorli et al., 2006; Bititci et al., 2005; Hongzhao et al., 2005; Lopez-Ortega and Hernandez, 2007: Kinder, 2003; Lau et al., 2003; Boardman and Clegg, 2001 Prahalad, and Ramaswamy, 2000; Kanter, 1999; Greis and Kasarda, 1997)* |
| Organisation stability | -Flexibility *(Hamblin, 2002; Stock et al., 2000; Greis and Kasarda, 1997)*<br><br>-Adaptibilty, the extended enterprise must be ready to change according to the market shifts *(Browne et el., 1995; Binder and Clegg, 2006; Malhotra et al, 2007; Post et al.; 2002 Prahalad, and Ramaswamy, 2000)* |
| Partnership characteristics | - Long-term relationship *(Jagdev and Browne, 1998; Jagdev and Thoben 2001; Hongzhao et al., 2005; Goethals et al., 2006; Kuczynski et al., 2006; Sorli et al., 2006; Malhotra et al., 2007; Post et al.; 2002; Martinez et al., 2001; Childe, 1998)* |

| | |
|---|---|
| | - Collaborative; co-operative *(Jagdev and Browne, 1998; Jagdev and Thoben 2001; Alvarez, 2007; Jiang et al., 2007; Siller et al., 2008; Post et al., 2002; De Leede and Looise, 2001 Prahalad, and Ramaswamy, 2000; Cagliano et al., 2005; Kanter, 1999)*<br><br>- Independent companies *(Browne et al.,1995, Jagdev and Thoben 2001; Goethals et al., 2006; Siller et al., 2008; Childe, 1998; Jagdev and Browne, 1998)*<br><br>- mutual trust and share a common goal *(Browne et al., 1995; Childe, 1998; Jagdev and Thoben, 2001; De Leede and Looise, 2001; Thoben and Jagdev, 2001; Kanter, 1999; Greis and Kasarda, 1997; Childe, 1998)* |
| Coordination and communication tools | -Extensive use of ICT and computer networks *(Jagdev and Browne, 1998; Jagdev and Thoben 2001, Goethals et al., 2006; Kuczynski et al., 2006; Lopez-Ortega and Hernandez, 2007; Siller et al., 2008; Rezayat, 2000; Davis and O'Sullivan, 1999)*<br><br>- EDI technologies *(Davis and O'Sullivan, 1998; Browne et al.,1995; Jagdev and Thoben 2001)* |
| Knowledge management | -The efficient information/knowledge exchange among the collaboration network's partners is a key ***(****Sorli et al., 2006; Mendikoa et al., 2008; Kuczynski et al., 2006; Lillehagen, 2001; Greis and Kasarda, 1997****)***<br><br>-The concept extended enterprise synthesises neatly with theories of innovative firm as a learning organisation *(Kinder, 2003; Raymond and Blili, 2000)* |

Summarising the issues covered by the literature, it appears that extended enterprise model, through the management as a whole of a product lifecycle, aims at providing a customer-defined product/ service, and reducing the time to market of new products. Partnerships are established to share costs, risks and to bring together the expertise, competencies and knowledge of the member firms. Relationships are typically long-term oriented based on collaboration, cooperation and mutual trust among individual companies that share a common goal. The extended enterprise needs to be quite flexible to adapt to market changes. ICTs play a critical role as coordination and communication tools used. In particular strong interest has been given on EDI technologies. Finally the efficient information/knowledge exchange among the collaboration partners is a key issue for the extended enterprise. These six issues may be considered the common foundations of the theoretical concept of the EE model.

Nevertheless, the literature review highlighted a number of issues not fully shared (table 6).

*Table 6: literature evidences on EE: non-shared issues*

| Issues | Literature evidences |
|---|---|
| Coordination unit | -The most powerful company leads the network *(Furst et al., 2002; Childe, 1998)* |
| | - Contracts as the principle coordination mechanism for the extended enterprise *(Linington 2004)* |
| Firm size | - Relationships in the EE are not only restricted to large manufacturers but also to small and medium sized enterprises *(Jagdev and Thoben, 2001)* |
| | - Extended enterprise implies new types of relationships between large and small firms *( Raymond and Blili, 2000)* |
| | - There are examples of EE of SMEs *(Greis and Kasarda, 1997)* |
| Organisational structure | - It is possible the existence of different extended enterprises *(Bititci et al, 2003; Bititci et al, 2005: Vila et al., 2005)* |
| | - EE has a hierarchical nature *(Hongzhao et al., 2005)* |
| | - The suppliers are viewed as a part of the focal company—the System Integrator *(Cagliano et al, 2005)* |
| | - Extended enterprise is better used when a dominant enterprise extends its boarders to all, or a majority, of its suppliers is present *(Pires et al.,2008; Furst et al., 2002; Childe, 1998)* |
| | - One enterprise requires to assign manufacturing contracts to those geographically distributed enterprises capable to satisfy quality, costs and delivery requirements *(Siller et al., 2008)* |
| | -The relationship between a set of nodes in an extended enterprise can be hierarchical or nonhierarchical *(Jagdev and Thoben, 2001)* |
| | - The structure of manufacturing firms tends to be more flat or less hierarchical, leading to the extended firm that comprises a group of member firms (or partner firms).*(Liu et al., 2008)* |
| | - The extended enterprise may be consonant with a single multinational organization or, as is increasingly the case, a set of strategically aligned companies which partner to capture specific market opportunities *(Stock et al., 2000)* |

The most relevant non-shared issues relate to the organisational model and coordination mechanisms. The literature does not indicate a unique EE organisational model. Two different views emerged in terms of hierarchical or non-hierarchical structures. On one hand, in the hierarchical approach the EE is created by a large focal firm (acting also as coordination unit) that extends its boarders to a majority of its suppliers. On the other hand, an alternative approach proposes horizontal structures among peer partners bringing together complementary competencies for a common goal.

Indeed literature doesn't clarify if the extended model is more suitable for large or small firms. Few works indicate that extended networks can involve SMEs. This seems a gap that needs to be addressed as many industrial systems in developed countries are populated by a large number of small company aggregations.

### *4.2 A holistic EE model*

The literature review presented above identifies a number of common and specific features that provide a comprehensive picture of the theoretical concept underlying the EE model. Considering the issues non-shared by the literature, with particular reference to issues of organisational structures and coordination mechanisms, a hierarchical EE approach clearly emerged.

In this case, as the extent of co-operation increases the principal company (generally a large OEM), the one who receives supplies from the other partners and from whose viewpoint we see them, begins to be as dependent upon its suppliers as if they were part of the same company. The suppliers become part of the business and can no longer be regarded as outside the principal company's affairs. This company also acts as product integrator, as it is responsible for the final product/service and relationship with the customer (Childe, 1998; Furst et al., 2002). This model could be seen as a holistic EE model (see figure 10), widely cited in different literature streams, but still not tested through empirical analysis.

However literature indicates that different EE configurations are possible. "Peer" firms could join together to share complementary competencies in order to achieve common goals, non hierarchical configurations could be assumed. Nevertheless the few works referring to the existence of such a kind of extended

networks (Jagdev and Thoben, 2001; Stock et al., 2000) don't provide strong evidences allowing to construct a framework (as done for the virtual enterprise in the previous section).

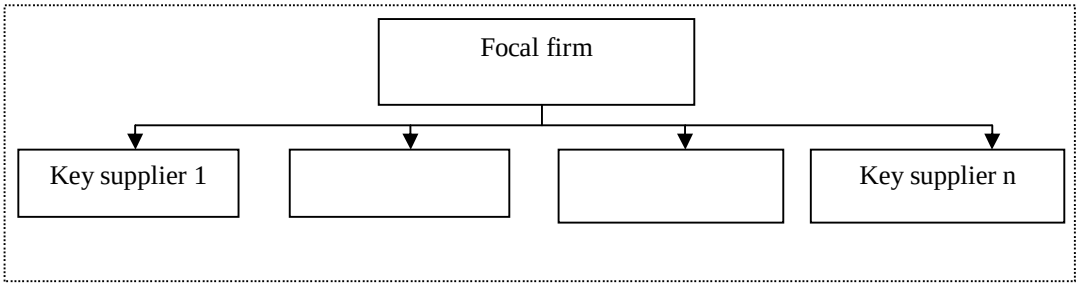


*Figure 10: a holistic EE model*

## 5. Discussion

This section has been organised into three paragraphs. In the first one we analyse the evolution of the extended and virtual enterprise concepts trying to find one way to interpret this. In the second paragraph we make a comparison between the two models, while in the final one we put in evidence the main literature gaps emerged.

### *5.1 The evolution of the virtual and extended enterprise concepts*

*Virtual Enterprise*

Analysing the evolution over the years of the different works and definitions on the VE (see the previous figure 7 and table 1) it is possible to highlight some interesting evidences.

First of all the most important definitions were provided between the late'90s and the early 2000s.

It is difficult to put in evidence a particular trend among the definitions. The most cited features of the model as the collaborative and short-term nature of the relationship, the independence of the member firms were widely cited over the years. Nevertheless it is interesting to notice as the role of the ICTs has been slightly neglected in the last formulations of the virtual model. This fits with the

trend described by the figure 7 which shows as the computer science based articles are decreasing in number (if compared with the engineering ones) during the past few years.

Oppositely the theoretical KM features of virtual model have been started to receive attention in literature only recently. This probably shows a common problem of the literature on knowledge management practice and ICTs. ICTs are a fundamental tool to facilitate the management of knowledge assets, but they are not sufficient and if not well planned investments in ICTS could be not effective. It is indeed important to consider other variables and features (for example the human resources and the tacit knowledge) when planning the adoption of a KM program. Therefore theoretical and modeling studies are also fundamental.

Evidences described in the section three have shown as it is not possible to identify a unique VE model. A variety of VE models could be considered within a framework between two extreme models: the hierarchical and holarchical models. This framework includes a number of shared issues (e.g. main aims of VE creation, the objectives on which the partnership is based, the stability of the virtual organisation, the partnership characteristics, and the coordination and communication tools) and other specific issues (e.g. coordination unit, firm size, organisational structure, KM and market relations).

These results match with the studies that don’t recognise the VE as a distinct organisational structure. For example Venkatraman and Hendersen (1998) assessed that “virtual organisation” is an unfortunate term while virtual organising is a more powerful concept because it focuses on the importance of knowledge and intellect to create value. They also argued that virtualness is a strategic characteristic applicable to every organisation and reflecting three vectors: virtual encounter, virtual sources and virtual expertise supported by a powerful, integrated IT platform.

Similarly, Kraut et al. (1999) assessed as the term "virtual organisation" as used in the literature, has no consistent meaning. The term has been applied to movie production, just-in-time manufacturing operations, "adhocracies," and informal regional consortia. Although these examples do not provide a tight definition, they suggest some of the features that may underlie the concept of a

virtual organisation. But for most firms, being virtual is a matter of degree (Kraut et al, 1999).

Therefore, the problem seems to be the identification of a framework able to involve all the potential configurations that can be assumed in a "*virtualisation process*".

An important research stream that has been receiving greater attention especially in the past few years refers to the methods partners' selection in the VE (Chen et al., 2007; Sari et al., 2008; Fei, 2010; Xinxing Luo et al., 2009; Tao et al., 2010; Wu and Barnes, 2010).

*Extended Enterprise*

The term extended appeared in the computer science literature in the early '90s without a definition of the model. Also in this case the most articles on the EE topic were published between the late '90s and the early '2000s. The most cited features of the model as the collaborative and long-term nature of the relationship, the independence of the member firms were widely cited over the years. But at the end of '90s the interest of scholars shifted to the knowledge management issues arising in the extended enterprise context putting in evidence the knowledge-based nature of the extended model. Indeed, in the EE the interest towards the ICTs continues to receive a great attention. This is because the longer term and the more stable nature of the relationships established in an extended model calls for ICTs tools and platform facilitating the efficient and effective communication and information exchange over longer periods.

An important research stream that has been receiving greater attention in the past few years refers to the construction of a performance measurement system for the extended enterprise (Folan and Browne, 2005; Bititci et al., 2005; Folan et al. 2006 and Lethinen, 2010).

The evidences presented in the section four have shown a number of common and specific features that provide a comprehensive picture of the theoretical concept underlying the EE model. In this case, considering the issues non-shared by the literature, with particular reference to issues of organisational structures and coordination mechanisms, only a hierarchical EE approach clearly emerged.

Literature indicates that non hierarchical EE configurations are possible as well, but the few works referring to the existence of such a kind of extended networks don't provide strong evidences allowing to construct a framework (as done for the virtual enterprise in the previous section).

### *5.2 A comparison between virtual and extended enterprise*

Reviewing the literature on the differences about these two models, different approaches could be put in evidence.

Sometimes it is possible to assist to some *degree of confusion* in the utilisation of the two concepts (Rolstadas 1997; Kovacs and Paganelli; 2003; Tatsiopoulos et al., 2002).

There are a lot of articles that define the *EE as a particular case of the VE model*.

Comparatively to extended enterprise, VE concept has a more extensive scope, and includes the first in it. Consequently, extended enterprise is a particular case of VE concept (Jagdev and Browne 1998, Camarinha-Matos et al., 1999). For Martinez et al., (2001) an EE could derive from a short term VE evolution deriving from a stabilisation in the market segmentation (Martinez et al., 2001).

For Jagdev and Browne (1998), the slight difference between the two models being a question of life duration: whereas EE is a stable cooperation to develop a long-term and loyal relationship with key subcontractors and suppliers, VE is rather a temporary network of independent companies to realise a specific product and disappear with it (Jagdev and Browne, 1998). In that sense EE appears as a particular case of VE though both are close from the point of view of production planning and scheduling (Lecompte et al., 2000).

Binder and Clegg (2006) suggest that vertically integrated enterprises (VIEs), virtual enterprises, and extended enterprises are not, as some would believe, structures resulting from completely different strategies. The authors show that they are better thought of as a closed-loop continuum of the same collaborative

strategy and the emergent structure of the enterprise at any one time is contingent upon the prevailing mix of endogenous and exogenous factors.

There are other papers which try to define a *clear distinction* among the two concepts.

In the opinion of some authors, extended enterprise is the dominant expression, and the difference between extended and virtual is resumed to be a semantic question (Jagdev and Browne 1998). In a VE the integration level is bigger and, comparatively to extended enterprise, the partnership agreements are shorter in time (Jagdev and Browne 1998). It is possible to say that extended enterprise is better used when a dominant enterprise that extends its boarders to all, or a majority, of its suppliers is present (Camarinha-Matos et al. 1998, Pires et al., 2008).

Whicker and Walton (1996) suggest that the EE concept differs from the virtual enterprise concept insomuch as it consists of a dominant trader that is associated with all, or some, of its suppliers. The boundary of any particular EE that an organisation belongs to can be defined by how far the influence of its internal value chain reaches throughout its suppliers and partners (Folan et al., 2006). It is probable and desirable that an organisation will belong to a number of EEs within different industry sectors (Clegg 2003).

A more complete discussion about differences and similarities between these two models could be found in Jagdev and Thoben (2001) and Browne and Zhang (1999). The authors defined a set of variables of interest to guide the comparison between extended and virtual enterprise

According to our review the following main issues arose:

- generally speaking the number of articles on the VE topic is larger than the ones about the EE. This is probably because in the VE context there is a stronger influence of the Computer Science area.

- The motivations behind the EE are more ambitious and not related just to the exploitation of a market opportunity. The adding value role of the

customer and the necessity to have a clear image of the total product life cycle are motivations strongly put in evidence.

- In the extended enterprise concept relationships are longer, while in both models the focus is on the cooperation and collaboration as a new way to build up more effective and efficient relationships.

- In the extended enterprise there is a stronger focus on trust in guiding the operation as a single unit of the network.

- The role of ICT is critical for both models. But, while the shorter-term of a VE calls for a strong integrations and therefore compatibility among the information systems of the member companies; in an EE ICTs act more as "facilitator". In the extended enterprise context the focus is on EDI technologies and common platform enabling the efficient exchange of data and the coordination among the member activities.

- Although KM has been recognised as a crucial issue for both VE and EE, the EE literature is richer of articles both theoretical and practical on knowledge and information sharing practices and mechanisms. The performances of an extended enterprise are strongly related to the capacity of its members to share relevant information and knowledge for the common goals.

- The difference between the two models doesn't relate to horizontal or vertical structures as assessed for example by Camarinha-Matos et al. (1998) and Pires et al (2008). As emerged in our review, it is possible to identify hierarchical and non-hierarchical (holarchical) configurations for both models. Nevertheless, this distinction is clearer in the VE literature, while the EE most cited structure is the hierarchical one managed by a focal larger firm.

### *5.3 Literature gaps*

#### *5.3.1 Virtual enterprise*

Although virtual enterprise models have received greater attention in literature from different research areas and perspectives it is possible to put in evidence some critical gaps that are not fulfilled. They mainly refer to the relationship between the VE and the supply chain concept and to the lack of empirical evidences on VE models. In particular:

- in the definition of the VE concept, there are some issues that are not sufficient covered by the literature, in particular issues on coordination mechanisms, organisational structure and size of the participating firms. These issues could lead to a set of different virtual configurations varying from hierarchical and holarchical forms.

- Since a number of definitions of VE have been suggested, it is not clear whether there is a unique organisational form or there are a variety of VE models presenting shared characteristics. Although, as seen above, it seems reasonable to argue that there are a variety of VE models presenting shared characteristics, there are still little research efforts on this subject.

- Although existing empirical studies focus mainly on traditional forms of collaboration among firms (such as supply chain and industrial districts), the evolutionary paths that allow firms to move from traditional forms to virtual configurations have not been fully explored.

- There is still little empirical research investigating real cases of VE (De Sanctis and Monge, 1999; Camarinha-Matos et al., 2003).

- There are few literature contributions focused on KM practices in VE through a theoretical perspective. (Pollalis and Dimitriou, 2008).

*5.3.2 Extended enterprise*

To date, extended enterprise vision has not achieved marked success, probably because facing the challenges and risks involved seemed like a greater evil than the existing problems (Gunn, 2000). Therefore it is important to highlight the literature gaps emerged from the review in order to suggest directions for future research on the topic. The following are some of the most important gaps emerged.

- The European Union's research and development objectives under the sixth framework program make it clear that, as yet, we do not understand how to manage a collaborative/extended enterprise (Bititci et al., 2005).

- We still see very few examples of extended enterprises in practice and in particular information infrastructures to support inter-enterprise communications. One of the reasons identified for this, is the lack of a standardised communications medium to enable the seamless co-ordination of information exchange across enterprises (Davis and O' Sullivan, 1999).

- Relation between Extended Enterprise concept and other traditional concepts such as the supply chain is still unclear. Boundaries of the EE concepts are blurred.

- In the definition of the EE concept, there are some issues that are not sufficient covered by the literature. In particular issues on coordination mechanisms and organisational structure.

- There is still little empirical research investigating the EE.

- The literature does not indicate a unique EE organisational model. A hierarchical approach clearly emerges. But, there are authors which propose alternative non hierarchical approaches. Nevertheless they don't provide

either a clear description, or real examples. Therefore, more studies are needed to investigate if different EE configurations emerge.

## 6. Conclusions

In this paper the literature on extended and virtual enterprise has been reviewed in a systematic way.

Different areas of literature have given to these two models greater attention especially in the early 2000s. The two concepts were born in the computer science area because of the revolution of ICTs that are changing the limits of what is possible in the leverage of strategic control through transformation of boundaries, relations, and markets. Nevertheless, in the past few years scholars are more focusing on managerial and engineering issues.

Although in both models the focus is on the cooperation and collaboration (enabled by ICTs) as a new way to build up more effective and efficient relationships, in the extended enterprise relationships are generally longer. Indeed, the management of information flows among member firms has been recognised as a crucial issue for both VE and EE, but the EE literature is richer of articles both theoretical and practical on knowledge and information sharing practices and mechanisms.

After an overview of most comprehensive definitions, this essay has ascertained that it is not possible to identify a unique VE model. A variety of VE models may be considered within a framework. This framework includes a number of shared issues (e.g. main aims of VE creation, the objectives on which the partnership is based, the stability of the virtual organisation, the partnership characteristics, and the coordination and communication tools) and other specific issues (e.g. coordination unit, firm size, organisational structure, KM and market relations).

In particular, two extreme VE forms were identified: the hierarchical and holarchical models. In the case of the hierarchical VE, a leader company assumes the coordination of the network, and generally manages market relationships acting as the product integrator. By contrast, the holarchical model is characterised by a self-organisation in which the success of the virtual enterprise

strictly depends on all partners co-operating as a single unit. Therefore, the problem seems to be the identification of all the potential configurations that can be assumed between these two extreme models in a "*virtualisation process*".

As for the VE, in the definition of the EE concept there are a number of shared issues: main aims of EE creation, the objectives and the characteristics of the partnership, the coordination and communication tools and the strong emphasis on the knowledge management practices. Nevertheless, issues on coordination mechanisms and organisational structure are not sufficient covered. The literature does not indicate a unique EE organisational model, but in this case only a hierarchical approach clearly emerges, while non-hierarchical configurations have still received less attention.

However, the main gaps affecting the literature on both models just refer to the partial lack of empirical studies testing the theoretical evidences in potential real cases of virtualisation process and extended enterprise.

It is to partially attempt these gaps that the next two essays have been conceived.

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# ESSAY 2 - THE VIRTUALISATION POTENTIAL OF SME NETWORKS: AN EXPLORATORY INVESTIGATION

## 1. Introduction

In Italy during the 1970s and 1980s, networks of small and medium-sized enterprises (SMEs), such as enterprise clusters and industrial districts, offered an important alternative to the advantages achieved through a larger production scale in many countries and industries. However, in more recent decades uniform growth in SME networks has come to an end. In order to respond to competitive challenges, local SME networks have experimented with new development paths, and the range of options has significantly expanded. Traditional unidirectional development paths have no longer proved valid, and various avenues have been pursued to face up to market globalisation. Accordingly, on discussing the future of industrial districts, Becattini et al. (2003) recognised that this organisational form of SMEs has often proved to be rather a 'stage' in one of the possible different paths of industrialisation.

The radical changes that have occurred in the competitive scenario in recent years have driven small firms to seek new development paths in order to cope with the growing complexity of the business environment and to ensure access to new sources of competitive advantage (Davenport and Short 1990; Manuelli 2002). In this new scenario, many studies have stressed firms' opportunities to redesign processes and business organisations through electronic networks on a worldwide scale (Jin and Robey 2008; Scott Morton 1991; Tapscott 1996). By focusing on the gains in efficiency stemming from the electronic management of business processes, physical proximity and localisation have become less important.

According to the recent literature and current business practice, small firms are seeking new forms of collaborative relationships with a higher degree of decisional and operational flexibility, in order to satisfy customer demands faster and at a lower cost. One of these emerging organisational forms is the virtual enterprise (VE) (see, for example, Davidow and Malone 1992; Thompson, 2008).

In this model, information and communication technology (ICT) is considered the driver of local SME network competitiveness. Specifically, ICT solutions are considered a powerful tool to enhance local innovation processes towards global networks. Electronic networks may increase the value of a firms' capacity to develop a high level of local expertise and specialised knowledge by enlarging its domains on a global scale. Major consequences for local SME networks may derive from the advent of the VE model. Information technologies can develop the local systems by enlarging their boundaries, so that they can manage more independently relations with their suppliers and with the final market, and share specific knowledge that is useful to the whole value-chain system.

Despite increasing academic interest in this organisational form, it is still not clear whether the VE model may be considered a possible response to the greater complexity and instability of today's business environment. Moreover, since a number of definitions of VE have been suggested, it is not clear whether there is a unique organisational form or there are a variety of VE models presenting shared characteristics (Cunha and Putnik, 2006). In addition, although existing empirical studies mainly focus on traditional forms of collaboration among firms (such as supply chain and industrial districts), the evolutionary paths that allow firms to move from traditional forms to the VE model have not been fully explored. Finally, even if this topic has been dealt with extensively, there is little empirical research investigating real cases of VE (De Sanctis and Monge, 1999).

There are two main objectives of this paper. The first is to ascertain whether it is possible to identify a unique VE model, or a framework that includes a variety of VE models through analysis of recent literature. The second objective is to contribute to plug the gap in the empirical research with a field analysis focused on a network of SMEs. From an empirical point of view, the chapter analyses a network of small and medium-sized firms located in the eastern area of Naples (ENES), through a questionnaire survey in order to assess whether the network is evolving towards the VE model.

The paper is organised into eight parts. This introduction is followed by a literature review on the virtual enterprise. The third section identifies different VE models on the basis of findings derived from the previous section. The fourth

section describes the research context. The methodology used to carry out the survey is detailed in the subsequent section. In the sixth section the findings emerging from the empirical analysis are presented and discussed. Next, the empirical and theoretical results are jointly discussed. Finally, conclusions and implications are outlined.

## 2. The theoretical framework

In the past few years, the competitive scenario has witnessed dramatic changes. These changes may be summarised as follows (Esposito et al. 2008):

1. Growing *market globalisation and competition* which has increased the rate in new product introduction and reduced their life cycle.
2. New *customer requirements*, resulting from the demand for products with greater customisation, higher quality and lower delivery times.
3. New *social conditions* arising from increasing environmental awareness and legal pressures.
4. *Acceleration in the rates of technology diffusion and adoption,* with particular reference to ICT.

In facing this new scenario, firms concentrate on 'core competencies' (Hamel and Prahalad 1990). Simultaneously, businesses are exploring new organisational models that better fit the conditions of the new competitive scenario. Such conditions force firms to adopt inter-enterprise formations following new organisational models. The search for developing new organisational approaches has to satisfy two elements: organisational structures need to be more flexible to allow swift adaptation to change (Pollalis and Dimitriou 2008), and firms need to use technological tools for knowledge management (KM) such as ICT (Iandoli and Zollo 2007; Preiss et al. 1996). These technologies offer wider access to information and knowledge and allow firms to manage collaborative relationships more efficiently and effectively.

The debate on new organisational forms has suggested the virtual enterprise (VE) as a responsive model to address changing market conditions through flexibility and KM. The substantial literature published on this subject shows the extensive use of the term 'virtual'. The review reported below provides a

spectrum of the main aspects and features that underlie the concept of the virtual enterprise model. In the late 1980s the term 'virtual corporation' first appeared, referring to links between companies supported by ICT. The concept of VE was mainly technology driven and based on the sharing of information systems. One of the first definitions of VE was given by Byrne (1993) who indicated the temporary nature of relationships in the network of independent companies belonging to VE managed through information technology. The main aims of VE relate to sharing skills, costs and to access to one another's markets.

Although Jagdev and Browne (1998) identified the same characteristics and aims, they stressed two additional important elements, namely the project-based approach and the relative shorter life span in comparison with the extended enterprises model. Zhang et al. (2000), Camarinha- Matos et al. (2001), Mikhailov (2002) and Kim et al. (2006) proposed a similar view in relation to VE.

Mezgar et al. (2000) suggested that a VE may be considered as a holarchy given that it is a temporary and goal- oriented aggregation of several individual enterprises. The authors also underlined that a VE may be created to pursue a specific business objective, and it remains in life as long as this objective is being pursued.

Choy and Lee (2001) introduce the concept of a VE as a network of value-adding services in a supply chain, which combine for a specific period of time for a specific business objective and disband when the goal is achieved.

Martinez et al. (2001) also found that the VE concept may be used to characterise the global supply chain of a single product in an environment of dynamic networks between companies engaged in many complex relationships. In their view, the main objective of a VE is to rapidly develop a common working environment and manage a pool of resources provided by the participating organisations towards the attainment of common goals. Hence, success of the VE depends on all partners cooperating as a single unit.

For Presley et al. (2001) the VE is a form of joint venture with the following substantial differences: (1) it is designed to be a temporary alliance among the member companies to take advantage of a market opportunity; (2) each member organisation provides its own core competencies in organisational functional areas

such as marketing, engineering and manufacturing; (3) a small headquarters staff is required to deal with the administrative and management details; (4) geographically separated shareholder companies, subcontractors, and partners are linked through computerized hardware and software; and (5) when the market opportunity has passed, the VE is dissolved.

As pointed out by Lefebvre and Lefebvre (2002) and Fenga and Yamashiro (2006), a VE is created by multinational companies that are responsible for complex products and act as product integrators. They also stress that a VE is often a temporary group of several actors, all operating on the same informational platform. These actors do not generally belong to the same enterprise and are not necessarily located on the same continent.

Park and Favrel (1999) argued that the VE model allows the gap between large and small firms to be bridged. Hence it may be considered a suitable organisational model for SMEs (Wu and Sun 2002).

Thompson (2008) pinpointed that a VE is a voluntary and dynamic community of SMEs that undertake to work together for a set period of time and collectively to seek opportunities to participate in collaborative projects of mutual business interest.

The view proposed by Corvello and Migliarese (2007) pointed out that in a VE arrangement partners are integrated in a productive system which is based on mutual adjustment processes supported by ICT. The authors indicated that, compared with vertically integrated firms, the VE model substitutes hierarchy with incentives, and formal and procedural coordination with complex communication systems.

Finally, Gunasekaran et al. (2008) argued that a VE is based on developing partnerships based on core competencies for achieving agility in a supply chain environment. They showed that virtual enterprises are highly dynamic and have several strategic objectives: (1) to maximise flexibility and adaptability to environmental changes, (2) develop a pool of competencies and resources, (3) reach a critical size to be in accordance with market constraints and (4) optimize the global supply chain.

What emerges from the literature review is that (a) there are a number of common issues related to the VE concept and (b) there are also important issues that are not fully addressed by the literature. An overview of both shared and non-shared issues is outlined in Table 1.

*Table 1 - Overview of literature review findings*

| | **Literature evidence** |
|---|---|
| ***Shared issues*** | |
| Main aims | -Exploit fast-changing opportunities<br>*(Jagdev and Browne, 1998; Park and Favrel, 1999; Mezgar et al., 2000; Choy and Lee, 2001; Presley et al., 2001; Jagdev and Thoben 2001; Mikhailov, 2002; Wu and Sun 2002; Lefebvre and Lefebvre, 2002; Kim et al., 2006; Corvello and Migliarese, 2007)* |
| Partnership objectives | - Share costs, skills, and core competencies<br>*(Jagdev and Browne, 1998, Park and Favrel, 1999; Camarinha-Matos et al., 2001; Martinez et al., 2001; Choy and Lee, 2001; Presley et al.. 2001; Mikhailov, 2002; Wu and Sun 2002; Fenga and Yamashiro, 2006; Corvello and Migliarese, 2007; Gunasekaran et al., 2008)* |
| Organisation stability | - Flexible, rapid, dynamic and reactive network<br>*(Park and Favrel, 1999; Mezgar et al., 2000; Camarinha-Matos et al., 2001; Martinez et al., 2001; Lefebvre and Lefebvre, 2002; Kim et al., 2006; Corvello and Migliarese, 2007; Gunasekaran et al., 2008)* |
| Partnership characteristics | -Temporary relationships<br>*(Jagdev and Browne, 1998; Choy and Lee, 2001; Camarinha-Matos et al., 2001; Jagdev and Thoben 2001; Wu and Sun 2002; Lefebvre and Lefebvre, 2002; Mikhailov, 2002; Fenga and Yamashiro, 2006; Kim et al., 2006; Corvello and Migliarese, 2007; Gunasekaran et al., 2008; Thompson, 2008)* |
| | - Collaborative; co-operative<br>*(Jagdev and Browne, 1998; Jagdev and Thoben 2001;Mikhailov, 2002; Fenga and Yamashiro, 2006; Kim et al., 2006; Gunasekaran et al., 2008; Thompson, 2008)* |
| | - Independent companies<br>*(Jagdev and Browne, 1998; Jagdev and Thoben 2001; Lefebvre and Lefebvre, 2002; Mezgar et al., 2000; Mikhailov, 2002; Corvello and Migliarese, 2007)* |
| Coordination and communication tools | - Extensive use of ICT and computer networks<br>(Jagdev and Browne, 1998; Park and Favrel, 1999; Camarinha-Matos et al., 2001; Mezgar et al., 2000; Jagdev and Thoben 2001; Mikhailov, 2002; Wu and Sun 2002; Lefebvre and Lefebvre, 2002; Martinez et al., 2001; Corvello and Migliarese, 2007; Gunasekaran et al., 2008) |
| ***Non-shared issues*** | |
| Coordination unit | - Coordination agent may be both internal and external to VE *(Jagdev and Browne, 1998)* |
| | - Small headquarters staff dealing with administrative and management details<br>*(Presley et al., 2001)* |
| | - The product integrator distributes the manufacturing tasks and manages in parallel the product's physical and virtual value chains *(Lefebvre and Lefebvre, 2002; Fenga and Yamashiro, 2006 )* |

| | |
|---|---|
| Firm size | - VE model bridges the gap between large and small firms *(Park and Favrel, 1999)* |
| | - VE is especially suitable for small and medium-size enterprises *(Wu and Sun 2002)* |
| | - VE is a voluntary and dynamic community of SMEs *(Thompson, 2008)* |
| Knowledge management | - KM critical resource to achieve competitive advantage in VE *(Pollalis and Dimitriou, 2008; Blecker and Neuman, 2000).* |
| Organisational structure | - VE members self-organise their activities *(Mezgar et al., 2000)* |
| | - The relationship in a VE is mostly non-hierarchical in nature *(Jagdev and Thoben, 2001)* |
| | - VE organisational structure is mostly hierarchical *(Fenga and Yamashiro, 2006)* |
| | - A VE substitutes hierarchy with incentives and formal and procedural coordination with communication systems *(Corvello and Migliarese, 2007)* |
| Market relationships | - Customer deals directly with the product integrator during product design or may interface with it through business platforms (Lefebvre and Lefebvre, 2002) |
| | - The manufacturer manages the relationships with customers (Jagdev and Browne, 1998) |

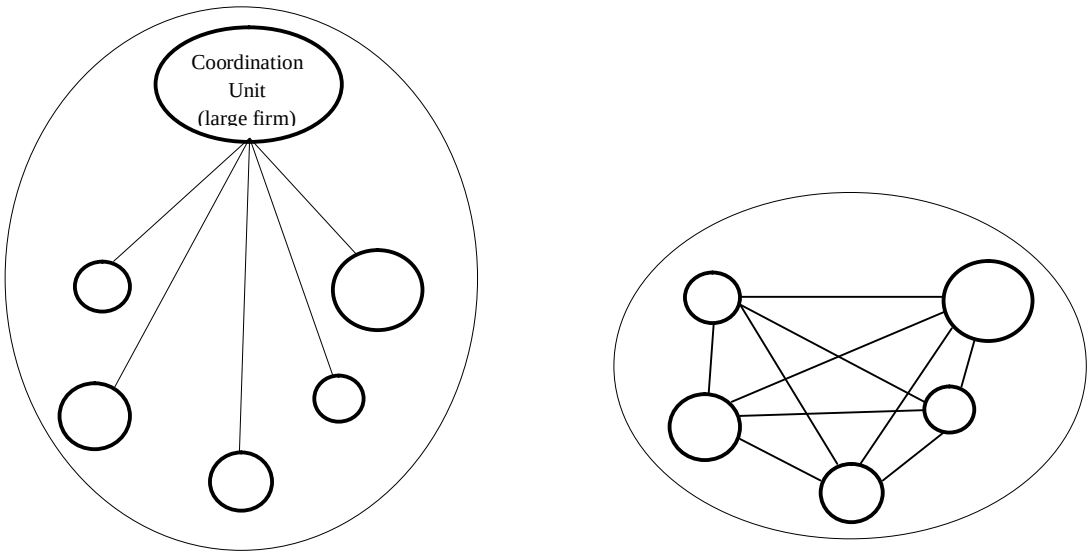
In relation to the issues covered by the literature on the subject, the first shared issue identified relates to the main aims of VE that mainly focus on exploiting fast-changing market opportunities. The main objectives of partnership between VE participating companies are the sharing of risks, costs and competencies. The virtual enterprise appears as a dynamic and flexible network, and relationships involve independent companies. Such relationships are typically temporary and based on a collaborative approach. Finally, the coordination and communication tools used are based on ICT. These five issues may be considered the common foundations of the theoretical concept of the VE model.

Nevertheless, the literature review highlighted a number of issues that are not fully shared. The most relevant non-shared issues relate to the organisational model and coordination mechanisms. The literature does not indicate a prevalent VE organisational model. Two different views emerged in terms of hierarchical or non-hierarchical structures. On the one hand, in the hierarchical approach the VE is created by large firms which act as a coordination unit of the network. On the other hand, an alternative approach proposes the self-organisation of VE members based on the substitution of hierarchy with incentives and formal/procedural

coordination with communication systems. The role of firm size in the VE context is generally underestimated. Few works indicate that virtualisation is particularly suitable for SMEs. This seems to be a gap that needs to be addressed as many industrial systems in developed countries are populated by a large number of small company aggregations, as in the case of Italian industrial districts. Moreover, the literature seldom refers to the increasingly important role of knowledge and knowledge management systems in the context of VE. Finally, it is not clear which specific participating company manages the relation with the final user of the product/service. These five non-shared issues may be considered the distinctive characteristics of VE models.

## 3. Hierarchical versus holarchical VE models

The literature review presented above identifies a number of common and specific issues that contribute to provide a comprehensive picture of the theoretical concept underlying the VE model. Considering the issues that are not shared by the literature, particularly issues of organisational structures and coordination mechanisms, it is possible to identify at least two extreme VE models: the *hierarchical* and *holarchical*[1] models (see Figure 1).




Hierarchical VE model Holarchical VE model

*Figure 1: Two extreme VE models*

In order to clarify the main differences between the hierarchical and holarchical models, in Table 2 the distinctive features of the two models have been summarised and compared.

*Table 2 : Comparison between the hierarchical and holarchical VE models*

| Issues | Hierarchical VE | Holarchical VE |
|---|---|---|
| Coordination unit | A large firm coordinates the network | No coordination unit |
| Firm size | Both large firm and small firms | Mainly SMEs |
| Organisational structure | Generally defined by the coordinator<br>Predominantly vertical relationships | Self-organisation<br>Mainly horizontal relationships<br>Mutual adjustment processes |
| Knowledge management | Knowledge flows are managed and integrated by the coordinator | Knowledge flows are distributed and need integration |
| Market relationships | The coordinator manages customer relationships | The product/service integrator manages customer relationships |

In the case of the hierarchical VE model, a leader company (generally a large firm) allocates the manufacturing tasks among partners sharing resources and costs (Fenga and Yamashiro 2006). The leader company assumes the task of coordinating the entire network of firms (Lefebvre and Lefebvre 2002) and manages the knowledge and information flows. This company also acts as product integrator, as it is responsible for the final product/service and relationship with the customer. By contrast, the holarchical VE model has no hierarchical coordination unit. The self-organisation approach is the main coordination mechanism (Mezgar et al., 2000), based on mutual adjustment processes (Corvello and Migliarese, 2007). The holarchical model appears particularly suitable for SMEs but knowledge and information flows need to be integrated as thereare differences in information systems used. Finally, due to the lack of a leader firm, the success of this type of model strictly depends on all partners cooperating as a single unit (Park and Favrel 1999).

In order to provide empirical evidence of the VE adoption model in SME networks, a questionnaire survey was carried out in a set of small firms operating in service and manufacturing industries. The findings emerging from the survey

provide empirical evidence and quantitative support for estimating the virtualisation potential of SME networks.

## 4. Structural characteristics of the East Naples high-technology enterprise system

The East Naples high-technology enterprise system (ENES) is an association of 25 SMEs established in March 2007. The main objective of ENES is to integrate firm resources and competences in order to capture market opportunities. The ENES mainly consists of SMEs as shown in Table 3. In Table 3, the latest SME definition proposed by the EU Commission is used (European Commission 2005).

*Table 3: ENES company breakdown by employees*

| Employee bands | Number | Percentage |
|---|---|---|
| Micro (0-9 employees) | 3 | 12% |
| Small (10-49 employees) | 10 | 40% |
| Medium (50-249 employees) | 11 | 44% |
| Large (≥250 employees) | 1 | 4% |
| Total | 25 | 100% |

The total number of ENES employees is about 3000 people and the total turnover is about 400 million euros. The total turnover increased by 28 per cent in the period 2004–07, and this led to a 21 per cent growth in investment in the same period.

The ENES firms operate in different manufacturing and service industries. They have a set of specific and different competencies as shown in Figure 2.

In Figure 2, ENES companies are indicated with the capital ‘F’ letter followed by a progressive number. The first six columns relate to manufacturing competencies such as: mechanical processing, aircraft precision processing, aeronautical assembly, electric (electronic) wiring and assembly, equipment and maintenance. The last five columns describe the competencies held by service firms such as: software development, management consulting services, training services, logistic services and specialised services. The number of competencies per company ranges from 1 to 4 (mean 2.54). A number of firms possess a single

competence (6 firms) showing a high level of specialisation. The remaining firms have a higher degree of diversification as they have more than one competency.

| | MANUFACTURING | | | | | | SERVICE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Compe-tencies / Firms | Mechanical processing | Aircraft precision processing | Aeronautical assembly | Electric (electronic) wiring and assembly | Equipment | Maintenance and service | SW Development | Management consulting | Training | Logistic services | Specialised services | Total |
| **F1** | x | | | | x | x | | | | | | 3 |
| **F2** | | x | | | | x | | | | x | x | 4 |
| **F3** | x | | | | | | | | | | | 1 |
| **F4** | | x | | x | | | | | | | x | 3 |
| **F5** | x | x | x | | | | | | | | | 3 |
| **F6** | | x | x | | | x | | | | | x | 4 |
| **F7** | | x | x | | x | x | | | | | | 4 |
| **F8** | | | | x | | x | | | | | | 2 |
| **F9** | x | | | | | x | | | | | x | 3 |
| **F10** | x | | | x | | | | | | | | 2 |
| **F11** | | | | | | | x | | | | x | 2 |
| **F12** | | | | | | | x | | | | | 1 |
| **F13** | | | | x | | | x | | x | | | 3 |
| **F14** | | | | | | x | x | | x | | x | 4 |
| **F15** | | | | | | | x | | | | | 1 |
| **F16** | | | | | | | | x | | | | 1 |
| **F17** | | | | | | | x | x | x | | | 3 |
| **F18** | | | | | | | | | | | x | 1 |
| **F19** | | | | | | | | x | x | | | 2 |
| **F20** | | | | | | | x | x | x | | x | 4 |
| **F21** | | | | | | | | x | x | | x | 3 |
| **F22** | | | | | | | | | | | x | 1 |
| **F23** | | | | x | | x | | | | | x | 3 |
| **F24** | | | | | | | x | | x | x | x | 4 |
| **F25** | | | | | | | x | | | | x | 2 |
| **Total** | 5 | 5 | 3 | 5 | 2 | 8 | 9 | 5 | 7 | 2 | 13 | **64** |

*Figure 2: Competencies of the sample firms*

Figure 3 reports the customer sectors served by ENES firms.

The main sectors served are: aerospace, automotive, railways, telecommunications (TLC), information and communication technology (ICT), energy, construction, public administration, banking and others. The figure shows that most of the companies serve the aerospace and TLC sectors. The number of customer sectors served per firm ranges from 1 to 4 (mean 2.4). Approximately, one-third of firms serve a single customer sector, showing a high degree of business risk concentration. Most of these firms operate in the aerospace sector.

| Customer sectors / Firms | Aerospace | Automotive | Railway | TLC | ICT | Energy | Construction | Public administration | Bank | Others | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **F1** | x | | | | | | | | | | 1 |
| **F2** | x | | | | | | | | | | 1 |
| **F3** | x | x | | | | | | | | x | 3 |
| **F4** | x | | | | | | | | | | 1 |
| **F5** | x | | | | | | | | | | 1 |
| **F6** | x | | | | | | | | | | 1 |
| **F7** | x | | | | | | | | | | 1 |
| **F8** | | | | | | | x | | | x | 2 |
| **F9** | x | x | | | | x | | | | x | 4 |
| **F10** | | | x | x | | | | | | | 2 |
| **F11** | x | | | x | | | | | | | 2 |
| **F12** | x | | | x | x | | | | | | 3 |
| **F13** | x | x | x | x | | | | | | | 4 |
| **F14** | | | | x | x | | | x | x | | 4 |
| **F15** | x | | | x | x | | | x | | | 4 |
| **F16** | x | | | x | x | | | | | | 3 |
| **F17** | | | | x | | | | x | | x | 3 |
| **F18** | x | x | | | | | | | | | 2 |
| **F19** | x | x | | | | | | x | | | 3 |
| **F20** | | | | | x | | | x | x | x | 4 |
| **F21** | x | | | x | | | | x | | | 3 |
| **F22** | | | | x | | | x | x | | | 3 |
| **F23** | | | x | | | | | | | | 1 |
| **F24** | x | | x | | | | | | | x | 3 |
| **F25** | | | | x | | | | | | | 1 |
| **Total** | 17 | 5 | 4 | 11 | 5 | 1 | 2 | 7 | 2 | 6 | **60** |

*Figure 3: Customer sectors served by the sample firms*

In Figures 3 and 4, it is interesting to note that firms with complementary competencies (for example, software development and training) are able to serve different markets. On the other hand, there are a number of firms with specialised competencies that are able to serve a few customer sectors. This is the case of small firms operating in the aerospace sector. These companies often act as subcontractors for larger firm.

## 5. Survey methodology

After reviewing the current literature on VE, a questionnaire survey was conducted. The literature review allowed for better understanding of the relevant

aspects to be analysed in the questionnaire survey. The main aim of the survey was to assess whether the ENES is evolving towards the VE model.

The survey was organised into the following five steps:

1. *Definition of basic survey objectives and preparation of the draft questionnaire.* In this phase a draft version of the questionnaire was prepared together with definition of the basic survey objectives.
2. *Establishment of focus groups.* In order to test the suitability of the basic survey objectives and comprehensibility of the draft questionnaire, a focus group of eight experts with different competence and professional background was established. The group was developed in three different phases. First, the topic investigated was presented in order to familiarise focus group participants. Secondly, the draft questionnaire was submitted to the panellists to obtain useful feedback and comments. Finally, panellists' remarks were discussed in a plenary session.
3. *Re-focusing of survey objectives and questionnaire.* On the basis of feedback received during the focus group discussion, the questionnaire was finalised. The final version of the questionnaire consisted of 60 questions divided into the following nine sections: company profile; knowledge management; products/services realised; customers; firm relationships; technological assets and research and development (R&D) activity; strategy; human resources management; and quality management. Most of the questions included in the questionnaire are based on a Likert scale ranging from 1 to 9. Some other questions allowed more open-ended responses in order to allow respondents to express their own personal opinion.
4. *Testing the questionnaire.* In this step, the final version of the questionnaire was tested in three pilot interviews carried out in ENES firms.
5. *Survey implementation*. The survey was conducted in spring 2008. The total number of respondents was 18 out of 25 companies with a response rate of 72 per cent. The questionnaire was administered during face-to-face interviews involving at least two managers with different skills and role (for example, a manager involved in the firm's strategic decision-making process and a manager involved

in operations management). This allowed both strategic and operational perspectives to be obtained.

In order to have a more comprehensive picture of the East Naples high-technology enterprise system, information from complementary sources (for example, company websites, company reports and industry magazines) were collected and analysed. However, it is worth noting that due to the small sample of firms investigated, the survey results presented in the next section cannot be generalised. From this point of view, the survey must be considered exploratory in nature. Nevertheless, the survey provides a contribution in enlarging the knowledge on the virtualisation of SME networks that is a relatively new and little investigated phenomenon.

## 6. Main survey findings

This section presents some of the findings emerging from the field analysis. In order to compare the main results of the literature review with the empirical evidence obtained from the survey, the results presented here only refer to the following sections of the questionnaire: section E (firm relationships) and section B (knowledge management).

### *6.1 Firms' Relationships*

In this section the relationships among the ENES firms are analysed, with the results summarised in Figure 4.

The figure may be considered a snapshot of relationships among the ENES firms. The symbol 'x' indicates that there is a relationship in place between two companies. In most cases this means that the two companies are involved in a collaborative project. Blank columns (or rows) refer to firms that are not involved in any collaborative relationship/project. The number of inter-firm relationships ranges between 1 and 7 (mean 3.04).

| | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 | F11 | F12 | F13 | F14 | F15 | F16 | F17 | F18 | F19 | F20 | F21 | F22 | F23 | F24 | F25 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F1 | | | | | | X | X | | | | X | | | | | | | | | | | | | | | 3 |
| F2 | | | | | | X | | | | | | | | | | | | | | | | | | | | 1 |
| F3 | | | | X | | X | | | | | X | | | | | | | | | | | | | | X | 4 |
| F4 | | | X | | | X | | | X | | | | | | | | | | | X | | | | | X | 5 |
| F5 | | | | | | | | | | | | | | | | | | | | | | | | X | | 1 |
| F6 | X | X | X | X | | | X | | | | | | | | | | | | X | | | | | | | 6 |
| F7 | X | | | | | X | | | | | | | | | | | | | | | | | | | | 2 |
| F8 | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| F9 | | | | X | | | | | | | | | | | | | X | | X | | | | | | | 3 |
| F10 | | | | | | | | | | | X | | | | | | | | | | | | X | | | 2 |
| F11 | X | | X | | | | | | | X | | | | | | | X | X | X | | | | | | X | 7 |
| F12 | | | | | | | | | | | | | | | | | | | | | X | | | | X | 2 |
| F13 | | | | | | | | | | | | | | X | X | | X | | | | | X | | | | 4 |
| F14 | | | | | | | | | | | | | X | | X | | X | | | | X | X | | | X | 6 |
| F15 | | | | | | | | | | | | | X | X | | | | | | | | | X | | | 3 |
| F16 | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| F17 | | | | | | | | | X | | X | | X | X | | | | | | | | | | | X | 5 |
| F18 | | | | | | | | | | | X | | | | | | | | | | | | | | | 1 |
| F19 | | | | | | X | | | X | | X | | | | | | | | | | | | | | | 3 |
| F20 | | | | X | | | | | | | | | | | | | | | | | X | | | | | 2 |
| F21 | | | | | | | | | | | | X | | X | | | | | | X | | X | | | | 4 |
| F22 | | | | | | | | | | | | | X | X | | | | | | | X | | | | | 3 |
| F23 | | | | | | | | | | X | | | | | X | | | | | | | | | | | 2 |
| F24 | | | | | X | | | | | | | | | | | | | | | | | | | | | 1 |
| F25 | | | X | X | | | | | | | X | X | | X | | | X | | | | | | | | | 6 |

*Figure 4: Relationships among ENES firms*

As regards the nature of relationships among ENES firms, the number of firms engaged in different types of collaboration is indicated in Figure 5. The most frequent forms of relationships concern shared new product development (NPD) programmes and exchange of technical information. Relationships in the production, design and development phase account for only a limited percentage.

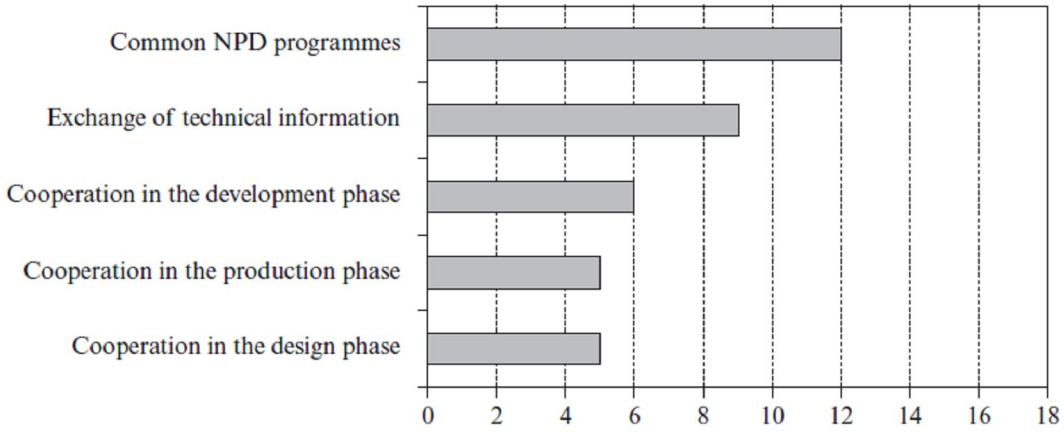



*Figure 5: Nature of relationship among ENES firms*

In order to provide a more detailed picture of collaboration within the ENES, the main projects undertaken by some ENES firms are shown in Table 4. In such projects, the proposer firm does not always coordinate the project: coordination is sometimes entrusted to another ENES firm involved in the partnership.

Most of the projects listed in Table 4 concern the TLC and aerospace sectors. According to the competencies required, each project may be considered a potential VE involving ENES firms. Indeed, the development of collaborative projects is the main objective of the partnerships in the VE model. This makes ENES a suitable context for the creation and implementation of VEs. To sum up, the ENES may be considered an association among peers that represents a potential pool of VEs.

*Table 4: Some ENES collaborative projects*

| **Project name** | **Project Description** |
|---|---|
| Electric aircraft | Mixed electric propulsion aircraft |
| KA-2H | Innovative helicopter |
| SAC | Composite anti-crash system for helicopters |
| SAEG | Steering electric innovative system |
| RTA | Advanced coverings for aircraft industry |
| IRENE | Space capsule for picking up cosmic dust |
| SPA | Advanced system for satellite antenna polymerisation |
| HM&M | Health monitoring and management systems for space aircraft |
| FSL-EC | Study of human - computer interaction systems |
| LBB - Liquid Bag Buffers | Development of liquid bag buffer systems for innovative bearing |
| HPF | Heat pipes for space vehicle control |
| 3D Modelling | Real-time 3D model capture system |
| Tele-medicine | System for telemedicine and remote-medicine using satellite system |
| SIGRI | Information system for monitoring and control of forest fires |

### *6.2 Knowledge Management*

In order to develop collaborative projects, companies generally adopt knowledge and information management tools. Hence the usage of KM Systems (KMSs) was explored in the context of ENES firms. First, the survey indicated that 15 firms of the sample have a KMS in place (see Figure 6). The vast majority

of these companies (11) adopt an internal systems aimed at supporting KM within the firm. Systems supporting the internal and external KM flows are implemented only in four firms.

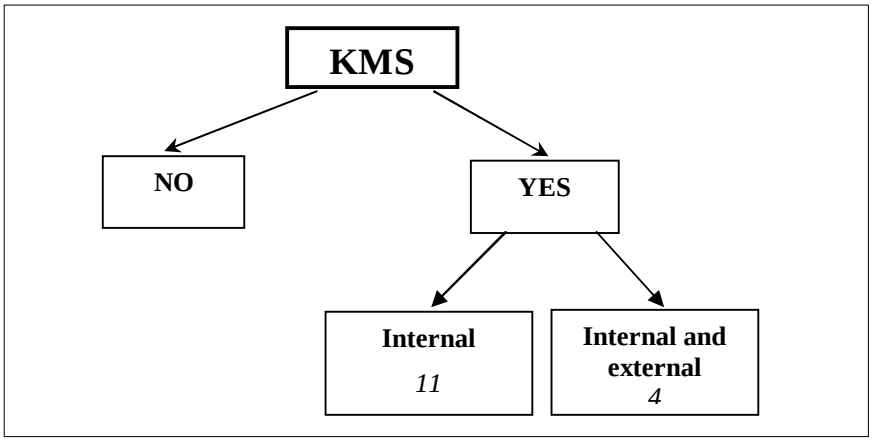



*Figure 6: KMS adoption in ENES*

The most widespread forms of internal KMS implementation (see Figure 7) are through the Internet site, work teams (13 firms out of 18) and the intranet (10 firms). The great importance attached to work teams is proof that in high-technology sectors, in addition to ICT, interactions and interpersonal relationships are a fundamental tool for problem solving.

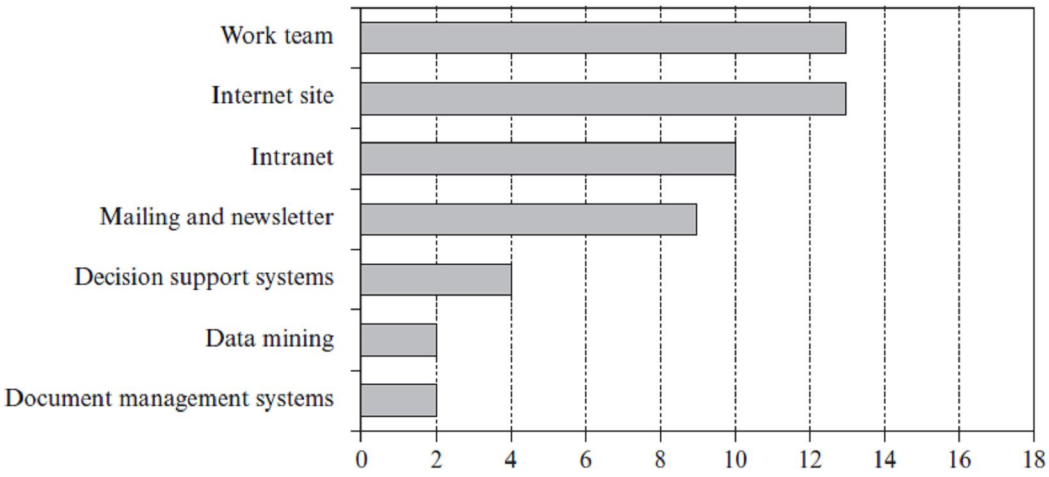



*Figure 7: Internal forms of KMS implementation*

In this context, it is worth distinguishing between services and manufacturing firms. Service firms operating in the telecommunications, ICT and aerospace sectors generally use advanced and structured KMSs equipped with a document management system, data mining, decision support systems and dedicated work teams. By contrast, manufacturing firms working in the aerospace sector as sub-suppliers use a less structured KMS for the purpose of management control and business resource management.

Although only four firms use internal and external KMSs, each surveyed firm hoped for wider KMS embracing the entire ENES. For this reason, the benefits of a KMS serving the entire network of the ENES were analysed (see Figure 8). In the figure the average value of the responses for each expected benefit is reported. Figure 8 shows that a KMS serving the entire ENES may have a positive impact, not only on innovation and on operational management, but also on identification of market opportunities. This feature further clarifies the support that a KMS can provide potential VEs arising in ENES. In fact, the main aim of a VE is to exploit market opportunities using the competencies of member companies. In this context, operational management is a fundamental tool that allows projects to be implemented effectively.

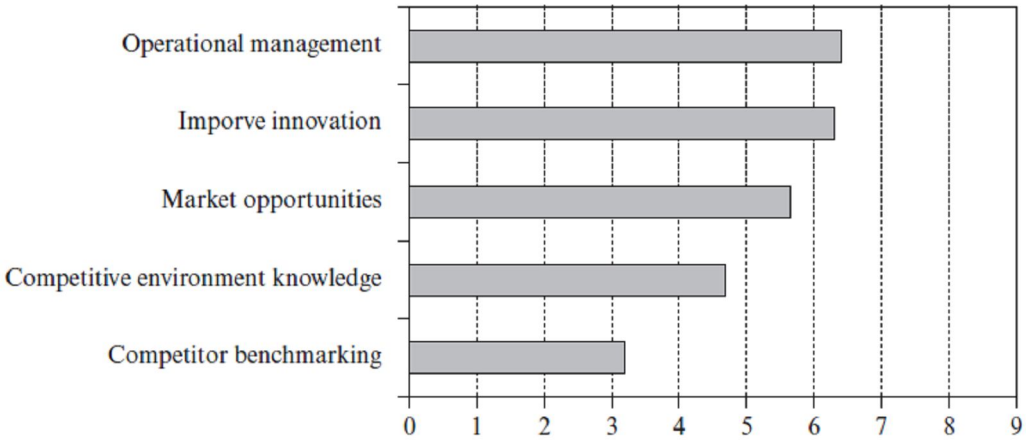



*Figure 8: Expected benefits of the KMS of the ENES*

However, there are a number of barriers to implementing KMS in the ENES context (see Figure 9). Interestingly, technological barriers and the tacit nature of

knowledge exchanged are the least significant barriers. This may be explained by the fact that in the SME context, work teams allow informal knowledge-sharing.

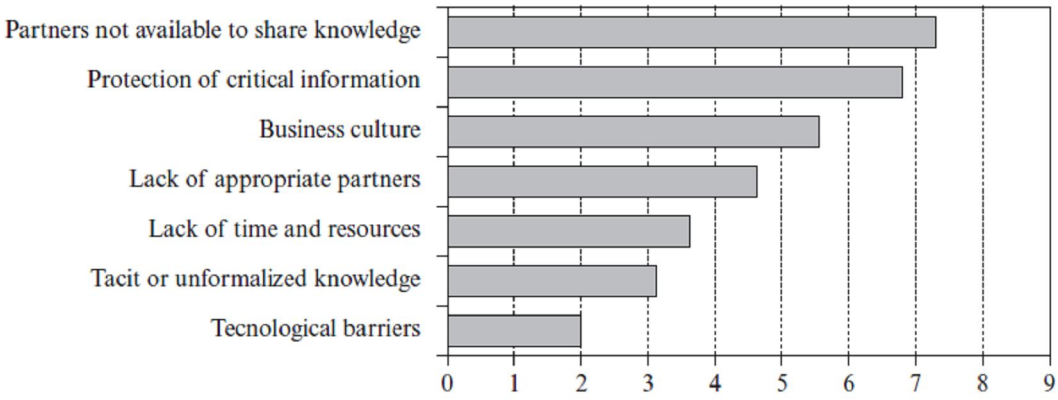



*Figure 9: Knowledge-sharing barriers*

Nevertheless, the lack of availability of partners to share knowledge and the need to protect critical information are the greatest barriers. This suggests that companies are oriented towards preserving their own intellectual assets from the opportunist behaviour of potential partners. Such obstacles may be overcome through increasing mutual trust. This objective may be achieved by stimulating collaboration among ENES firms.

Another aspect investigated relates to information that companies are willing to share through the adoption of a KM platform as shown in Figure 10.

This platform may assume the structure of a complex knowledge base in which ENES firms involved in different projects may share critical information. The most important information that firms are willing to share concerns linkages with institutions and funding opportunities. This appears to be motivated by the lack of resources in SMEs that traditionally prevents such firms from managing relationships with local authorities effectively. Other important information relates to market. Firms attach significant importance on market information in order to exploit opportunities faster and more effectively in the current dynamic business context. This is a common VE feature highlighted by the literature review (see Table 1). Indeed, as knowledge assumes a critical importance in new product/service development, information of this kind is critical to be shared.

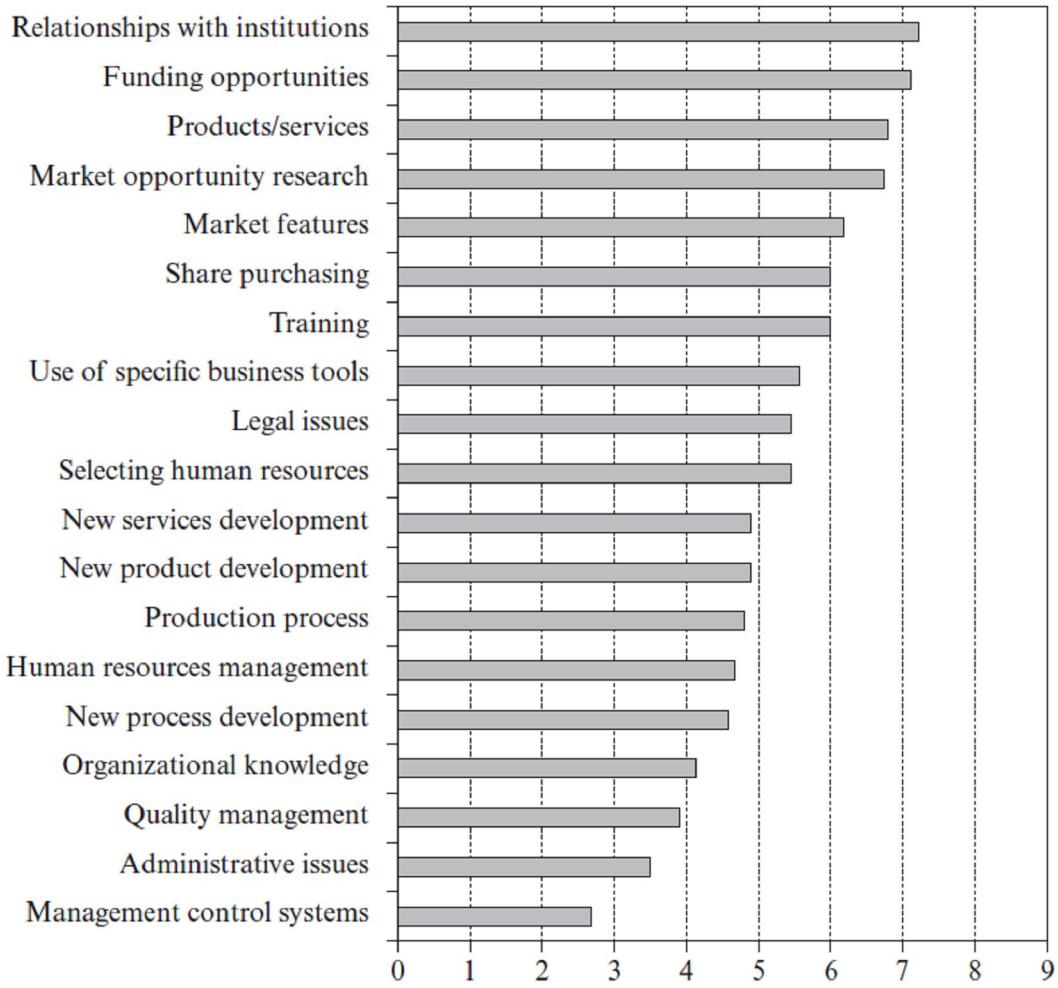



*Figure 10: Information that firms are willing to share through a KMS platform*

Another issue concerns the human resources management. In fact, as shown in the Figure 10, a KM platform can provide useful tools for both recruiting and training employees and new staff. Finally, ENES firms show a low interest in sharing information about management control systems, administrative issues and quality management. This may be explained by the fact that such information is generally firm specific.

## 7. Discussion

In this section, the findings emerging from the questionnaire survey are related to the main results of the literature review. The aim is to ascertain whether the system of relationships among ENES firms is evolving towards the VE model.

It is important to outline the working mechanisms of the ENES association. On the basis of a specific market opportunity, a firm proposes a project and it launches a call for adhesion. The firms that join the project create a network inside the ENES, selecting a coordinator and developing the project. Usually, the project proponent is chosen to be the coordinator. In some other cases, the role of coordinator is played by another firm participating in the project. In both cases, the coordinator is not the hierarchical leader of the project, but just the '*primus inter pares*'. In this way, ENES is characterised by a set of temporary peer relationships for specific projects. It is a dynamic network in which project collaboration relationships are continuously formed and re-formed.

The comparison is organised in two steps. In the first step, the issues shared by the current literature are compared with the issues emerging from the questionnaire survey (see Table 5).

*Table 5: Comparison between shared issues emerging from literature review and empirical evidence*

| **Issues** | **Evidence emerging from the literature review** | **Evidence emerging from the questionnaire survey** |
|---|---|---|
| Main aims | - Exploit fast-changing opportunities | - Pursue mainly local market opportunities<br>- Strong interest in sharing information about new market opportunities |
| Partnership objectives | - Share costs, skills, and core competencies | -Sharing costs, risks and core competencies for specific projects |
| Organisation stability | - Flexible, rapid, dynamic and reactive network | - Stability of the overall ENES network<br>- Forming and re-forming of temporary organisations according to project requirements |
| Partnership characteristics | - Temporary<br>- Collaborative and co-operative<br>- Independent companies | - Temporary and dynamic according to project needs<br>- Collaborative and co-operative<br>- Independent companies |
| Coordination and communication tools | - Extensive use of ICT and computer networks | - Strong emphasis on interpersonal relationships<br>- Information systems mainly internally oriented and not integrated |

Generally speaking, it appears that the empirical evidence fits most of the shared issues covered by the current literature. Nevertheless, there are some major differences which emerge in relation to the main aims in creating VE. In particular, the partnerships created within the ENES target local market opportunities. For this reason, the member companies are greatly interested in sharing information about new market opportunities.

Other differences appear in relation to coordination and communication tools where the stress is on interpersonal relationships and information systems are mainly internally oriented and not fully integrated.

In the second step, issues not fully addressed by the current literature are compared with the empirical evidence obtained (see Table 6). Some specific features of the partnership created within the ENES are highlighted, referring particularly to the following elements:

1. In some projects, the proponent acts as coordinator.
2. In some other projects, coordination is assumed by the product integrator.
3. Most projects involve SMEs.
4. The organisational configuration is hybrid in comparison with the other two found in Figure 1 due to different existing coordination mechanisms.
5. There is no KMS serving the entire ENES.
6. The need for a shared KM platform is acknowledged by the surveyed companies.
7. The companies involved in the project have a clear visibility of the target market.
8. It is the proponent and/or the product integrator that manages relationships with the customer.

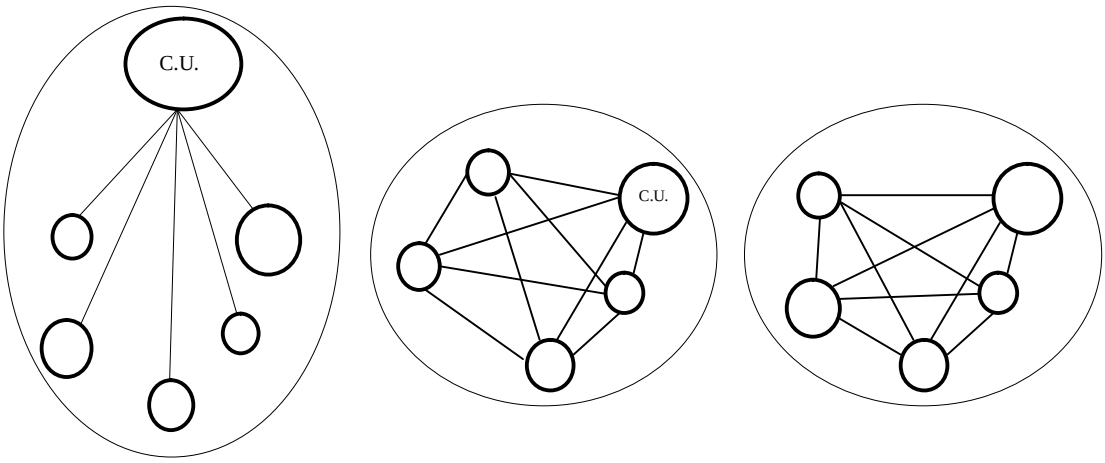
Summarising, the empirical results suggest that the ENES is a potential pool of VEs. Indeed, it is characterised by a set of dynamic networks in which collaborative relationships are continuously formed and re-formed. Moreover, it emerges that these specific VEs created within the ENES assume a hybrid form

between the two extreme VE models identified above (hierarchical and holarchical) (see Figure 11).

*Table 6: Comparison between issues not addressed by the literature review and empirical evidence*

| Issues | Evidence emerging from the literature review | Evidence emerging from the questionnaire survey |
|---|---|---|
| Coordination unit | - There is no shared view about the presence of a coordinator or mechanisms of coordination (coordination unit vs. self organisation) | - In some cases, the project proponent acts as coordinator<br>- In other projects coordination is assumed by the product integrator |
| Firm size | - The role of firm size in VE arrangements is not clear (large multinationals vs. SMEs) | - Most projects involve SMEs |
| Organisational structure | - The VE organisational configuration is underestimated (vertical vs. horizontal relationships) | - Hybrid organisational configuration due to different coordination mechanisms |
| Knowledge management | - No reference to the mechanisms of knowledge circulation in the VE configurations.<br>- There is no shared view on the presence of a knowledge management system in the VE | - There is no KMS serving the entire ENES<br>- The need for a shared KM platform is acknowledged by the surveyed companies |
| Market relationships | - The literature does not clearly identify the member company that manages customer relations. | - The companies involved in the project have a clear visibility of the target market<br>- The proponent and/or the product integrator manages customer relations |

This hybrid model has some characteristics in common with the two forms identified in Figure 1. In particular, the hybrid model shares the relationships among peers with the holarchical model, and the presence of a coordinating firm with the hierarchical VE model. Moreover, the ENES VE model presents some specific characteristics as the coordinating unit is not the hierarchical leader of the project, but just the *primus inter pares*.




Hierarchical VE model Hybrid VE model Holarchical VE model

*Figure 11: Taxonomy of VE models*

## 8. Implications and conclusions

This chapter is based on an exploratory study analysing the possible forms that VE may assume in the context of small firms. It provides empirical evidences concerning the diffusion of this new organisational model in SME networks.

On the basis of a literature review, the chapter has ascertained that it is not possible to identify a unique VE model, but rather a variety of VE models may be considered within a framework. This framework includes a number of shared issues (for example, main aims of VE creation, the objectives on which the partnership is based, the stability of the virtual organisation, the partnership characteristics, and the coordination and communication tools) and other specific issues (for example, coordination unit, firm size, organisational structure, KM and market relations).

In particular, two extreme VE forms were identified: the hierarchical and holarchical models. In the case of the hierarchical VE model, a leader company assumes the coordination of the network and generally manages market relationships acting as the product integrator. By contrast, the holarchical model is characterised by a self-organisation in which the success of the virtual enterprise strictly depends on all partners cooperating as a single unit.

As far as the empirical analysis is concerned, a questionnaire survey has been carried out on 18 SMEs belonging to the East Naples high-technology enterprise system. The ENES is characterised by a set of temporary peer relationships oriented to specific projects, in which collaborative relationships are continuously formed and re-formed.

This suggests that it may be considered a potential pool of VEs.

Comparison between the literature review and survey findings establishes that VEs created within the ENES assume a hybrid form between the two extremes originally identified. In comparison with the above two forms, the hybrid model has common characteristics (for example, the presence of a coordinator) and specific characteristics (for example, the coordinating unit is *primus inter pares*).

In light of the above results, some managerial and policy implications that could help the virtualisation process and competitiveness of SMEs may be drawn. From the managerial point of view, in order to fully exploit the potential of virtualisation, SMEs need to implement new technological solutions. For this reason, for small businesses it is necessary to support their virtualisation process through the adoption of technological platforms that allow information and knowledge to be managed and shared more efficiently. In terms of policy implications, one of the basic concepts of new organisational models is collaboration among participating companies in the network. Particularly in the VE model, collaboration issues assume critical importance as competitive success may be achieved only if member companies operate as a single unit. Nevertheless, setting up collaborative relationships is known to be a somewhat difficult process. The SME virtualisation process should be supported through a number of actions developed by universities and local authorities. Universities should develop technological solutions particularly geared to meeting the needs of SMEs. In this context it is crucial to involve SMEs in collaborative projects. On the other hand, the role of local authorities also appears important. Such institutions should support SME virtualisation processes through a set of policy measures aimed at facilitating not only the process of innovation but also collaboration among small firms.

Finally, it is important to keep in mind that the exploratory nature of the survey limit the generalisation of the results achieved. Further investigations involving a large number of firms operating in different contexts and industries are needed to validate results and models proposed in this chapter.

NOTES

1. The term holarchy has been used extensively in several sciences including philosophy and astrophysics. The term holarchy in this chapter has been borrowed from the manufacturing systems optimisation research where a holarchy is defined as a set of holons that cooperate to achieve a goal (Hsieh 2008). The author stated that a holon is an autonomous, cooperative and intelligent entity. Autonomy and cooperation are two important characteristics of holons. Autonomy allows holons to decide the actions needed to be taken to accomplish the objectives without consulting any supervisory entity. Cooperation makes it possible for holons to agree on common plans and mutually execute them. In the models outlined in Figure 9.1, each small firm in the network may be considered a holon.

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# ESSAY 3 - INVESTIGATING THE EXTENDED ENTERPRISE CONCEPT IN THE AEROSPACE SUPPLY SYSTEM: THE CASE OF THE A380 AIRCRAFT

## 1. Introduction

In the last few years the competitive scenario has faced dramatic pressures. The globalisation and the high level of business competitiveness generate demand for quality products that are manufactured at the lowest cost and by continually reducing the production times (Prahalad and Ramaswamy, 2000; Gunasekaran, 2008; De la Fuente, 2010).

To this end, companies have been prompted to establish alternative management strategies and to re-consider the design and manufacturing of new products in order to be responsive to customers' unique and rapidly changing needs (Prahalad and Ramaswamy, 2000; Gunasekaran, 2008). Companies will contract out more and more activities and retain core-performing activities (Hamel and Prahalad, 1990) which will result to a more dependency on a network of suppliers (Cheng and Popov, 2004). Firms operate in value streams involving many firms in supply chains within a supply network, and the competitive performance of the entire network depends upon learning and the development of the whole system, not just the leading players (Bessant et al., 2003).

These changing business dynamics has been the focus of managerial debate and practitioners and scholars have often discussed about alliances, networks, and collaboration among companies over the past few years (Prahalad and Ramaswamy, 2000).

The emergence of the extended enterprise (EE) concept is the result of the hope of some firms to form alliances with others, after careful selection and to set up long-term and valuable exchange relationships, so as to lighten infrastructures. The network keeps going thanks to the competence that each brings to a common project participation which does not affect their legal independence (Pachè, 93).

According to many authors (Davis and O'Sullivan, 1999; Jagdev and Thoben, 2001; Goethals et al., 2006; Kuczynski et al., 2006; Lopez-Ortega and Hernandez,

2007; Siller et al., 2008; Rezayat, 2000), the effectiveness of the network structure is highly dependent on the effective and efficient use of information and communications technologies (ICT) applications such as electronic data interchange (EDI), workflow and Internet. These applications facilitate the coordination of interdependence among the different units of the extended enterprise. As asserted by Jagdev and Thoben (2001): the "extended enterprise is merely new paradigm reflecting the extent to which the information systems of the collaborating enterprises are integrated with one another and the way they actually communicate and collaborate with one another."

Despite the extended enterprise model received greater attention by the scientific literature in the last decades, there are a number of issues that are not sufficiently clarified (in particular issues on coordination mechanisms and organizational structure of the network). With reference to coordination, the hierarchical approach has been considered an option for the effective government of the EE where a focal firm leads the network and expands its boundaries to incorporate key suppliers and share critical competencies (Jagdev, 1998; Furst, 2000). Nevertheless literature indicates that different non - hierarchical EE configurations are possible (Jagdev and Thoben, 2001; Bititci et al., 2005), but little empirical research has been conducted this issue. Therefore there is the need to investigate the adoption of the EE concept elaborated by literature in industry contexts.

One of the most suitable sector to develop such research is the aerospace industry. In fact, it is a knowledge intensive industry characterised by organisational, technological, market and financial barriers. To overcome these barriers the aircraft production system is organised at international scale where the large players collaborate with their smaller scale suppliers. The productive organisation may be depicted as a pyramid with different productive levels and different subsectors. The supply system underlying the operations of such a pyramid is facing a complex evolution (Esposito and Raffa, 2007). In order to reduce costs, aerospace original equipment manufacturers (OEMs) are concentrating on coordination and marketing competencies and are increasingly outsourcing productive activities to suppliers of subassemblies. As results of the

above dynamics, the EE model has been used by a number of scholars as a possible organisational option that is characterising the evolution of the supply system in the aerospace industry (Tannock et al., 2007; Boardman and Clegg, 2001; O'Neill and Sackett, 1994; Greis and Kasarda, 1997; Aguilera et al., 2006; Pardessus, 2001). Nevertheless, these research works provide few evidences based on rigorous empirical research.

In order to fill this gap, this paper empirically investigates the adoption of the EE model in the aerospace industry. The objective is to identify the main characteristics of the EE model and its implication for the management of the supply system. To achieve this objective the paper focused on a specific aircraft project: the Airbus A380. The analysis has been organised into three steps. Firstly, a comprehensive literature review on the EE concept has been carried out. The most common and specific features have been identified. In the second stage, the Airbus A380 project has been analysed in details using the single case study approach. The case study investigation has been conducted collecting information from company documents and archival records and, in a further step, through a set of face-to-face interviews carried out at Italian and UK partner companies involved in the A380 project. Finally, the results of both literature review and case study analysis have been compared in order to ascertain the level of alignment between academic thinking and business practice.

The paper is organised into seven sections. This introduction is followed by the section containing the literature review on the EE concept. In the third section, the main features and characteristics of the aerospace industry are described. The methodology adopted and the empirical context have been detailed in the sections four and five. Findings are presented in section six and then discussed in section seven.

## 2. Literature review on the extended enterprise concept

The literature review presented below is organised into two steps. Firstly I put in evidence the evolution of the extended enterprise concept through the review of the most important EE definitions and perspectives appeared over the last twenty years. Secondly, a number of common and specific features that provide a

comprehensive picture of the theoretical concept underlying the EE model have been identified through the analysis of definitions.

### *2.1 The evolution of the extended enterprise thinking*

Extended enterprise is a relatively novel concept and thus has no generally agreed definition (Lethinen and Ahola, 2010). Some authors did not explicitly define the term Extended Enterprise (Loh et al., 2006; Meixell and Wu, 2005; Goethals et al., 2004; Chan and Chung, 2002; Davis and O'Sullivan, 1999; Prahalad and Ramaswamy, 2000; Thoben and Jagdev, 2001; Janowsky et al., 1999). While different definitions highlighting different features emerged in the literature from different research streams (computer science, operational research, and engineering).

The term extended enterprise appeared in the first '90s in the computer science literature thanks to Konsynsky (1993) and Elofson and Konsynsky (1993). Although these articles did provide neither a definition nor a picture of the management issues in the EE model, they put in evidence the key enabling role of information and communication technologies. Emerging ICTs change the limits of what is possible in the leverage of strategic control through transformation of boundaries, relations, and markets (Konsynsky, 1993).

But, because of massive changes in the competitive environment and marketplaces, in the middle of '90s the EE model rapidly started to be analysed in the engineering manufacturing and operations research literature.

Browne et al. (1995) provided a comprehensive description of the context that was pushing firms to participate in extended enterprise forms of networking. According to the authors, five major trends have been identified, namely: i) the fact of *reduced product life cycles* and the consequences in terms of flexibility in the manufacturing capability; ii) the issue of *time-based competition* and the associated need to reduce the time to market for new products; iii) the necessity of taking *a total product life cycle view* due to the heightened awareness of environmental problems; iv) the challenge of *creating organisations* and systems which attract *high-quality people* and make full use of their capabilities and v) the problem for the individual manufacturer of developing a m*anufacturing strategy*

which is appropriate to the business environment and which takes account of the position of the manufacturing facility in the value chain. Given these pressures and trends, it is no longer feasible to look in isolation at the manufacturing system. The manufacturing system must be seen in the context of the total business and the linkages of the business back through the supplier chain and forward into the customer chain. This concept of inter-enterprise networking is called the extended enterprise. The authors also highlighted as the Extended Enterprise is made possible and viable through information and communication technologies such as EDI supporting the networking among different members. Similarly, Gunn (2000) identified four clusters of drivers enabling the EE adoption: political, economic, social and technological drivers; and three levels of barriers: human, business and technological barriers.

In their discussion of the new role of logistics in the information era, Greis and Kasarda (1997) assessed as an extended enterprise might include manufacturers, suppliers, and logistics providers in a confederation that differs from a traditional strategic alliance or joint venture in the fluidity of its underlying nature and a tacit acknowledgment of its transient existence. Each extended enterprise member contributes to the collective enterprise by sharing facilities, resources, technology and know-how. Transactions within the extended enterprise represent a balance between markets and hierarchies. Indeed, the collaborative and longer-term relationships among customers and suppliers in the collective enterprise is accompanied by a level of information-sharing that is deeper than that traditionally associated with the simple exchange of faxes or electronic mail to transact an order, transmit a technical drawing, or tally a bill. It is through the creation of new information exchange channels and the depth of information sharing that the extended enterprise sets itself apart from both markets and hierarchies (Greis and Kasarda, 1997).

Childe (1998) defined the extended enterprise as a conceptual business unit or system that consists of a purchasing company and suppliers who collaborate closely in such a way as to maximise the returns to each partner. The extended enterprise does not necessarily comprise the entire supply chain, but a group of companies within it. The author provided a clear description of a hierarchical

extended enterprise form of cooperation. He assessed that it appears that the initiative for all these examples comes from the final company at the high-value, big name end of the supply chain, the point where the money flows in. It may be difficult for the struggling manufacturer of castings or machined parts to initiate a supply chain strategy from a position many stages removed from the final customer. A similar hierarchical view is described by Furst (2002). However, there are other authors (Bititci et al., 2005; Vila et al., 2005) which assessed as it is also possible the existence of different extended enterprises configurations (even for the same company).

Similarly, Jagdev and Browne (1998) defined the extended enterprise as the formation of closer co - ordination in the design, development, costing and the coordination of the respective manufacturing schedules of co - operating independent manufacturing enterprises and related suppliers. The following are the major characteristics of the extended enterprise arising from Jagdev and Browne (1998):

- The manufacturing enterprise focuses on core business activities, and outsources non-core business activities to outside suppliers and other service providers.
- The manufacturer of the manufacturing-centred extended enterprise develops loyal and long-term relationships with key customers and suppliers, and treats them as his most important business partners.
- The extended enterprise has methods and technologies to support business activities that cross boundaries in order to support supplier-customer integration through the interchange of commercial and technical information.

Probably the work of Jagdev and Thoben (2001) represents the most comprehensive (and one of the most cited) study of the Extended Enterprise topic. The authors put this model within a continuum of industrial cooperation with the market and the hierarchy at the extremes. In between these two extremes are many types of bilateral relationships. Jagdev and Thoben (2001) mention three types: supply chain, extended enterprise and virtual enterprise. These types of industrial

cooperation vary in the degree of integration between the partners and related to this the level of cooperative confidence. It is the exchange of relevant operational information on top of existing long term (and successful) relationship that distinguishes the extended enterprise models other forms of long-term collaboration such as a supply chain. It should also be noted that ICT are enabler technologies and a necessary (though not sufficient) condition for an extended enterprise to exist. The following are some of the main characteristics of the EE model put in evidence by Jagdev and Thoben (2001):

- the partners in the extended enterprises are willing to form long-term relationships and treat each other as business partners;
- within the scope of collaboration, partners share vision and work towards shared goal;
- the decisions are jointly arrived at by making best use of the competencies among the partners;
- it is, therefore, important to have available advanced ICT tools to support the extended enterprise communication and sharing of information;
- the efficiency of the extended enterprise is greatly determined by the speed and efficiency with which information can be exchanged and managed among business partners.
- Extended enterprise can occur between any two enterprises across the value chain of any product or service;
- technology permitting, extended enterprise can take the form of a complex enterprise network where each enterprise can be seen as a node;
- the relationship between a set of nodes in an extended enterprise can be hierarchical or nonhierarchical.

Goethals et al., 2006 defined the Extended Enterprise as "*a collection of* legal entities ($N \geq 2$) that pursue repeated, enduring exchange relations with one another". Although an Extended Enterprise is usually not a real enterprise from a legal (financial) point of view, it is noticeable that an Extended Enterprise

conceptually forms a new enterprise (the constituting organisations share and redesign processes, data).

At the end of '90s the interest of scholars shifted to the knowledge management issues arising in the extended enterprise context putting in evidence the knowledge-based nature of the extended model.

The concept extended enterprise summarises neatly with theories of knowledge interdependency, competence and technology-centred theories of the firm and the view of the innovative firm as a learning organisation. Firms gather and exploit knowledge using processes of its transfer, accumulation, generation and socialisation (Kinder, 2003).

Similarly Bititci et al.(2005) defined the extended enterprise as a knowledge-based organisation which uses the distributed capabilities, competencies and intellectual strengths of its members to gain competitive advantage to maximise the performance of the overall extended enterprise.

Also Greis and Kasarda, (1997); Kuczynski et al., (2006) and Sorli et al., (2006) assessed that in the EE the efficient information/knowledge exchange among the collaboration network's partners is a key issue. The generation and usage of innovations can be improved by methodologies and means to efficiently analyse, store and share innovation knowledge within the EE collaboration network.

### *2.2 Evidences of the literature review*

Literature evidences show that there are a number of common issues related to the EE concept and other specific issues that are not fully shared by the literature. An overview of shared issues is outlined in Table 1.

Summarising the issues covered by the literature, it appears that extended enterprise model, through the management as a whole of a product lifecycle, aims at providing a customer-defined product/ service, and reducing the time to market of new products. Partnerships are established to share costs, risks and to bring together the expertise, competencies and knowledge of the member firms.

*Table 1: Literature evidences on EE, common issues*

| Issues | Literature evidences |
|---|---|
| Main aims | -to provide a customer-defined product/ service *(Jagdev and Browne, 1998; Jagdev and Thoben 2001; Hongzhao et al., 2005; Kuczynski et al., 2006; Sorli et al., 2006; Post et al., 2002; Prahalad, and Ramaswamy, 2000; Kanter, 1999)* |
| | -to reduce the time to market of new products *(Browne et al.,1995; Jagdev and Browne, 1998; Rezayat, 2000; Stock et al., 2000; Greis and Kasarda, 1997; Martinez et al., 2001)* |
| | -product lifecycle must be managed as a whole (*Browne et al.,1995; Jagdev and Browne, 1998; Bititci et al. 2005; Kuczynski et al., 2006; Sorli et al., 2006; Cao et al., 2009)* |
| Partnership objectives | -Reduced costs *(Browne et al.,1995; Rezayat, 2000; Jagdev and Browne, 1998)* |
| | - Risk sharing *(Kuczynski et al., 2006; Boardman and Clegg, 2001)* |
| | - Share and focus on core competencies *(Browne et al.,1995; Jagdev and Browne, 1998; Goethals et al., 2006; Frederix, 2001; Lakhal et al., 2001; Kanter, 1999; Greis and Kasarda, 1997; Childe 1998; Jagdev and Browne, 1998)* |
| | - Knowledge-based organization incorporating knowledge and expertise coming from all participants *(Mendikoa et el.,2008; Jiang et al., 2007; Kuczynski et al., 2006; Sorli et al., 2006; Bititci et al., 2005; Hongzhao et al., 2005; Lopez-Ortega and Hernandez, 2007: Kinder, 2003; Lau et al., 2003; Boardman and Clegg, 2001 Prahalad, and Ramaswamy, 2000; Kanter, 1999; Greis and Kasarda, 1997)* |
| Organisation stability | -Flexibility *(Hamblin, 2002; Stock et al., 2000; Greis and Kasarda, 1997)* |
| | -Adaptibilty, the extended enterprise must be ready to change according to the market shifts *(Browne et el., 1995; Binder and Clegg, 2006; Malhotra et al, 2007; Post et al.; 2002 Prahalad, and Ramaswamy, 2000)* |
| Partnership characteristics | - Long-term relationship *(Jagdev and Browne, 1998; Jagdev and Thoben 2001; Hongzhao et al., 2005; Goethals et al., 2006; Kuczynski et al., 2006; Sorli et al., 2006; Malhotra et al., 2007; Post et al.; 2002; Martinez et al., 2001; Childe, 1998)* |
| | - Collaborative; co-operative *(Jagdev and Browne, 1998; Jagdev and Thoben 2001; Alvarez et al., 2007; Jiang et al., 2007; Siller et al., 2008; Post et al., 2002; De Leede and Looise, 2001 Prahalad, and Ramaswamy, 2000; Cagliano et al., 2005; Kanter, 1999)* |
| | - Independent companies *(Browne et al.,1995, Jagdev and Thoben 2001; Goethals et al., 2006; Siller et al., 2008; Childe, 1998; Jagdev and Browne, 1998)* |
| | - mutual trust and share a common goal *(Browne et al., 1995; Childe, 1998; Jagdev and Thoben, 2001; De Leede and Looise, 2001; Thoben and Jagdev, 2001; Kanter, 1999; Greis and Kasarda, 1997; Childe, 1998)* |
| Coordination and communication tools | -Extensive use of ICT and computer networks *(Jagdev and Browne, 1998; Jagdev and Thoben 2001, Goethals et al., 2006; Kuczynski et al., 2006; Lopez-Ortega and Hernandez, 2007; Siller et al., 2008; Rezayat, 2000; Davis and O'Sullivan, 1999)* |
| | - EDI technologies *(Davis and O'Sullivan, 1998; Browne et al.,1995; Jagdev and Thoben 2001)* |
| Knowledge management | -The efficient information/knowledge exchange among the collaboration network's partners is a key *(Sorli et al., 2006; Mendikoa et al., 2008; Kuczynski et al., 2006; Lillehagen, 2001; Greis and Kasarda, 1997)* |
| | -The concept extended enterprise synthesises neatly with theories of innovative firm as a learning organization *(Kinder, 2003; Raymond and Blili, 2000)* |

Relationships are typically long-term oriented based on collaboration, cooperation and mutual trust among individual companies that share a common goal. The extended enterprise needs to be quite flexible to adapt to market changes. ICTs play a critical role as coordination and communication tools used. In particular strong interest has been given on EDI technologies. Finally the efficient information/knowledge exchange among the collaboration partners is a key issue for the extended enterprise. These six issues may be considered the common foundations of the theoretical concept of the EE model.

Nevertheless, the literature review highlighted a number of issues not fully shared (table 2).

The most relevant non-shared issues relate to the organisational model and coordination mechanisms. The literature does not indicate a unique EE organisational model. A hierarchical approach where the EE is created by a large focal firm (acting also as coordination unit) that extends its boarders to a majority of its suppliers clearly emerges. But, even if they don't provide a clear description, there are authors which propose alternative non hierarchical approaches where peer partners bring together complementary competencies for a common goal.

Indeed literature doesn't clarify if the extended model is more suitable for large or small firms. Few works indicate that extended networks can involve SMEs. This seems a gap that needs to be addressed as many industrial systems in developed countries are populated by a large number of small company aggregations.

Considering the issues non-shared by the literature, with particular reference to issues of organizational structures and coordination mechanisms, a hierarchical EE approach clearly emerged.

In this case, as the extent of co-operation increases the principal company (generally a large OEM), the one who receives supplies from the other partners and from whose viewpoint we see them, begins to be as dependent upon its suppliers as if they were part of the same company. The suppliers become part of the business and can no longer be regarded as outside the principal company's

affairs. This company also acts as product integrator, as it is responsible for the final product/service and relationship with the customer (Childe, 1998; Furst et al., 2002). This model could be seen as a holistic EE model, widely cited in different literature streams, but still not tested through empirical analysis.

*Table 2: literature evidences on EE, specific issues*

| Issues | Literature evidences |
|---|---|
| Coordination unit | -The most powerful company leads the network *(Furst et al., 2002; Childe, 1998)* |
| | - Contracts as the principle coordination mechanism for the extended enterprise *(Linington 2004)* |
| Firm size | - Relationships in the EE are not only restricted to large manufacturers but also to small and medium sized enterprises *(Jagdev and Thoben, 2001)* |
| | - Extended enterprise implies new types of relationships between large and small firms *(Raymond and Blili, 2000)* |
| | - There are examples of EE of SMEs *(Greis and Kasarda, 1997)* |
| Organisational structure | - It is possible the existence of different extended enterprises *(Bititci et al, 2003; Bititci et al, 2005: Vila et al., 2005)* |
| | - EE has a hierarchical nature *(Hongzhao et al., 2005)* |
| | - The suppliers are viewed as a part of the focal company—the System Integrator *(Cagliano et al, 2005)* |
| | - Extended enterprise is better used when a dominant enterprise extends its boarders to all, or a majority, of its suppliers is present *(Pires et al.,2008; Furst et al., 2002; Childe, 1998)* |
| | - One enterprise requires to assign manufacturing contracts to those geographically distributed enterprises capable to satisfy quality, costs and delivery requirements *(Siller et al., 2008)* |
| | -The relationship between a set of nodes in an extended enterprise can be hierarchical or nonhierarchical *(Jagdev and Thoben, 2001)* |
| | - The structure of manufacturing firms tends to be more flat or less hierarchical, leading to the extended firm that comprises a group of member firms (or partner firms).*(Liu et al., 2008)* |
| | - The extended enterprise may be consonant with a single multinational organization or, as is increasingly the case, a set of strategically aligned companies which partner to capture specific market opportunities *(Stock et al., 2000)* |

However literature indicates that different EE configurations are possible. "Peer" firms could join together to share complementary competencies in order to achieve common goals, non hierarchical configurations could be assumed. Nevertheless the few works referring to the existence of such a kind of extended networks (Jagdev and Thoben, 2001; Stock et al., 2000) provide neither a clear

picture of the characteristics of such a kind of partnerships, nor empirical evidences.

Therefore there is the need to empirically investigate the evidences emerged from the literature on the EE in a specific sector such as the aerospace industry.

## 3. The research context: the aerospace industry

### *3.1 The productive organisation of the industry*

The production organisation in the aircraft industry is influenced by a complex system of factors, which are strictly connected. Esposito and Raffa (2007) have highlighted the importance of four main factors as shown in Figure 1:

- *high technological level;*
- *technological complexity;*
- *high development costs;*
- *breakeven point reached after a long time.*

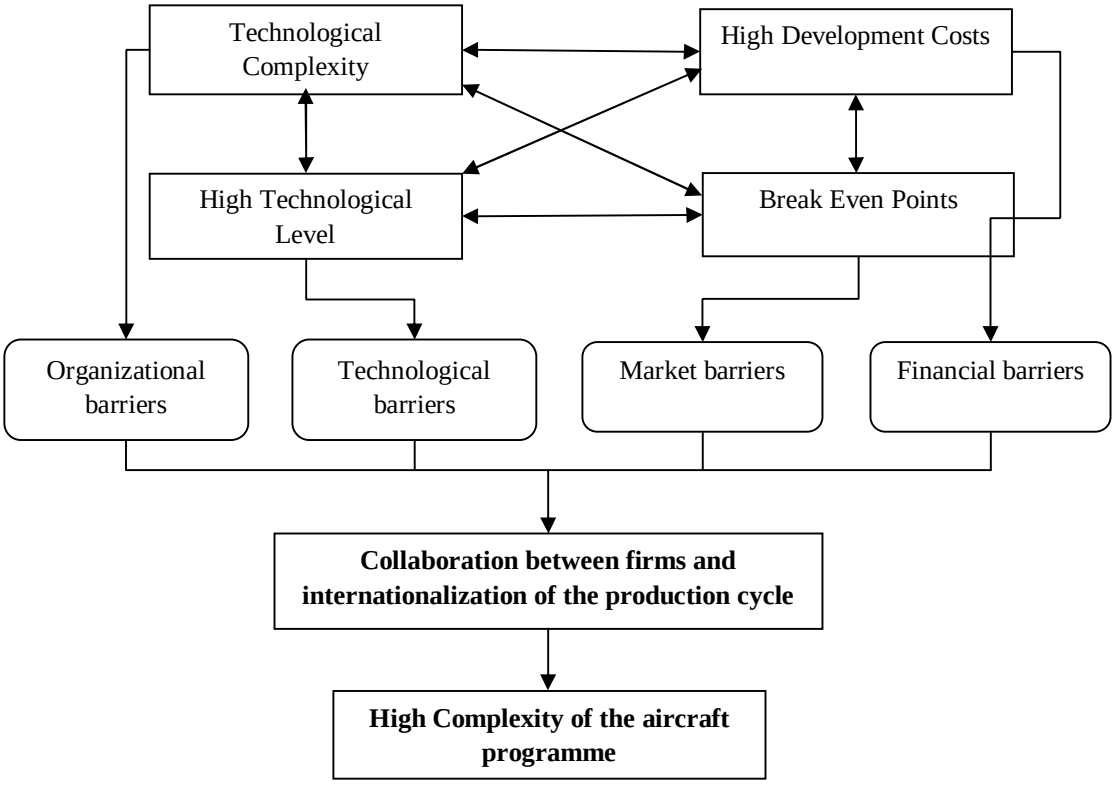


*Figure 1. Structural characteristics of the production organisation in the aircraft industry (source: Esposito and Raffa, 2007)*

The result of these drivers is an aircraft production organisation set on an international scale and based on intense collaboration between firms. This specific organisation develops according to a hierarchical structure including a final assembly area, where the parts and components come from three sub-sectors are assembled (Esposito and Bianca, 2007; Esposito and Raffa, 2007; Esposito, 1996):

- airframe structures (fuselage, wings etc.);
- propulsion systems;
- equipments and avionics systems.

According with this breakdown, the productive organisation of an aircraft assumes a pyramidal structure (Esposito and Bianca, 2007; Esposito and Raffa, 2007; Niosi and Zhegu, 2005; Esposito, 1996) as shown in figure 2.

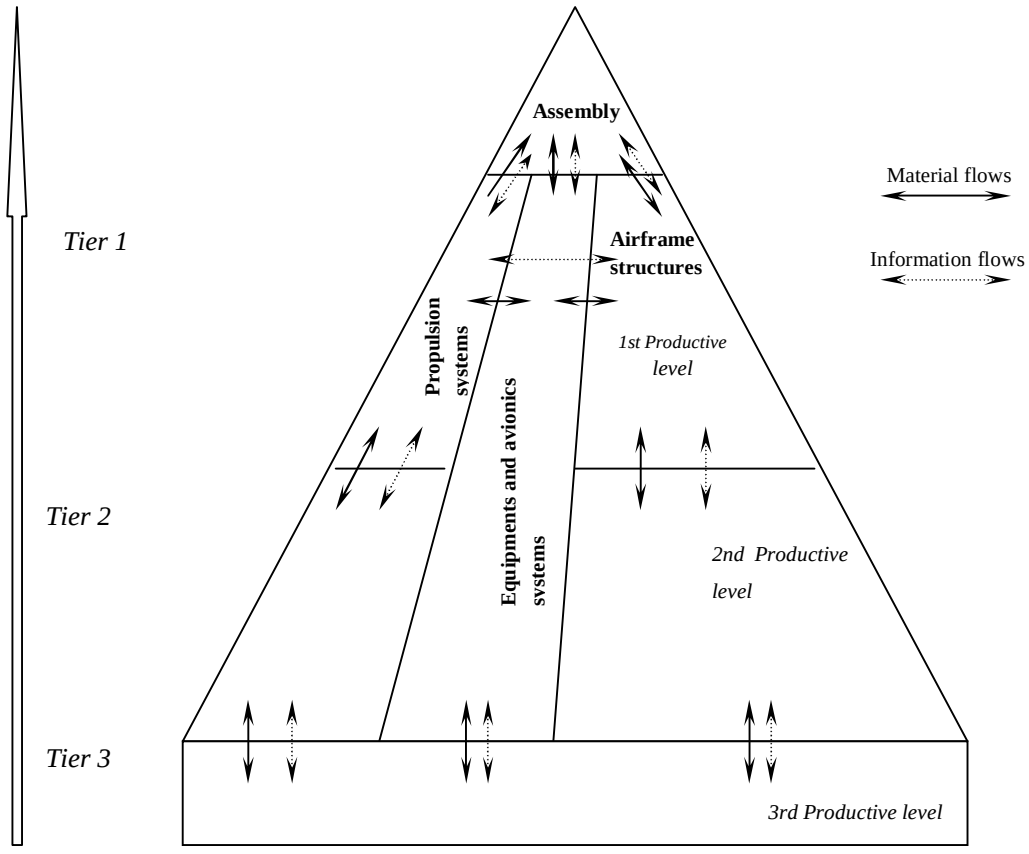


*Figure 2: The pyramidal productive organisation in the aircraft industry (adapted from Esposito and Bianca, 2007; Niosi and Zhegu, 2005)*

At the top of the pyramid there is the leader firm (or a consortium). It coordinates the program, assembly the final product and at the same time it has a direct or indirect control of the whole production process; furthermore the leader firm store all the information relative to the product, in order to be able to track back the history of every component in every moment; it also manage the relations with the airlines and it is legally responsible for the aircraft.

The pyramid vertex branches in the three sub-sectors identified above. Each subsector, although it is bound to the project specifics, has its own structure and autonomy.

The pyramid has also different productive levels. The propulsion systems and airframe structures subsectors are articulated in three productive levels while the equipments and avionics systems subsector is organised into only two productive levels. The first productive level involves few large firms, which are able to manage an entire subsector and to assembly sub-systems. They receive from the leader firm all the specifications for the components, then they decide what they will produce in-house and what will be outsourced to lower level suppliers. On the other hand, lowest levels involve hundreds of sub-supplying SMEs offering parts and components.

The figure 2 also shows that the working of the aircraft productive pyramid requires an intense parts and information flows along three directions:

1) top-down flow of raw material and components to work and of information about the project, production process and quality. This flow starts from the leader company and it ends to the 3$^{rd}$ production level firms;

2) bottom-up flow of worked parts and subsystems and information about the productive process and the components history;

3) transversal flow among firms working in parallel on different parts of the project. It ensures the coordination of the different entities that operate in the project and that manage the three subsectors (1$^{st}$ level firms).

Through these different flows, the complex system of relationships that characterises the production of an aircraft takes place. According Esposito and Bianca (2007), this system of relationships involves:

- oligopolistic relationships among large firms operating at the top of the pyramid;

- vertical relationships among top-levels firms and sub-supplying ones.

There are only two large commercial aircraft makers, Boeing and Airbus. Bombardier is the leading regional and business jet producer.

The engine market is dominated by the big three: General Electric, Pratt & Whitney and Rolls-Royce.

### *3.2 The evolution of the supply system*

The aerospace industry is undergoing a phase of remarkable change (Patillo, 1998; Texier, 2000; Bales et al., 2004; Choi and Rossetti, 2005; Smith and Tranfield, 2005; Esposito, 2004; Esposito and Raffa, 2007).

Historically OEMs acted as the focal point of supply chains, carrying out the majority of transformational manufacturing and assembly processes in-house and coordinating work placed with third parties. The OEMs also controlled and coordinated raw material purchase and stock, balancing the key supply chain control mechanisms of supply and demand to satisfy operational requirements (Bales et al., 2004).

The development of the global business environment and the introduction of new players from emerging countries, such as China and Russia among others, pushed the leader firms to move their core competences and re-organise their system of alliances in a changing context (Bales et al., 2004; Esposito, 2004; Smith and Tranfield, 2005; Esposito and Raffa, 2007).

Within the new emerging supply chain structure, the pressures which forced the OEMs to co-ordinate and maintain in-house productivity have reduced. They moved their core technology towards the program coordination, the final assembling, and the interaction with the market (governments, airlines). A greater proportion and variety of work is now carried out by specialist third-party organisations and small sub-suppliers. The result is that the suppliers have a

serious possibility to move up in the production pyramid. They are engaged not only in technical problems, like realising more or less complex components, but also in the management of the significant technological and production processes. In other words, the supply activity is evolving from the mere production of parts and components to the offer of a service (from production phase to service phase) (Esposito and Raffa, 2007). In this context sub-supplying firms must reduce costs, improve their technological offer and assure a better quality and service level to the customer. This pushes sub-supplying SMEs: i) to growth, ii) towards the creation of collaborative networks which involve different competencies and therefore which are able to respond better to the new customer demands (Esposito, 1996; Niosi and Zhegu, 2005; Esposito and Bianca, 2007).

To describe the evolution of the aerospace supply systems, the extended enterprise model has been widely used in literature on the aircraft industry even if in an unstructured way (Tannock et al., 2007; Boardman and Clegg,2001; O'Neill and Sackett, 1994). Articles for example on Boeing 777 (Greis and Kasarda, 1997) and Airbus Consortium (Pardessus, 2001) confirm that the extended enterprise model fits the characteristics of the aerospace industry. But these papers adopt a theoretical approach. They don't put in evidence the characteristics of the supply systems to justify this assumption. A framework to compare literature on extended enterprise and a real case in the aerospace industry still misses.

## 4. Methodology

### *4.1 The choice of research methodology*

The choice of the methodology to be adopted depended upon three conditions (table 3): i) the type of research questions, ii) the extent of control an investigator has over actual behavioural events and iii) the degree of focus on contemporary as opposed to historical events (Yin, 2009):

*Types of research question.* The main objective of this study is to identify the main characteristics of the EE model and its implication for the management of the supply system. Therefore, the research question underlying this paper is:

- What are the main characteristics of the extended enterprise model assumed in the A380 supply system?

The research question is a "what" question. In this case it is important to define if the question is an exploratory one or if the "what" may assume the form of a "how many" or "how much" line of inquiry. In the first case any methodology could be used even if following an exploratory design, while in the second case a survey method is more appropriate. As already said, this study has an exploratory nature. In fact the potential extended enterprise established in the aerospace industry is not a topic that has been extensively researched, and it is a dynamic and highly sensitive topic.

*Extent of control over behavioural events.* When there is the need to have the direct control over the relevant behaviours only experiments can be used, otherwise all the other methods are appropriate. This research, definitevely, doesn't call for the possibility to manipulate the relevant behaviours.

*Degree of focus on contemporary as opposed to historical events.* The events analysed in this paper are quite recent. The first delivery of the A380 aircraft has been made in the 2007 and the project is still ongoing as the vast majority of the Airbus A380 ordered has not been delivered yet.

According to Yin, 2009 and the considerations made above, the survey and the exploratory case study methods could overlap. Nevertheless, the survey method seems not appropriate as the nature of this research is a qualitative inductive one. The research question doesn't derive from specific theoretical concerns. The aim of this paper is not to "test" theoretical propositions, but to "build" new theory on the extended enterprise model in the aerospace industry. Therefore, we have chosen the case study approach as we are exploring new areas of research through and inductive logic (Eisenhardt, 1989).

### *4.2 The case study design*

It has been decided to use the single case study method: the Airbus A380 project. Considering the complexity and actual nature of the project, it could be seen as a representative case (Yin, 2009; Bryman and Bell,2007) for the aerospace

industry. Due to the nature of the industry and the complexity of an aircraft it is impossible to find other projects comparable with the A380 for a multiple case study analysis. Indeed, as asserted by Gummerson, (2006) the Airbus A380 is a huge object of study for those who want to get under the skin of management and industrial politics; it offers all the drama and trauma there is. It covers every management discipline, from engineering and design to manufacturing and assembly, purchasing, human resource management, marketing, customer service, finance and accounting, and in addition political action on a global arena. There is no need for more than a single case, although through definitional conjecture (Gummerson, 2006).

Following the taxonomy provided by Yin (2009) (figure 3), the case study design to be adopted may be seen as a *single-case embedded design.*

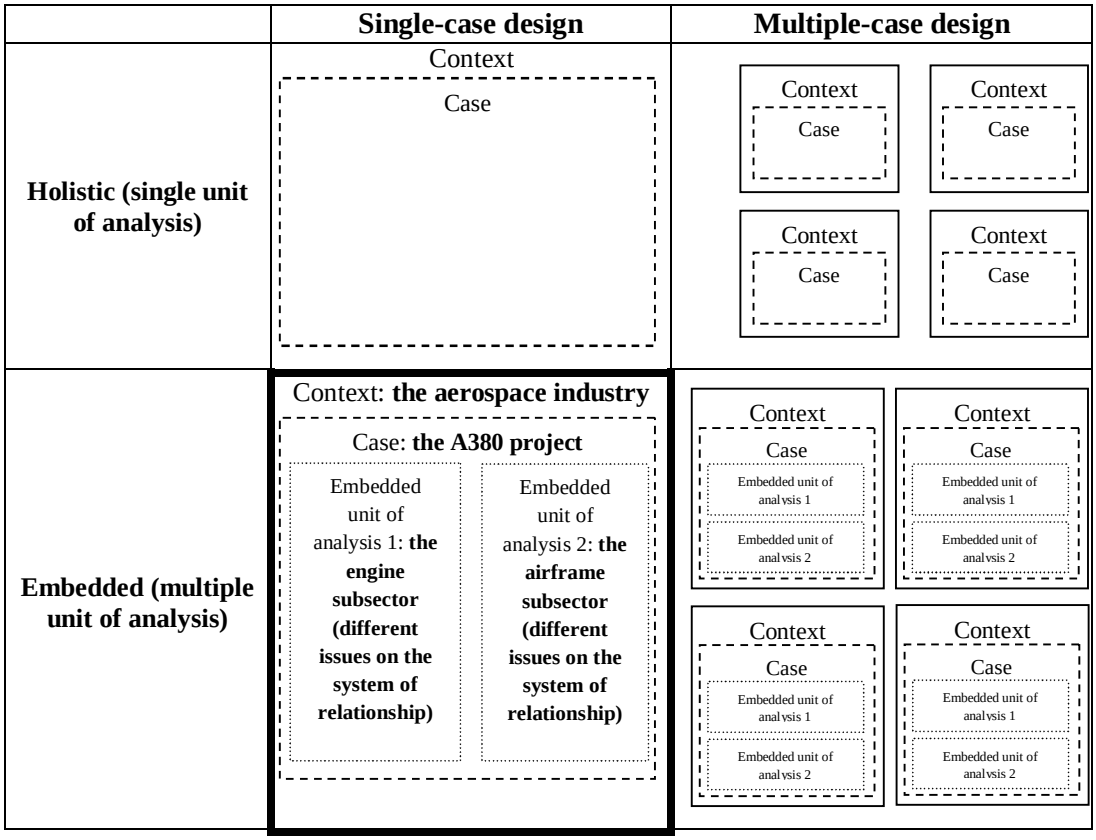


*Figure 3: Case study designs (adapted from Yin, 2009)*

The unit of analysis is the system of relationships established among the different partners involved in the A380 project. Due to the high amount of firms

involved, with different tasks in different productive levels and because of the large number of variables which can be used to describe a system of relationship, the analysis conducted in this paper has mainly focused on a specific set of issues characterising the system of relationship established in the supply systems of two subsectors (airframe and propulsion systems). Therefore according to figure 3, the single case study design adopted has an embedded nature.

In particular, the characteristics of the relationship system established in the supply systems of the two subsectors analysed need to be considered in terms of:

- characteristics and objectives of the partnerships established;
- coordination and communication tools used;
- knowledge management practices;
- coordination mechanisms and organisational structure of the partnership.

I have chosen these issues, as they fit with the issues emerged from the literature review on the extended enterprise. Therefore, this will allow a better comparison between the literature evidences and the field analysis results through a qualitative pattern matching logic analysis.

### *4.3 Data collection process*

Two have been the main sources of evidence to conduct the case study analysis. Firstly documentations and archival records providing useful details about the project has been analysed. In particular, according to the taxonomy provided by Bryman and Bell (2007), the following types of documents have been included in the analysis:

- public documents: annual reports from national and international associations such as European Association of Aerospace Industries (AECMA), Aerospace Industries Associations (AIA), Federazione Aziende Italiane per l'Aerospazio la Difesa e la Sicurezza (AIAD), Advancing UK AeroSpace, Defence & Security Industries (ADS);
- organisational documents: annual reports, press releases, newsletters from Airbus, Boeing, Rolls Royce, Alenia and other relevant companies;

- mass media outputs: specialised newspaper and magasines such as Air Press, Aviation Economist, Aviation Week;
- virtual outputs: internet documents, reports, A380 production forum.

Secondly, a set of qualitative interviews through face to face and phone meetings with key people inside a set of firms involved in the project has been conducted. Two firms operating in the engine subsector in the UK and one firm operating in the airframe subsector in Italy have been selected. The aerospace industry is a critical sector for the economy of both the countries chosen. Firms selected operate at the second and third productive levels of the productive pyramid. The documental sources helped to obtain relevant information also about the highest levels of the productive pyramid, in order to have a complete picture of the system of relationship for the subsectors considered. The process followed to conduct the interviews has been organised in the following four steps.

*Definition of the case study data collection guide*. A set of 20 qualitative questions has been used. Questions relate to the following areas: a) company profile; b) general trends observed for the aerospace industry; c) relationships with customers and suppliers in the A380 project; and d) changes inherent the last civil aircraft projects the firm is involved in. The vast majority of questions (10) concerned the relationships established in the A380 project. Issues covered by this set of questions are both referred to the characteristics highlighted above and in the table 1.

*Case study protocol*. In order to develop the data collection a case study protocol organised into the following sections has been designed:

- an overview of the case study project;
- field procedures (credentials, procedural reminders, language pertaining to the protection of human subjects, etc.);
- case study data collection guide;
- a framework for the case study report.

Therefore the protocol contained the instruments but also the procedures and the general rules to be followed in implementing the protocol. It is an important way in increasing the reliability of the case study research.

*Interviews implementation.* In order to make the respondents more confident with the questions and the research, a copy of the case study protocol has been sent to the interviewees before conducting the interviews. The interviews have taken place from May 2010 to December 2010. Interviews transcripts, summary and notes were complemented with the documentary data into a *case study database*. To assure the rigor and the validity, I returned interviews transcripts to respondents for comments and clarifications.

*Case study report.* The case study evidences have been discussed and validated in two focus groups carried out both in Italy and UK. Academics and practitioners were invited at the two meetings. The final output of these discussions has been a comprehensive report. Draft versions of this report have been presented for reviewing to informants in order to generate further discussion around any remaining areas of ambiguity (Eisenhardt, 1989; Yin, 2009) and to corroborate the essential facts and evidences highlighted (Schatzman & Strauss, 1973).

### *4.4 The validity of the research design*

In order to guarantee the quality of the research design, four tests have been conducted while planning the methodology (Yin, 2009).

*Construct validity.* To ensure the construct validity of the design, it is important to develop a sufficiently operational set of measures avoiding "subjective judgments". As suggested by Yin (2009), three tactics have been used to increase the construct validity of the research design. Firstly, as highlighted above during the data collection phase multiple sources of evidence (documentations, archival records and interviews) have been used during the data collection phase in order to encourage a convergent line of inquiry. Secondly, while collecting data I tried to establish a chain of evidence (Figure 4) from the case study questions to the

case study report. In this way the reader of the case study is in the position to track the derivation of any evidence from initial research questions to ultimate case study conclusions. Finally we allowed informants of the case to review the case study report to corroborate the essential facts and evidences highlighted.

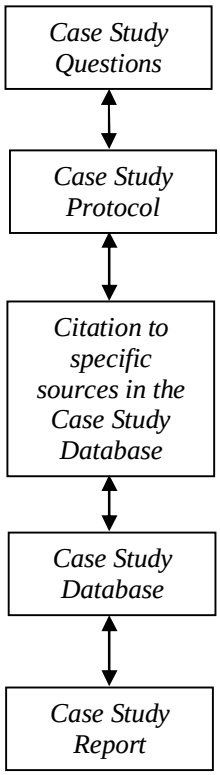


*Figure 4: The chain of evidence (source Yin, 2009)*

*Internal validity.* This test is a main concern for explanatory case studies. The pattern matching logic used to analyse data allow to increase the internal validity of the design. Empirical based patterns have been compared with theoretical ones. However, due to the qualitative nature of this matching, a certain level of interpretive description by the investigators has been required.

*External validity.* This item represents the most challenging test for the methodology used in this research. The single case design and the exploratory nature of the analysis limit the generalisation of the results achieved. Nevertheless, due to the complexity of the aerospace industry, a single and relevant case could certainly provide a contribution in enlarging the knowledge on the evolution of the supply system in this industry towards an extended enterprise

which is a new but little investigated phenomenon. Even if some dynamics observed in the aerospace industry are similar to other industries, I think that the extent of the results of this study should be confined to the sector investigated. Further investigations involving different projects from different contexts and industries are needed to validate results and models proposed in this paper.

*Reliability*. To ensure that the operations of the case study analysis can be repeated with the same results all procedures used to collect and analyse data has been documented. To this purpose a case study protocol to guide the interviews and a case study database involving all the raw evidences collected have benn developed.

## 5. The empirical context: the Airbus A380

### *5.1 An overview of the project*

The Airbus all-new design superjumbo, the A380, is the world's first twin-deck, four-engines airliner manufactured by the European corporation Airbus, a subsidiary of European Aeronautic Defence and Space Company (EADS) (Aerospace Technology, n.d.). The launch of A380 program revealed Airbus' ambition in terminating Boeing's long term dominance in the long haul jumbo jet market with its famous Boeing 747. The mission of the A380 was to transport a large number of people in a safe and efficient way (Ramba et al. 2005). It is the world's largest commercial aircraft flying today, with capacity to carry 525 passengers in a comfortable three-class configuration, and up to 853 in a single-class configuration (Airbus, 2010a).

The former largest aircraft, the venerable Boeing 747-400, burns 20 percent more fuel per seat than the A380 (Airbus, 2011).

The A380 also delivers on reduced noise, being the quietest long-haul aircraft for the foreseeable future, generating only half the noise on departure than the 747-400, and three to four times less noise on landing – while carrying 40% more passengers (Airbus, 2011).

Some milestones of the project are shown in table 3.

*Table 3: The A380 project milestones (adapted from Jane's All the World Aircraft, 2010)*

| | |
|---|---|
| *Engineering work began* | June 1994 |
| *Programme go ahead* | December 1999 |
| *First orders* | July 2000 |
| *Launched* | December 2000 |
| *First metal cut* | January 2002 |
| *Rolled out* | January 2005 |
| *First flight* | April 2005 |
| *Certified* | December 2006 |
| *First delivery (Singapore airlines)* | October 2007 |
| *Service entry (Singapore airlines)* | October 2007 |

In June 1994, Airbus began to discuss the design concept of a large single deck transport airliner, A3XX (Bowen, 1994). On 19 December 1999, the supervisory board of Airbus voted to launch a € 8.8-billion programme to build the A3XX, re-named as the A380 (Pae, 2000) with 50 firm orders from six launch customers (Wall Street Journal, 2000). The aircraft's configuration was finalised in early 2001, and manufacturing of the first A380 wing box component started on 23 January 2002. The development cost of the A380 had grown to €11 billion when the first aircraft was completed (Wallace, 2007).

After three announced delays, the A380 made its maiden flight on 27 April 2005 (Airbus, 2005) from Toulouse, France, and made its first commercial flight on 25 October 2007 (Wallace, 2007) from Singapore to Sydney with Singapore Airlines.

Seventeen customers have ordered the A380. Total orders for the A380 stand at 234 as of 8 June 2010 (Airbus, 2010b). The biggest customer is Emirates, which in June 2010 increased its order by 32 aircraft to 90 total, or nearly 40% of all A380 orders.

### *5.2 The productive pyramid*

The productive pyramid of the A380 project is shown in figure 5. The EADS through EADS-SPAIN, EADS-GERMANY, EADS-FRANCE acts as leader. At the top of the pyramid is EADS-FRANCE which holds the leadership in the consortium precisely for this reason. They assemble the final product, and handle (with the other members of the consortium) the network of relationships with the other sub-sectors (Esposito and Raffa, 2007). The Airbus A380 has about 500 suppliers (Airframer, n.d.).

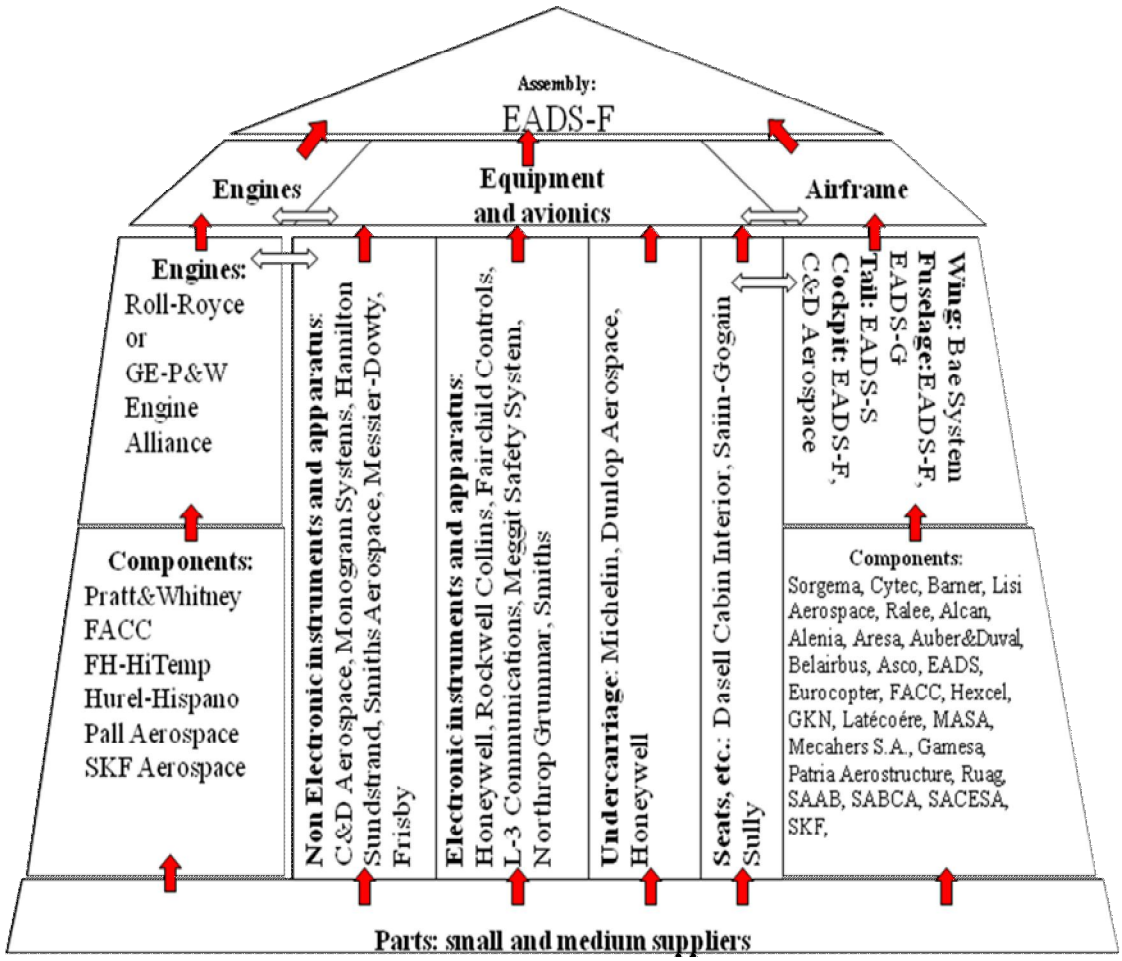


*Figure 5: the A380 productive pyramid (Source: Esposito and Raffa, 2007)*

The aircraft is assembled in Toulose (France) and then it is flown to Hamburg in Germany where it is painted and furnished.

The A380 can be fitted with two types of engines: A380-841, -842 and -843F with Rolls-Royce Trent 900, and A380-861 and -863F with Engine Alliance GP7000 turbofans (Airbus, 2010c). Therefore, Rolls Royce and Engine Alliance are the leaders of the propulsion system subsector.

In the airframe subsector the four firms of the EADS consortium hold the first production level. BAE designs the wings, EADS-FRANCE designs part of the fuselage, with the collaboration and, and the cockpit, together with C&D Aerospace, EADS-SPAIN designs the tail. The firms look after their own part of production. They decide by themselves what to produce in-house and what to have done outside, and form relationships with many other European firms (these firms are the components suppliers of the wings, fuselage, tail and cockpits in figure 5), which are on the second level.

### *5.3 Case companies description*

In total there are three firms participating in this analysis. The following table 4 gives an overview of these companies (the names of the companies are not disclosed according to the confidentially agreement).

Company one is a privately-owned company based in the South West of England. Today, Company one comprises two manufacturing divisions – the Gas Turbine Division (GTD) and Turbine Components Limited (TCL), employing approximately 720 people. Specialising in power generation, the Gas Turbine Division supplies gas turbine-driven generator sets - of their own design and exclusively incorporating Rolls Royce turbines. Turbine Components Limited is an approved supplier of high-quality complex machined components and assemblies to many of the major Original Equipment Gas Turbine engine manufacturing companies (OEM's) world-wide. Company one is located at the 2$^{nd}$ productive level as it is a key supplier for Rolls Royce in the propulsion system sub sector. Our respondent was the director manager of the TCL division (named as Respondent 1 in the follow).

*Table 4: an overview of the participating companies*

| | **Company 1** | **Company 2** | **Company 3** |
|---|---|---|---|
| **Product category** | - Gas turbine-driven generator sets<br>- High-quality complex machined components and assemblies | - Cutting tools<br>- Industrial supplies<br>- Integration | - Centre fuselage upper units<br>- Centre-forward lower unit<br>- Side panels (central doors)<br>- Middle-Upper Floor Grid |
| **Supplier status in the A380 program** | 2nd tier supplier | 3rd tier supplier | 2nd tier supplier, risk sharing partner |
| **2009 Turnover** | 199 million $ | 10,4 million $ | 3555 million $ |
| **Employees** | 720 | 23 | 13000 |
| **Respondents** | - One respondent: Director manager of the Turbine Component Limited Division | - One respondent: Director and share holder | Two respondents:<br>- head of civil aircraft analysis & forecasting<br>- aeronautic engineer |

Company two is based in the South West of England as well. It has a long term experience in tooling supply, integration, industrial supplies and tooling management. It is located at the 3rd productive level as it operates for Company one as tooling integrator. I submitted the questions to the director of the Company (named as Respondent 2 in the follow).

Company three is a global aeronautical player active in the military and civil markets. It controls a number of subsidiaries located in America and Europe. The Company three product portfolio includes proprietary products like a modern tactical airlifter, or special mission aircraft developed for maritime patrol roles. The company also plays key roles in world-class programs like the A380 project where it is a risk sharing partners of Airbus and it provides: i) centre fuselage upper units, ii) centre-forward lower unit, iii) side panels (central doors), iv) middle-upper floor grid. In this company I had two respondents: the head of civil aircraft analysis & forecasting (respondent 3) and an aeronautic engineer operating in the engineer function (respondent 4).

## 6. Results

As described in the section four, apart from the company profile questions, three have been the main area of investigation. Therefore this section is divided into three sub-sections describing: i) the general trends in the aerospace industry, ii) the system of relationships in the A380 project and iii) the eventual changes inherent the last civil aircraft projects.

### *6.1 Trends in the aerospace industry*

Our respondents generally confirmed all the changes literature has already described and I have briefly summarised in section 3.

The most important dynamic highlighted reflects the prime contractors' desire to leave to their suppliers all the low-adding value activities. They just want to act as final integrators and to manage relationships with the customers. The lower level suppliers have more responsibilities. As asserted by the respondent 4 of the company 3:

"In raw terms, responsibilities are increasing if we look at the productive pyramid from the top to bottom. The strong consequence is that the way we relate with our suppliers is changing. […] The supply base is increasing. This is because from one side we help our suppliers to grow by outsourcing them new activities, from the other side we need to limit this growth. Therefore we involve in our supply base lower suppliers. The complexity of the supply base management is increasing and this is why our business model is evolving towards an extended enterprise"

Therefore, tasks required to 2$^{nd}$ tier supplier are changing as "not only you are responding to your customer but you have to do a lot of management that the OEM would have traditionally done" (Respondent 1). 2$^{nd}$ tier companies need that their suppliers growth. This is because in order to respect their customers' requirements, they need high quality suppliers which are able to accomplish the new tasks.

Complex systems of ratings and penalties are adopted to manage the complex supply bases and therefore to ensure the respect of the project milestones and parameters.

Another important phenomenon refers to the attempt of standardising some activities in order to reduce costs. As described by the respondent 3 " while in the past each production plant needed to be designed ad hoc for the activity to be implemented in, now we are trying to reduce the production sites. More workload is going towards machinery".

All the respondents agreed that these dynamics are current phenomena which only partially reflect the organisation of the A380 project, while they are driving the organisation of more recent civil projects such as the Boeing 787 and the Airbus A350.

### *6.2 The system of relationships in the A380 project*

In relation to the system of relationships among the major supplier of the Airbus, the characteristics emerged from the analysis are organised according the issues put in evidenced in the methodology section.

*Characteristics and objectives of the partnerships established*

The system of relationship established in the A380 project is complex and highly dynamic. It is important to outline that Airbus has the *design authority* of the project. Airbus totally manages the preliminary design of the aircraft. Then Airbus develops the different areas of the projects thanks to a set of risk sharing partners which actively participate to the engineering phase. During this phase teams of engineers from partners' companies go to Toulose to study the preliminary designs in order to propose technological solutions to implement the project. This is a collaborative phase directly coordinated by the Airbus. Suppliers work in parallel as each interaction is mediated by the leader of the program. After the engineer phase each partner has a certain degree of freedom in organising its own supply chain to develop the parts they are responsible for. Airbus directly (in the case of the airframe subsector) or indirectly (in the case of the other two subsectors) has the control of the supply system. Prime contractors decide by themselves what to produce in-house and what to have done outside, and form relationships with many other firms which are on the second and third level of the

pyramid. A complex system of rating and penalties ensure that all the suppliers involved respect time and quality specifics.

More specifically, the different types of relationships emerged from our analysis are described below.

- Airbus established *risky and sharing partnerships* with more than 30 suppliers. Suppliers were asked to absorb 3,1 billion US $ non-recurring costs which is 25% of total non recurring costs (Tzu-Ching Horn, 2006). Company 3 is a risk sharing partner of Airbus in the project (about the 4% of the airframe structures). Therefore the contract established with Airbus is not related to a fixed amount of parts due for a specific period of time. A risk and sharing contract depends on the estimation of the aircrafts' orders the Airbus has and on the percentage of non recurrent costs you have to sustain.

- A set of long term collaborative agreements are established between the 1st tier and 2nd tier suppliers. 1st tier suppliers are leaders of a sub sector (Rolls Royce is responsible for the propulsion system subsector) or of specific filieres related to parts of the aircraft. They act as sub-system integrators as they assembly the final sub-systems before the final assembly made in Toulose by EADS France. They collaborate with Airbus during the preliminary engineering phase, but they also collaborate (through an increasing outsourcing of activities) with their suppliers when developing the specific part of the program they are responsible for. Company one is not a risk and sharing partner of the A380 project, but it is engaged in long term relationships with Rolls Royce. They work together on the design of specific components for the propulsion systems.

- 2nd tier suppliers are pushed to enlarge their supply base in order to be responsive to the new customer requirements. Therefore, apart from the traditional transactional sub-supplying relationships, they are collaborating more strictly with a number of suppliers which are becoming key partners.

- 3rd level suppliers are therefore pushed to growth or to collaborate more strictly with new partners located at the same level in order to better respond to their customer requirement. As asserted by respondent four "in the past we provided to our suppliers materials to be processed and transformed according to our specifics and indications, now we provide to our suppliers only the design, some specifics and a certification for the productive processes. Unless Airbus' indications, our suppliers become completely responsible for all the activities from the material supplying to the final delivery, we assume the responsibility of the component only when the component passes through the suppliers' gates. [...] The more our suppliers satisfy our requirements, the more its rating will be higher and we'll reduce the quality controls on its processes."

- In the propulsion systems sub-sector a new integration logic emerged. When there are a lot of small components to be assembled by an OEM or a 2nd tier supplier, a "tooling integrator" is appointed. This firm procures all the components to its customers. The nature of this relationship depends on the nature of the final sub-assembly. If this is critical for the OEM business, the OEM applies more control to the integrator activities, while if the components are for a standardised part, the integrator is free to find the best suppliers. Company two acts as tooling integrator for company one in the A380 project.

The motivations behind this architecture are:

- costs reduction: "in the past the best aircraft was the lightest one, nowadays the best aircraft is the lightest and the cheapest one" (Respondent 4);
- risk reduction by splitting the risk among the risk-sharing partners;
- with long term agreements you can have "sustainability in your business so you can invest in programs for 3 years, 5 years maybe even 10 years.

You know that you are not going to compete for those every year" (Respondents 1 and 2)

- focus on core competencies: if each firm outsources its non core activities, the final quality of the aircraft will be better as the productive pyramid involves *the best of everything* for each technology to be adopted.

On the other side each firm interviewed highlighted a number of barriers encountered in the project:

- the increase in outsourcing results in a more complex supply base management. Indeed lower levels firms need to acquire new competencies to respond to the customer requirements.
- To be a risk-sharing partner you must be a pretty large organisation with the ability to raise a large amount of cash.
- With long term agreements you are more subject to inflation and currency exchange fluctuations.

*Coordination and communication tools used*

In the Airbus A380 a wide use of ICT tools has been made at different levels with different objectives.

Airbus started to adopt a product lifecycle management (PLM) system few years ago. "With PLM Airbus mainly means the creation of a virtual environment which allows managing all the product life cycle from the idea to the customer support. In this environment all the Airbus functions could interact, and Airbus could meet all its partners and customers as well. Each entity can obtain some data (relatively to the part of the project they are involved in) elaborate on them and then put them again in the central repository. In this way all the transaction are recorded and registered and Airbus can also virtually manage the numerical control machineries" (Respondent 3).

To follow the Airbus strategy, recently all the main suppliers are adapting their information systems according this PLM logic. Companies one and two are still behind this adoption, while company three is already facing this evolution:

"..we don't have a PLM, we are evolving towards a PLM logic. Now we have a product data management (PDM) to manage only the product not the entire life cycle of the product (from the idea to the disposal). We are transforming our customer relationship management CRM, enterprise resource planning ERP and supply chain management (SCM) systems towards the PLM. Indeed the creation of a PLM system will be a pre-requirement that we are going to ask to our suppliers to be considerate high rating suppliers. […] Therefore, in the future the problem will be the integration of different PLM systems" (Respondent 4).

In particular looking at the most important technological tools that Airbus adopted to set up the virtual collaborative environment for the PLM we found:

- most companies adopt *supplier portal information systems* which are password-protected web-based platform where the suppliers can distribute contents/services or exchange documents.
- Airbus developed the *Airbus Concurrent Engineering* (ACE ) system in the ACE project to combine "best in class" tools and methods to enable simultaneous and interactive engineering within its EE (Hobday n.d.). The digital mock up (DMU) technology was a fundamental component of the ACE system in order to allow the full visualisation of complete product designs in three dimensions.
- Airbus has equipped its A380 with about 10,000 *RFID* chips on removable parts (Tzu-Ching Horn, 2006). Through RFID the manufacturers will get more accurate information about their demand for parts. They will be able to reduce their parts inventory and cut the time it takes to repair planes. Suppliers will also be able to reduce inventory, improve the efficiency of their manufacturing operations and use the technology to verify to Airbus that parts they get are genuine, thereby reducing the amount of unapproved parts that enter the supply chain (Roberti, 2004).
- All the companies analysed responded that they utilise EDI technologies to exchange business documents and technical data.
- Videoconferences and face to face meeting however are still considering as the most important way to build up relationships. In particular the

respondent 2 of the company two highlighted as “face to face meeting are still the key”.

*Knowledge management practices*

With “knowledge management practices” respondents referred to the exchange information mechanisms and to the protection of its own intellectual capital.
Each respondent interviewed has highlighted that the efficient and effective exchange of information has received in the A380 project an increasing attention if compared with previous civil aircraft projects. Definitively, the availability of modern ICTs has enabled the accomplishment of this complex task. However, the communication tools utilised have been already described and here I want to outline some considerations respondents have made on this topic.

Firstly, respondents confirmed the picture detailed in figure 2 as the information flows could be horizontal among firms belonging to the 1st productive level and vertical among firms belonging to different productive levels. In the first case, the exchange of information is contingent to the projects as different partners working in parallel to different parts that will be assembled together need to communicate frequently and in an efficient way. This is enabled by large repositories managed by the Airbus where all the relevant information about the project are stored. Each partner has a limited visibility of such databases related to the part of the project it is responsible for. Therefore this allows a sort of “virtual” communication where the information flows are indirectly managed by the Airbus. Also the vertical exchange of information is enabled by ICTs and it assumes often the form of a virtual communication through web-based access to restricted areas. It is important to worth that the frequency and the consideration given to this information exchange is considerably increased over the last years. As assessed by the respondent 3:
“nowadays we have conference calls with our customers on weekly bases, while the exchange of information, designs is continuous […].When we are contacted by a potential customer, before the discussion of any contract, the first step is the creation of a virtual link where data are exchanged with particular security protocols. The first function to be involved is the information system area.”

Knowledge management also means protection of the intellectual property. Companies located at the 1st and 2nd productive level must manage the complex trade-off between the necessity to help their smaller suppliers to growth and the need to protect their core knowledge. This has been put in evidence both in the engine and in the airframe subsector: "We do define certain areas of intellectual properties and we are very careful about whom we share that with, when our customers come to certify our processes, we don't give to them the complete visibility" (Respondent 1).

*Coordination mechanisms and organisational structure of the partnership*

In the A380, the structure of the productive pyramid has a strong hierarchical base as the Airbus owns the design authority of the entire project and directly or indirectly manages the implementation of the project. The propulsion system and the equipments subsectors have a higher autonomy degree while Airbus, through EADS France, Germany and Spain, directly controls the airframe subsector. Therefore, Airbus is not only the final assembler and the outsourcing is limited to production activities. In the past paragraphs we have already described some mechanisms Airbus uses to coordinate the entire supply system, here we try to summarise them as follows.

- Airbus has established a set of programmed meetings involving the main suppliers. This allows suppliers to align timing of the project and to discuss eventual problems all together.
- Airbus adopts a complex rating and penalties system for its main suppliers to stimulate them to respect all the project specifics. Consequently, the Airbus partners adopt similar penalties and rating systems for their smaller suppliers.
- Airbus manages the central repository and the virtual environment where all the data are stored and relatively available for partners. Airbus is also responsible for the engineering phase where it directly works with its risk-sharing partners and handle the horisontal flows among the prime contractors.

- In some cases, Airbus could dictate to its suppliers the material suppliers to be contacted.
- In some cases Airbus could impose to work with some suppliers especially suppliers in emergent markets (e.g. in China).

Each 1st tier supplier becomes responsible for technological filieres. They outsource more activities to 2nd tier suppliers and they reflect to them the penalties and rating systems Airbus dictates. Indeed, the contracts established to all levels depend from the contracts established between Airbus and its prime contractors.

### *6.4 The most recent civil aircraft projects*

The newest, and also rival, civil aircraft projects are the Boeing 787 Dreamliner and the Airbus A350. All the companies analysed are involved in these two projects as well. Even if they don't are the subjects of this paper, I asked to our respondents to put in evidence if the business models adopted to produce these aircrafts have substantial differences with the A380. It is important to outline that neither the B787 nor the A350 are operative aircrafts. They are long range, medium-size jet airliners. The oldest one is the B787 program, launched in the late 2002. Compared with the A380, the first business model proposed by Boeing was a revolutionary one (Tzu-Ching Horn, 2006) as:

- Boeing acts as system integrator outsourcing an increasing amount and variety of activities. "In the airframe subsector, in the 787 project, Boeing externalises about the 60% of the activities, while Airbus outsourced about the 18% for the A380". (Respondent 4).
- During the engineering phase it is responsibility of the first tier partnering suppliers to develop the detailed interface to work together with the other major suppliers. Boeing acts as referee in the case of any conflict and it encourages multilateral communication flows among the first tier suppliers without managing them directly.
- Partnering suppliers work as peer suppliers in the design phase.

But these measures, although they reflect the general trends observed in the industry, led to some problems in the implementation of the project. As put in evidence by the respondent 3 “Boeing assumed a high risk position for the adoption of a completely new business model. The more you outsource, the less you can control. For example we and another company assembled the central part of the fuselage in a plant located in USA before supplying the section to the Boeing, but recently Boeing assumed again the property of that plant as it realised that it was losing too much control on the project. Boeing now wants to re-acquire some competencies it is losing. Therefore the peer relationships established in the engineer phases are now turning again in hierarchical ones where the Boeing control is increasing. The sub-integration of the macro part of the fuselage has been re-assumed by the Boeing”.

In 2007 in order to make Airbus more efficient and competitive, together with the new A350 project the Airbus launched the Power8 program to transform the Airbus business model and to develop a global network of partners. Measures adopted through this transformation could be summarised as (Airbus, 2007):

- Lighter and cost efficient management through:
- ✓ Reduction of Airbus Overhead Costs
- ✓ Develop faster
- ✓ Lean production principles across all plants
- ✓ Smart buying and maximise cash
- Focus on core business
- Long-term global partnership network
- Streamline the final assembly lines
- Fully integrated and transnational organisation

The Power8 measures overlap with the first business model adopted by the Boeing for the B787 production. They represent a real attempt made by the Airbus to evolve towards the creation of an extended enterprise model where more responsibilities are allocated to 1$^{st}$ tier suppliers in return for a better distribution of the costs and risks (Airbus, 2007). In this case the restructuration of the

business model operated by the Airbus could take the form of the sale of entire plants together with people, technologies and therefore competencies. In this way, Airbus focuses more on core competencies and it becomes more dependent to its suppliers.

## 7. Discussion and implications

### *7.1 Comparison between literature and empirical evidences*

In this section, the findings emerging from the case study analysis have been matched with the main results of the literature review. The objective is to identify the main characteristics of the EE model and its implication for the management of the supply system.

The comparison is organised in two steps. In the first step, the common issues in the current literature (see Table 1) have been compared with the issues emerging from the case study analysis (see Table 5).

Generally speaking, it appears that the empirical evidences fit most of the shared issues covered by the current literature. Therefore it is appropriate to match the extended enterprise concept with the organisation of the supply system in the aerospace industry. As testified by some respondents, the extended enterprise concept arose when companies need to enlarge their supplier base as the increasing outsourcing politics adopted by the prime contractors. Companies focus on their core competencies and they start to become dependent to a number of key partners to collaborate with in order to reduce risks and costs. This process starts from the 1$^{st}$ productive levels and extends to the 3$^{rd}$ level where sub-supplying small companies are pushed to growth or to create collaborative networks in order to be responsive to the new customers' requirements.

Nevertheless, there are some differences which emerge in relation to the strong authority and to the outsourcing politics exercised by the Airbus. Airbus is strongly responsible for the preliminary design of the aircraft. Risk and sharing partners don't have a high degree of autonomy and the relationships in the engineering phase, even if have been defined as collaborative, appear far to be among peer partners. The autonomy is higher for partners involved in the engines and equipments sub sectors, while the airframe subsectors is directly managed by

the EADS companies. The outsourcing and the collaboration in this last subsector are increased if compared to previous programs, but it is still limited mainly to non core activities.

*Table 5: Comparison between common issues emerging from literature review and empirical evidences*

| Issues | Literature review evidences | Case study evidence |
|---|---|---|
| Main aims | -To provide a customer-defined product/ service<br>-Product lifecycle must be managed as a whole<br>-To reduce the time to market of new products | - To provide a new generation commercial jetliner<br>- To manage the aircraft production as a whole |
| Partnership objectives | - Share costs, skills, and core competencies<br>- Knowledge-based organisation | - Sharing costs, risks and core competencies<br>- Outsource of non core activities |
| Organisation stability | - Flexible, adaptive | - The flexibility is limited by the large number of the firms involved |
| Partnership characteristics | - Long term<br>- Collaborative and co-operative<br>- Independent companies<br>- Mutual trust and share common goals | - Long term<br>- Collaborative and co-operative especially in the design phase even if the Airbus has the total design authority<br>- Independent companies |
| Knowledge management | -The efficient information/knowledge exchange among the collaboration network's partners | -Strong attention to the efficient management of knowledge flows<br>- Airbus directly manages the horizontal information flows among its partners |
| Coordination and Communication tools | - Extensive use of ICT and computer networks<br>- EDI technologies | - EDI technologies to exchange data and relevant information<br>- PLM systems adopted by larger firms |

In the B787 project, Boeing made a first tentative to develop a more collaborative supply system since the engineering phase, but the recent phenomena testify as it is very difficult to accept a strong decrease of control on the project. With the Power8 Airbus tried to make a similar strong effort in the extended enterprise direction but we still have to wait in order to see the results.

It is important to outline the strong use of the ICTs to enable information and knowledge exchange. Airbus allows a virtual collaboration among the partners and manages the storing and the exchange of all the data and project documentation through a PLM system. Nevertheless this evolution towards these modern information systems is a current phenomenon which is now involving larger partners and it is still far to smaller ones.

In the second step, specific literature issues (see Table 2) have been compared with the empirical evidence obtained (see Table 6). Some specific features of the partnership created within the ENES are highlighted. They particularly refer to the following elements:

- Airbus through a set of mechanisms and contracts has the direct or indirect control of the supply system. In the airframe sub-sector EADS companies act as prime contractor while the other two sub-sectors are more independent.
- Each 1st tier supplier is leader of a particular part of the project. They decide what produce in house and what to outsource. Airbus could manage this process by imposing to collaborate with certain suppliers. However a higher degree of freedom is ensured. 2nd tier supplier are pushed to acquire new competencies. In particular they must be able to manage entire supply chain and to dispose a more complex supply base.
- These dynamics affect smallest sub-suppliers located at the 3rd productive level. They are pushed to supply not only a component, but also a service. Therefore they need to growth or to collaborate more strictly with a higher number of partners. In this sense the extended enterprise appears to involve also small firms.
- The organisational structure of all the subsectors has a hierarchical nature. This hierarchy has different levels related to the different productive levels and to the different parts of the aircraft.

Summarising the above, the extended enterprise concept fits with the organisation of the supply system in the A380 project. The characteristics of the extended enterprise established mainly overlap the common issues emerged from the literature review. In relation to the specific literature issues, it appears that the EE configuration is a hierarchy starting from the top of the pyramid. The hierarchy assumes a tree shape and it branches into the three subsectors. Each subsector (except the airframe one) has a certain degree of autonomy. As the increasing outsourcing smaller suppliers have to carry out new and more complex activities. Therefore the hierarchy has different poles, each pole has a certain degree of autonomy in managing lower suppliers but it partially depends from the superior one. In this sense, the network each pole establishes for a specific part of the aircraft could be seen as a *micro extended enterprise.*

*Table 6 Comparison between specific issues emerged in the literature review and empirical evidences*

| Issues | Literature Evidences | Case Study Evidences |
|---|---|---|
| Coordination unit | - The most powerful firm leads the network | - Airbus has the direct or indirect control of the supply system<br>- Each 1st tier supplier is leader of a particular part of the program and has a certain degree of autonomy |
| Firm size | - Few references about the involvement of small firms in the extended enterprise | - The extended enterprise logic appears to involve both large and small firms |
| Organisational structure | - Hierarchical structure<br>- Few references on horizontal structures | - Hierarchical structure with different levels |

### *7.2 Implications*

As emerged by our analysis the extended enterprise concept fits with the organisation of the supply system in the A380 project. The characteristics of the extended enterprise established partially overlap the issues shared on literature on the EE model.

Nevertheless, there are some concerns which emerge in relation to the strong authority and to the outsourcing politics exercised by the Airbus. The outsourcing in the A380 project is increased if compared to previous programs, but it is still

limited mainly to non core activities. The Airbus has the total design authority and this limited the horizontal collaboration among the risk sharing partners.

Latest programmes (Boeing 787 and A350) indicate that Boeing and Airbus are changing their business models towards complex configurations more fitting the EE concept whith particular reference to:

- horizontal alliances among top suppliers and the programme leader are established in the R&D phase;
- increasing outsourcing of more critical tasks to lower suppliers in order to reduce costs and risks.

However the difficulties encountered during this evolution (and the delays characterising both the A380 and the B787 projects) show as these changes are difficult to be absorbed and implemented.

Some managerial implication could be drawn after this analysis.

The aerospace industry has entered the era of global competition, therefore large aerospace companies must learn to globalise their own supply chain activities and design new business models and strategies. It is also important to learn as to manage cultural differences when finding the best supplier/partner all over the world.

As the prime contractors, and therefore their major suppliers, increasingly outsource activities and functions they used to perform internally, they must find quality suppliers that can assume such responsibilities.

For the suppliers located at the lowest levels of the productive pyramid, to be considered a “good quality supplier”, it is therefore imperative:

- to be equipped with electronic and communication technologies which can be integrated with the partners’ ones according to a PLM logic ;
- to be equipped with higher R&D capabilities;
- to have the ability to assume full supply chain responsibilities (selection of lower tier suppliers, quality insurance etc.);
- to have a strong financial banking to assume more risks.

Finally, it is important to outline that the exploratory nature of this case study analysis, the peculiarities of the industry investigated and the reduced number of interview conducted limit the generalisation of the results achieved. Further

investigations about other projects in the aerospace industry or in other industries are needed to validate results and recommendations proposed in this essay.

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