

THE OUSOURCING OF INNOVATION ACTIVITIES.
A LONGITUDINAL STUDY IN THE SUPPLY CHAIN OF AIRCRAFT INDUSTRY

Abstract

Many companies have redefined their own business model implementing an extensive use of outsourcing strategies. This phenomenon has, increasingly, involved activities of the value chain with high-intensity of technology innovation (R&D activities) and industries with global and high technology-based supply chains. In accordance with this trend, today, the outsourcing is considered to be an important potential source of innovativeness, because it permits to leverage on specialized technological resources and capabilities of strategic suppliers' networks and sustain, more effectively and efficiently, the research and development activities for new product development strategies. Using a longitudinal case study approach, the aim of this study, therefore, is to address the outsourcing decisions relatively to the innovation activities for the new product development (namely, R&D activities) across the global boundaries of aircraft supply chain, one of the industries with highest-intensity of research and development investments.

Keywords: strategic outsourcing, outsourcing of innovation (R&D) activities, partnership outsourcing, supply chain management.

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Introduction

The outsourcing decisions making was, in the past, identified with the term “*make or buy*”, and was based, prevalently, even if not exclusively, on economic convenience evaluations about the price-cost trade off. The importance of the cost economies about the outsourcing decisions is largely based on the Transaction Cost Economic Theory (TCET), as developed earlier by Coase (1937) and, later, by Williamson (1981).

In recent years, the outsourcing has rapidly spread in the business world, involving several activities of the firms' value chain, not only operational ones, but strategic ones, too (Quinn

& Hilmer 1994; Baden-Fuller, Targett & Hunt 2000). In particular, several studies have faced the issue of the outsourcing in new product development (Calantone & Stanko 2007; Zhao & Calantone 2003; Rundquist 2008).

In a strategic perspective, the decision making process of an outsourcee¹ puts in evidence not only the effects on the transaction costs, but in terms of the impact that it has in terms of extending and integrating internal resources, capabilities and knowledge base, too. The outsourcing, therefore, has to be interpreted in accordance with the Resource-based Theory (RbT) and all the other theories which have epistemological rooted in it, such as Competence-based Competition Theory (CbCT), Knowledge based Theory (KbT), Dynamic Capability Theory (DCT).

Many companies have redefined their own business model implementing an extensive use of collaborative outsourcing strategies, and that is related to many general trends. In summary, the fundamental motive is the increased and increasing uncertainty of the environment. In fact, to absorb the sources of uncertainty – technology and market changes – the firms extend the relationships with other external organizations, and pursue an higher cooperation with trusted and skilled supply partners (Lorenzoni & Lipparini 1999). In accordance with the wide set of resources-based theories – Resource-based Theory (Grant 1991; Barney 1991; Peteraf 1993), Competence-based Competitive Theory (Hamel & Prahalad 1996; Hamel 1994), Knowledge-based Theory (Nonaka & Takeuchi 1991, Liebeskind 1996), Dynamic Capability Theory (Teece & Pisano 1994; Teece, Pisano & Shuen 1997) - in the industries characterized by an high-intensity of competition and technological product innovation, the creation and development of the competitive advantage of the firm originate, fundamentally, by the resources, competencies and knowledge base that it owns and/or can access through collaborative relationships with selected external organizations.

As we'll better put in evidence in the following, with the longitudinal case study presented in this paper, the outsourcing of product innovation activities (namely, R&D activities), based on a dense network of collaborative relationships, generates several benefits both for the outsourcee and for the outsourcer. More specifically: 1. the shared investments are focused on the resources and capabilities of each firm, optimizing the relative returns; 2. the access to the basis of complementary resources of independent and specialized supply partners; 3. the opportunity that among more organizations of the network can develop distinctive relational advantages, originating by inter-firms collaborative relationships for the product technological innovation (Hagedoorn 2002; Doz & Hamel 1998; Dyer & Singh 1998; Freeman 1991; Howells 1999) in different forms, such as partnership, alliances, joint ventures, accords; 4. the opportunity to absorb and transfer capabilities and tacit knowledge, imperfectly transferable (Cohen & Levinthal 1990); 5. the creation of new knowledge and competencies useful to carry out product innovation process, not realizable just leveraging the internal capabilities of any single firm of supply chain (Capaldo 2004); 6. the risk sharing of idiosyncratic investments; 7. the improvement of the flexibility inside the supply chain; 8. the improvement of the efficiency with decreasing of the costs.

The aim of this study is to address the outsourcing of innovation activities related to new product development² (Howells 1999; Carson 2007; Griffith, Harmancioglu & Droge,

¹ In this article the term “outsourcee” will be used for the firm externalizing an activity of the value chain, and the term “outsourcer” for the supplier getting the responsibility for that activity. Alternatively and interchangeably is used the terms “outsourcing firm” or “outsourcing company” for the firm externalizing an activity of the value chain, and “outsourcing partner” for the supplier getting the responsibility for that activity.

² In this article the term “*new product development*” recognizes the firm’s innovation process that yields products completely or radically new, not a simple incremental improvement of existing products (Garcia, Calantone, 2002). The term “*outsourcing of innovation activities*” , instead, concerns activities that are an

2009) in supply chains characterized by: *a.* an high-intensity of product innovation; *b.* the product is technological complex, namely, it is the result of the convergence of several and specific technologies that are developed and supplied by a lot of organizations operating along the supply chain; *c.* a relative dispersion of the activities across more countries that made up, over the time, regional agglomerations, such as regional innovation systems, clusters, milieu innovateurs and industrial districts, which permit to exploit Marshallian externalities (Marshall 1920) as either economies of specialization, labor market economies (based on the local human capital pool) and/or knowledge spillovers.

The focus of the paper is the commercial aircraft industry. The industry supply value chain, as it will be better deepened in the following, is configured, to give just a simplified picture, in four vertical tiers, articulated in a typical pyramidal configuration (Niosi & Zhegu 2005). The analysis is based on the study of the outsourcing relationships industry-level through four longitudinal in-depth case studies (Yin 2003) of firms operating at the first three tiers of the supply chain in the commercial aircraft industry: Boeing Co., at the top level, as “system integrator” or “Original Equipment Manufacturer (OEM)” or “prime contractor”; Alenia Aermacchi at tier-1, as “small prime contractor”; Dema SpA and Geven SpA, at tier-2, as “subcontractor”. The collaborative outsourcing relationships across the supply chain have been analyzed through the case study of Boeing 787 Dreamliner (the first model 787-8), the most revolutionary and innovative mid-sized commercial aircraft that industry has known until today. This airplane, currently, is still under the final testing phase by Boeing Co (the first test launch was 15th December 2010, three years of delay respect to the scheduled date (7th August 2007, in accordance with the name of the project “787”), even if some series have been produced and delivered to the airlines (as in the case of the ANA-All Nippon Airways).

1. Outsourcing of innovation activities: the theoretical background and research’s hypothesis

The meaning of innovation recognized in this study is relative to research and development activities, such as production ones, for the new products development. The product innovation is strictly related to processes’ innovation, because product’s breakthrough innovations are supported by manufacturing and/or the designing processes radically new, such as by using innovative materials. The innovation activities, until recently, were carried out internally by the same companies for strategic reasons. Recent years, however, this managerial orientation of innovation activities is changed. The outsourcing of innovation (R&D) activities is increased because it permits to reduce the costs and the risks (i.e.: through risk sharing contracts) of R&D projects, to access to new and complementary resources, competencies and knowledge (tacit and explicit) of external organizations, to shorten the time to market of new product development. In accordance with the main tenets of TCET, the outsourcing of innovation activities is preferable to insourcing when this strategic choice determines a reduction of cumulated cost of innovation development, production and transaction, such as the risks related to that decision (quality, time to market, knowledge spillovers) are low³. TCET is an useful theoretical framework to explain

“innovative part” of the new product development process, and, therefore, have a strategic value for the performance of product innovation (Rundquist 2008, p. 427).

³ According to TCET, outsourcing can lower the costs of the innovation activities for producing new products or services offered by the outsourcee firm (i.e.: no or less investments for assets and personnel, more efficiency of external specialized suppliers) but, at the same time, can increase the transaction costs (i.e.: costs of negotiation, legal agreement definition, coordination, monitoring and legal disagreement). The transaction costs increase when higher are: a. the specific investments by the outsourcing partners; b. the uncertainty (unpredictable

the outsourcing decision making of innovation activities; therefore, it has several limits to explain theoretically and extensively this strategic choice. These limitations have been overcome by the wide set of theoretical assumptions contained in the theories based on the resources, competences, knowledge and dynamic capabilities.

In the RbT perspective, in fact, the outsourcing of innovation activities should originate from the need of the firm, under the pressure of competitive end environmental changes, to access to new resources, complementary, heterogeneous, imperfectly imitable, mobile, reproducible and substitutable. This situation could induce the firm to create relationships with external organizations of the supply chain and, more in general, of the business system (suppliers, customers, competitors, substitutes, complementors) that have these kind of resources⁴.

The CbCT approach, instead, emphasizes the role of distinctive competencies to create and develop the firm's competitive advantage. In accordance with the definition of Prahalad and Hamel (1990) about "*core competencies*", and with the main tenets of CbCT, the outsourcing of innovation activities should permit to access to the stream of complementary, unique and untradeable technological capabilities for the new product development which a single firm couldn't have interest to have or be able to develop internally.

The KbT, also, sees the firm as a portfolio of individual and organizational knowledge. In the KbT's theoretical framework, the outsourcing relationships - but more in general, the inter-firms relationships - are a way to extend and integrate the basis of technological and organizational knowledge critical for the innovation deployment, establishing relationships with specialized and valuable suppliers.

The DCT, finally, recognizes that the firm, to survive in hypercompetitive contexts, should dynamically modify and renew the own organizational set of capabilities. In some circumstances - for example, when the time to explore new strategic technological capabilities is too long and/or the investments are highly risky - the innovation or integration or extension of the firm's capabilities portfolio may require necessarily the collaboration of capability-holders, external to the organizational boundaries.

When the decision makers have to decide about the outsourcing of R&D activities for innovation face two important issues (Cantone & Testa 2009): 1. what are the circumstances in which is important to outsource these activities? Namely, when the outsourcing could usefully occur? 2. Which are the activities to outsource?

Relatively to the first issue, in accordance with the general model of Baden-Fuller, Targett & Hunt (2000), fundamentally there are four circumstances: a. need to "*catch-up*" the competitors. The firm could have the need to meet the competitive parity in the product's innovation activities in which it has a strong disadvantage in terms of number of new products introduced on the market and, consequently, of competencies indispensable to manage these activities. This competitive gap can't be easily got back in short-time and with the work of the internal resources; b. *changes of the value chain in the industry*, as the consequence of changes in the customers' needs. These discontinuities can require new

markets, technological uncertainty, goals uncertainty, contractual complexity); c. information asymmetries; d. infrequency of business relationships between the partners. Also, opportunism and bounded rationality are the other two factors that generate higher transaction costs (Williamson 1981). Therefore, the choice to outsource innovation activities for new product development depends by the interaction between the production cost and transaction costs.

⁴ Relatively to new product development activities (NPD), "*resource-base theory discusses outsourcing as a strategic decision to fill gaps between the firm's NPD resources and the desired NPD resources. This gap can be filled with either outsourcing (buying) the resource or re-deployment of internal resources, i.e. investing economic resources to create internal human resources or internal physical resources such as prototype machines, laboratories or CAD*" (Rundquist 2008, pp. 429-430).

technology capabilities for the innovation development whose the firms couldn't have experience with; *c. changes of the technology in the industry*, which determine obsolescence of technological capabilities and knowledge for the innovation of the firms; *d. emerging markets*, in which both the technologies and the market needs are uncertain and changeable. The outsourcing of innovation activities shapes through complex alliances.

As it we'll be better explained in the following, the case study Boeing 787 Dreamliner highlights the strength of more circumstances: *a. the changes in the customers' needs* (namely, airlines companies), that require airplanes with higher fuel efficiency, lower maintenance costs, more comfortable for the final customer; *b. changes of the technology in the industry*, in terms of materials' technology used for the aero structures (fuselage, wings), technology of manufacturing and design processes; *c. the pressure of the competition*, in terms of product's quality or performances, time to market and costs. Since 2003, Boeing Co. missed the control of the market share against the rival Airbus, that introduced on the market new aircrafts with new design. This heavy competitive action of Airbus drove Boeing to design and launch on the market new planes for retaking the control of the commercial aircraft industry. However, Boeing needed to launch the new airplanes quickly and with costs lower possible.

Relatively to the second issue (which are the innovation activities to outsource?) we argue that there are six strategic dimensions which could affect the decision (Figure 1).

1. The *strategic importance (high or low)* of the innovation activities. This decision making dimension emphasizes the role that innovation activities have in order to create, maintain and develop the competitive advantage and the growth of the firm in the actual and future markets. It highlights which activities are "*core*" or "*non core*" for a product innovation project to be successful. A general assumption is that the "*non core*" innovation activities are particularly subject of outsourcing, while the "*core*" ones are more consistently to internalize. However, as we'll better say in the following, the choice to insource or outsource a specific innovation activity depends by a mix of elements. Not necessarily all the "*core*" innovation activities must be carried out inside the firm; it depends if the technological domain of these activities belongs to the core capabilities of the firm. To decide if to outsource or insource innovation activities is fundamental to recognize if they are "*core-domain inside*"⁵. According to a common point of view, relatively to the "*core-domain inside*" activities, the firm, as a rule, should have the absolute leadership and governance, as long as it has the control of the technological domain in which they are embedded. To avoid knowledge and capabilities spillovers, interesting "*core-domain inside*" product innovation activities, the firm should maintain the internal control of the "*core-domain inside related*" activities, too. Of course, the insourcing of "*core-related*" activities could be the more rational decision when the firm is the best or one of the best performers of these

⁵ In accordance with Arnold (2000), the innovation activities are "*core-domain inside*" since they interiorize the key capabilities for the innovation process, therefore, are indispensable to create, maintain and dynamically develop the competitive advantage in the industry. They are embedded in specific technological domains (i.e.: final assembling of airplane; design configuration of the whole fuselage of an airplane). From these activities depends on the same survival of the firm, so they are "inside", namely, not to outsource. Other innovation activities are "*core-domain inside related*", that is, interrelated to "*core-domain inside*" ones by ties of technological complementary, and, therefore, hardly to divide, except with high risks of knowledge and capabilities spillovers (i.e.: design and manufacturing of subassemblies of airplane, such as single fuselage sections, wings, etc.). Other activities, instead, can be "*core-domain outside*"; they are strategic for the innovation but don't belong to the technology domain of firm's core capabilities (i.e.: design and manufacturing of airplane's engine, avionics, etc.).

activities. However, when the firm doesn't excel or hasn't a competitive parity with other potential suppliers for these kind of activities the decision to outsource or to insource depends by several contextual situations: are there suppliers for the innovation activities to outsource? Have they the technological and organizational capabilities to carry out efficiently and effectively the activities to outsource? Which are the risks of knowledge and capabilities spillovers? Is it possible to control these spillovers' risks by formal contracts? Could be a feasible objective in the short-time for the outsourcee to learn or to absorb innovation capabilities by these external potential outsourcers? The answer to these questions is crucial to choice if to outsource or insource the "core-related" innovation activities. Obviously, the innovation activities "core-domain outside" should be outsourced to best-in class suppliers.

2. The *technological discontinuity* expresses the change of technological paradigm underlying the innovation activities, and can be product and/or process related (Anderson & Trushman 1991). A process technological discontinuity can also be considered the innovation of materials used for manufacturing a product. The intensity of a technological discontinuity can be considered *broad* if it substantially changes the technological paradigm both of product and process. When this situation occurs, however, there is a need to change the basis of the overall business capabilities in terms of both product and process technologies. Instead, the technological discontinuity could be ranked as *narrow* when involves a change of product or, alternatively, of process. In fact, in this latter case, the innovation maintains a certain relationship with the current basis of firm's capabilities (incremental value innovation).

3. Any technological discontinuity of the innovation activities, however, can be analyzed in terms of *familiarity degree* with the technological domain underlying them. Therefore, the technological domain can be *familiar* or *unfamiliar*. This dimension highlights if the firm is able to control the current and the future technological domain of the innovation activities. Obviously, when occurs a *broad* technology discontinuity of the innovation activities, and the new technological domain underlying them, of product and process, is *unfamiliar*, the firm undertakes unexplored paths of growth, more complex and risky to manage internally (should prevail, in this case, a decision for outsourcing). Instead, if the discontinuity is *broad* but *familiar*, the technological change could be more consistent with the current capabilities and knowledge basis of the firm, and, therefore, the process of innovation could be, in general, less complex and more manageable internally (should prevail, in this case, a decision for insourcing).

4. The *competitive pressure*. The technological discontinuity, and its characteristics of familiarity/unfamiliarity with the technological domain of the firm, should be analyzed under the perspective of the competitive pressure existing on the market, in terms of product's quality or performance and/or time to market and/or costs. That competitive pressure could be *high* or *low*. Therefore, for example, not necessarily the product innovation activities characterized by a technological discontinuity familiar-like should be managed inside of an outsourcee when the pressure of competitive and environmental changes require a quality of the innovation higher and/or a time to market faster and/or costs lower than the single outsourcee would able to provide with own internal resources.

5. *Degree of strategic risk of the outsourcing choice*. This concept is similar to the degree of "strategic vulnerability" (Quinn & Hilmer 1994). The degree of risk is determined by two variables. The first is the *impact of the risk*, namely, the negative effects on the relative competitive position of the firm for inefficient and ineffective performances of the selected outsourcers involved on the innovation activities (poor quality of the innovation, lengthening of time-to-market, increasing of costs, etc.).

Secondly, the *probability of the risk*, that is, how much the inefficient and ineffective performances of outsourcers involved on innovation activities shall effectively take place. Still relatively to the concept of risk, and in accordance with the classification proposed by Aron and Singh (2005), companies face two different kinds of risks when they offshore or outsource its innovation activities: *operational* and *structural*. The *operational risk* originates from the difficulty of the outsourcers to execute the innovation activities as well as they are performed in-house by the outsourcee, at least, not for a long time. This risk falls when the work of innovation activities outsourced can be codified and the quality performed by the outsourcers on this work can be measured with precise and objective metrics; differently it increases when the innovation activities outsourced are difficult to codify and the metrics to measure the performance of the outsourcers are imprecise and subjective. The *structural risk*, instead, is the risk that the relationship with the outsourcers shouldn't work as expected (they act to maximize own interests through the outsourcing relationship). It falls when the outsourcee has an effective supervising of the outsourcers' work, even thanks to advanced information technology systems, and has an effective metrics' system to measure the outsourcers' performances.

6. *Width of the knowledge and capabilities basis that the outsourcee may have internally, comparatively to the supply partners.* The capabilities basis of the outsourcee could be *narrower* or *broader* than or *very similar* to that supply partners ones. Of course, when the outsourcee has less capabilities than the outsourcers the outsourcing of the innovation activities could be a consistent decision; vice versa, when the outsourcee has a capabilities basis greater than the outsourcers, or there is a substantial parity, the need of outsourcing is less urgent.

Combining the six decision making dimensions above described, it's possible to individuate the following options about the insourcing/outsourcing choices of innovation activities (Figure 1).

1. *Outsourcing of critical innovation activities.* This choice of outsourcing could involve innovation activities which have an high strategic importance (innovation activities "*core*" or "*core-related*"), a low strategic risk (or vulnerability) and the outsourcee hasn't the right capabilities to develop the activities, in other words it has a capabilities basis comparatively narrower than the supply partners available on the market. The outsourcing of innovation activities should be a consistent choice regardless of the technological discontinuity that they create and the familiarity degree with the technological domain of the outsourcee (i.e.: engines, avionics, interiors, systems). Even the competitive pressure, in this case, isn't a discriminating dimension for the decision. In this case, the innovation activities to outsource could be the "*core-domain outside*", as defined before. The strategic aim of the outsourcee company is to leverage the innovation capabilities and knowledge of the outsourcers available on the market. In particular when the innovation activities "*core-domain outside*" are unfamiliar with the technological domain of the outsourcee, the firm hasn't absolutely capabilities, comparatively to the potential outsourcers operating on the supply market, to manage those activities with the level of efficiency and effectiveness imposed by the competition. Insourcing them would mean develop a risky diversification of the competencies basis.

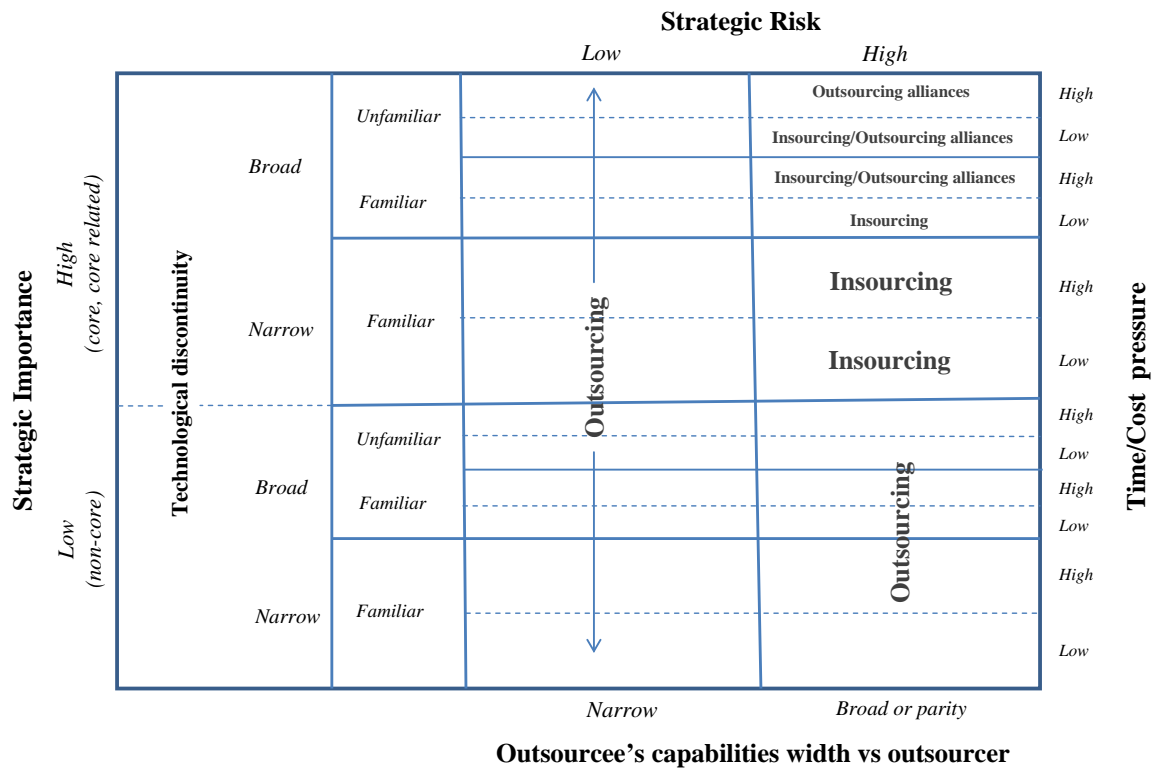
2. *Insourcing of critical innovation activities.* This option could involve innovation activities whose strategic importance is high (activities "*core*" or "*core-related*"), the technological discontinuity is narrow, the familiarity degree with the technological domain of the outsourcee is high, and the strategic risk is high. The outsourcee possesses, obviously, capabilities broader than the outsourcers operating on the supply market, or there is a

substantially parity in terms of technological and organizational capabilities. In this case, the competitive pressure isn't a discriminating dimension for the choice (it can independently be low or high). In accordance with the aforesaid classification, the innovation activities to insource could be the "*core-domain inside*" (i.e.: design of the airplane, final assembling) and "*core-domain inside related*" activities (i.e.: design and manufacturing of key components or subassemblies of an airplane, such as wings, for example). The strategic control of these activities and the underlying capabilities is the aim of the firm to avoid the risks of knowledge spillovers. An insourcing strategy is particularly consistent if the firm has familiarity with the technological domain underlying the innovation activities. The upper quadrant on the right of the Figure 1 represents a more complex situation. The strategic importance of innovation activities is *high* (namely, they are "*core*" or "*core-related*"), their technological discontinuity is *broad* (it involves either the product or the process), the strategic risk is high. Also, the capabilities basis of the outsourcee can be broader than of potential outsourcers or substantially equal. This situation occurs when the innovation activities need a multiple and complementary competencies which nobody firm has alone internally, because the product and process technology competencies that sustain them is new. To access the all new competencies you could build outsourcing alliances whose contractual aspects are very complex to define and manage (i.e.: sharing of knowledge and intellectual property, sharing of findings, etc.) or, alternatively, buy one or more specialized firms. The creation of outsourcing alliances could be a consistent choice in particular when the competitive pressure in terms of time to market, quality and/or costs is high. The choice of the insourcing is consistent only when there is nobody supply partner with the indispensable capabilities to realize the activities and the competitive pressure is low. When the technological discontinuity is *broad* but the innovation activities are familiar with the technological domain of the outsourcee, the choice of insourcing is consistent when the competitive pressure is low. Instead, when the competitive pressure is high the choice of outsourcing could be a confident decision if the outsourcers are able to perform efficiently and effectively the innovation activities with the right and indispensable standard of performance. In our idea, that is the condition lived by Boeing Co. for developing the new aircraft B787 Dreamliner. As we'll say in following, this new airplane is a technological breakthrough in terms of customers' needs satisfied, product concept, materials for the production and designing models. Relatively to the aero structures of the new aircraft, Boeing Co. has, evidently, the capabilities to design and manufacture internally all the subassemblies with the new materials in carbon fiber and titanium, because the new technological domain was familiar. The decision to outsource the designing and the manufacturing of complete sessions (fuselages, wings, etc.) was driven, fundamentally, by the need to regain, as soon as, the leadership in the industry lost in favor of Airbus, launching an innovative commercial airplane and producing it with competitive costs. Of course, this decision was affected by the availability of an international suppliers' network with the right and feasible competencies to carry out the innovation activities. Obviously, for that activities which put in evidence an high strategic importance ("*core*" and "*core related*" activities), a narrow technological discontinuity and, therefore, a familiar technological domain, the insourcing strategy could be a consistent choice, independently if the competitive pressure is low or high. Instead, that innovation activities "*non core*", with an high strategic risk and for which there are outsourcers with the right capabilities to perform them effectively and efficiently, generally, the strategic logic more consistent could be the outsourcing.

3. *Outsourcing of innovation activities "non core"*. That is the solution for all activities not critical for the success of product's innovation project on the market. It's a consistent decision when the strategic importance of the innovation activities is low, the strategic risk is

low and the outsourcee has a portfolio of technological capabilities narrower than the available supply partners. Even if there may be some kind of strategic risk – structural and/or operational, as defined above – the outsourcing can be consistent choice associated with an efficient management of the specific risk.

Figure 1. The strategic outsourcing-insourcing choices.



On the basis of the theoretical assumptions, above discussed, the following research questions (RQ) are advanced to be discussed in this paper.

RQ 1: would be possible to produce an aircraft like Boeing 787 Dreamliner without leveraging so much on strategic outsourcing of R&D?

RQ 2: has the outsourcing model increased the total cost of production and time to market rather than decreased them?

RQ 3: has the outsourcing approach changed the structure of supply chain relationship of the industry?

2. The longitudinal study

2.1 Research design and method

In order to examine the outsourcing of innovation activities in industry with high-intensity of research and development, we have analyzed the collaborative outsourcing relationships of four firms which are positioned at different tiers of the commercial aircraft industry. Every firm was deemed as appropriate case of any tier into supply chain of the industry. In fact, the first firm, Boeing Co., is an “OEM-Original Equipment Manufacturer” or “system integrator” or “prime contractor”, and is positioned at the top of the supply chain. The

second firm, instead, Alenia Aermacchi⁶, is a “small prime contractor” of Boeing Co., similarly of Airbus, and is positioned at tier-1 of the aeronautical supply chain. The third firm, Dema SpA, is a “subcontractor” of Alenia Aermacchi in programs of mid and large-sized commercial aircraft, and is positioned at tier-2 of the supply chain. The same position as subcontractor, at tier-2 of supply chain, is occupied by the fourth firm involved in the research project, Geven SpA. The choice of commercial aircraft industry was deemed as an appropriate research setting mainly for the following reasons. First of all, the industry is characterized by an high intensity of technological innovation, the development and manufacturing of an airplane is driven by multiple technology platforms (materials, aero structures, engines, systems, facilities construction); the innovation is high intensity of investments in research and development. Secondly, this is an industry setting in which the interfirm relationships are, and will be increasingly in the future, strategic due to increasing need to share the high R&D investments risks, achieving time compression in the development and launch of the new airplane on the market. Thirdly, in the industry the interfirm relationships deploy across an international context due the firms are located in several countries in the form of clusters or poles (Niosi & Zhegu 2005)⁷. The study, also, was conducted relatively to the most recent and innovative commercial airplane: Boeing 787 Dreamliner of Boeing Co. The analysis was developed for the first model Boeing 787-8⁸. The collection of data and information, initiated in June 2009, was at industry level, first, and at firm level, then. First of all, we gathered information on the structure of the supply chain of commercial aircraft industry; secondly, we have analyzed the kind of interfirm outsourcing relationships of the supply chain for innovation activities; thirdly we have identified the changes in the outsourcing relationship over time. Individual interviews were conducted with managers of commercial aircraft firms involved. When we started with the interviews to the management of the firms involved into the longitudinal case study, the B787-8 Dreamliner project was still ongoing; in fact the first flight test of the new airplane rollouts on December 2010, with a delivery delay nearly three years behind schedule. This delay in deliveries resulted, by some estimates, in loss of several billions dollars over budget and in loss of several orders by the airlines (Peterson 2011). A first set of interviews was completed in the late November 2009.

The information about the structure and competitive characteristics of commercial aircraft industry, and its global supply chain, have been got both by the academic literature (Niosi & Zhegu 2005) and by professional, ones (Carson 2009). Useful were the website of primary companies (Boeing Co., Airbus, Embraer, Bombardier, Alenia Aermacchi). The case study Boeing 787 Dreamliner has been arranged using documents on Boeing Co. website, working papers (Mahmoody 2009), articles on specialized industry’s reviews, business magazines, journals and blogs (Gates 2006, 2011a, 2011b; Vittachi 2003), earlier case studies (Cizmeci 2005; Tang & Zimmerman 2009; Cantone & Testa 2009) and special

⁶ On January 1, 2012 was born Alenia Aermacchi as merger of Alenia Aeronautica and its subsidiaries Alenia Aermacchi and Alenia SIA. The case study began in 2009 when the company had the name Alenia Aeronautica. In the following of the paper we will use, generally, the new name of the company, Alenia Aermacchi. However, as the case study exploration begins since the origin of the program 787 (1998 as product design program and 2004 as product development one) in some part of the paper the telling stories of the managers involved has registered and reporting the use of the old brand name Alenia Aeronautica.

⁷ In Italy the industry has the highest concentration of the firms in four regions: Lazio, Piemonte, Campania and Puglia.

⁸ The Boeing 787 Dreamliner is designed and will be built in three models: the 787-8 Dreamliner will carry 210-250 passengers, while 787-9 will carry 250-290 passengers. The 787-3 Dreamliner will accommodate 290-330 passengers. www.boeing.com. In this paper we shall use the term “Boeing 787 Dreamliner”, “B787 Dreamliner”, “787 Dreamliner”, “B787 Dreamliner”, “787” and “Dreamliner” interchangeably. When not specified referring to the first model 787-8.

reports (Peterson 2011). At the end of November 2010 has been sent a questionnaire to the management of Boeing Co. to deep some aspects of the partner model adopted by the company for the outsourcing on the 787 Dreamliner. This questionnaire was sent to a representative of the 787 Supplier Management of Boeing Commercial Airplanes, by the introducing of a top manager (Chief Operating Office) of North America Alenia Aeronautica (subsidiary of Alenia Aermacchi until January 1th 2012), involved in this research project. At 15th April 2011, the representative of 787 Supply Management of Boeing Commercial Aircraft e-mailed to the manager of North America Alenia Aeronautica that the company could not participate in the academic study with the following words: *“Dear, while we are flattered to be asked to participate in this academic study, if we were to answer thee questions posed we would reveal proprietary information. For this reason we respectfully decline to participate. Please communicate our regrets to your associate”*. The case study Alenia Aermacchi, instead, was arranged working on internal documents of the company, information gathered by several personal interviews to managers⁹ committed on the 787 program. Some of these were committed on the program since early design phase, started in Everett, Washington, in 1998. Similarly, the case studies Dema S.p.A. and Geven S.p.A were carried out on the base of internal documents of the company and information gathered during an interview to some managers of both firms. We have interviewed 16 manager, total hours of interviews were 24. All managers interviewed have been involved on the B787 Dreamliner program since its start. A second set of interviews began in early January 2012 was completed at the end of the month. We have interviewed two managers of Dema S.p.A., both respondents in previous phase of field research, and still involved on the 787 program. Also we have interviewed three managers of Geven S.p.A¹⁰.

2.2. The sample of companies involved

The empirical evidence of the study is based on a longitudinal study of three firms operating at three distinct levels of commercial aircraft industry supply chain. These firms compete on the global market and are specialized in the design and production of airplanes, components, part and subassemblies. The distinctive competencies of these firms have contribute to their growth at the international level, leveraging on their capabilities to create value through product innovation, increasing investments in R&D, creating relationships with specialized external partners. These firms, as will be discussed in more detail below, are linked by supply relationships, involving design and manufacturing activities. As a consequence of their competencies, they have a recognition in the organizational community and leading role in the relationship sets in which they are embedded.

Boeing Co. is the world's leading aerospace company and the largest manufacture of commercial jetliner and military aircraft combined. Also, Boeing Co. designs and builds rotorcrafts, electronic and defense systems, missiles, satellites, launch vehicles and advanced

⁹ The managers interviewed have been the following ones: Dr Vincenzo Caiazzo, Chief Operating Officer, North America Alenia Aeronautica; Ing. Nazario Cauceglia, Senior Vice President of Chief Technical Officer; Ing. Aldo Gianni, Senior Advisor of CEO; Ing. Giovanni Sagnella, Head of aero structures engineering; Ing. Generoso Iannuzzo, Head of aero structures technology; Ing. Danilo Cannoletta, Engineering Manager; Ing. Marco Sguanci, Chief of Procurement and Supply Chain; Ing. Rosario Neri, Budget and Control for Procurement and Supply Chain Manager; Dr Giancarlo Mezzanatto, Planning and Development Supply Chain Manager; Ing. Pierantonio Cerreta, Program manager B787-9; Ing. Nicola Miani, CPE 787 horizontal stabilizer.

¹⁰ For Dema SpA, Ing. Paolo Bellomia, Vice President Strategic Marketing and Institutional Relations, Ing. Placido De Alcubierre, Head of Plant in Somma Vesuviana (near Naples). For Geven SpA Dr. Rodolfo Baldascino Chief Marketing Officer, Ing. Federico Manna, Program Manager of 787 Dreamliner, Dr. Angelo Romano, Strategic Initiatives & Commercial Partnership Director.

information and communication systems. Boeing has a broad range of technological and organizational capabilities about the design and manufacturing of airplanes, intelligence and security systems, communication architectures and extensive large-scale integration expertise reached across military and commercial business units. Boeing Co., also, has high relational capabilities that permit it to leverage collaboratively a broad, skilled and global suppliers' network. Headquartered in Chicago, Boeing Co., in 2010, employs more than 165,000 peoples (more than 170,000 at the end of 2011) across the United States and in 70 countries. The turnover was US dollars 64,3 billion in 2010, with net earnings of US dollars 3,3 billion (The Boeing Company. 2010 Annual Report). Boeing is organized into two business units (www.boeing.com): "Boeing Commercial Airplanes" and "Boeing Defence, Space & Security". Supporting these units are Boeing Capital Corporation, a global provider of financing solutions; the Shared Services Group, which provides a broad range of services to Boeing worldwide; and Boeing Engineering, Operations & Technology, which helps to develop, acquire, apply and protect innovative technologies and processes. Boeing is leader on the innovation of commercial airplanes, developed in cooperation with customers (airline companies), in order to meet the emerging needs of them. In this business segment, it acts as system integrator, or OEM, in the aeronautical supply chain for the production of medium and large-sized commercial aircrafts. It's able to design and assemble a wide family of airplanes and to manage collaborative agreements with many suppliers tiers-1 at worldwide. Boeing has been the premier manufacturer of commercial jetliners for more than 40 years. With the merger of Boeing and McDonnell Douglas in 1997, Boeing's leadership in commercial jets, joined with the lineage of Douglas airplanes, gives the combined company a 70-year heritage of leadership in commercial aviation. Today, the main commercial products are the 737, 747, 767 and 777 families of airplanes and the Boeing Business Jet. New product development efforts are focused on the Boeing 787 Dreamliner, and the 747-8. In 2010, the Boeing Commercial Airplanes had revenues of US\$ 31,8 billions and, approximately, 74,000 employees (The Boeing Company. 2010 Annual Report).

Italian Alenia's Aermacchi (www.aleniaaermacchi.it), a Finmeccanica company, is Italy's largest aircraft company, engaging in the design, development, manufacture, maintenance and inspection of civil and military aircraft, trainer, unmanned aircraft and aerostructures. On 1 January 2012 the new AleniaAermacchi was born as the merger of Alenia Aeronautica and its subsidiaries Alenia Aermacchi e Alenia SIA. Alenia Aeronautica was created in 1990 by concentrating the Finmeccanica aerospace and defense industries Aeritalia and Selenia. Alenia Aeronautica was incorporated in 2002, when Finmeccanica spun off its divisions as independent companies. The integration between Alenia Aeronautica and Alenia Aermacchi will trigger industrial synergies, with significant economies of scale, in terms of both processes and products, through the strengthening of engineering, the redefinition of production systems and the related supply chain in view of the specialisation of each site by technology/product. *"This merger will bring together an extraordinary wealth of knowledge, technology and products, to ensure that the Italian aeronautics industry will continue to play a leading role in an increasingly global market in the years to come"*, as said Giuseppe Giordio, the CEO of the AleniaAermacchi and Head of Finmeccanica's Aeronautics Sector (www.aleniaaermacchi.it). Venegono Superiore (Varese), the traditional headquarters of Aermacchi, houses the registered office, while Pomigliano d'Arco (Naples) and Torino Caselle act as operational headquarters for the civil and defence aircraft sectors, respectively. The operational headquarters are the hubs of the manufacturing activities performed by six different Integrated Manufacturing Centres (training systems, defence aircraft, military transportation aircraft, civil aircraft, composite materials, metal structures) distributed over nine sites located throughout Italy. The product portfolio of the present Alenia Aermacchi includes proprietary products (i.e: the C27J, a modern tactical airlifted; the ATR42 and ATR

72, commercial airplanes for regional transport); the company, also, plays key role in worldwide programs (i.e: Eurofighter Typhon, 135 Joint Strike Fighter, Neuron European UCAV demonstrators). On the market of medium and large-sized commercial aircrafts, it plays leading roles as global partner, designing and building aero structures of airplanes families developed by Boeing and Airbus. For some programs, as major system supplier, Alenia Aermacchi is involved as risk sharing co-developer. In a equal-share joint venture with EADS, Alenia Aermacchi owns the ATR commercial aircrafts family, which dominates the regional turboprop market; recently, started a partnership with Russian company Sukkoi, to develop and market the Superjet 100, an advanced and environmentally regional jet available worldwide. Alenia Aermacchi controls Alenia North America, Alenia Hellas, and Superjet International. It is, also, system integrator, or OEM, in collaboration with EADS France, in the regional aircrafts with the design and production of ATR (Avion Transporte Regional) family (ATR 42 e ATR 72). To develop technological capabilities and nurture the R&D activities, the company cooperate with the major national and international aerospace centers, Universities, aerospace companies, IT and automobile industry (Ferrari, Fiat, Renault, IBM). Research projects are carried out with Airbus, Dassault, EADS, Eurocopter, Saab and SNECMA. It owns capabilities and know-how covering a full range of activities including development, production, integration and support of fixed wing aircraft; it is a partner in European and international programs and competes selectively in the global market. It leverages its traditional “*core competencies*” – system integration capability and airframe technologies - to strengthen its global customer support activities and exploit synergies with other Finmeccanica companies. The main technological and organizational distinctive capabilities of Alenia Aermacchi, today, are in the field of: composite materials; aero structures manufactured in carbon fiber; development, production, integration, support of fixed wing aircrafts; system integration. In 2010, then operating as Alenia Aeronautica, the company has about 2,8 billion Euros consolidate revenues (+6.4% over 2009); it has a strong spending in research and development (about 369 million Euros in 2010). Adjusted EBIT has reached 205 million Euros.

Dema – Design Manufacturing S.p.A. - at last, is one of the most important Italian subcontractors. Dema includes connected and subsidiaries companies which have specialized capabilities for engineering and manufacturing of aircrafts, helicopters and aerospace (tooling, sheet metal, machining, composites). The locations of subsidiaries are in Campania (Headquarters is in Naples, plants in Pomigliano d’Arco and Somma Vesuviana), Lombardia (Gallarate), Emilia Romagna (Podenzano), Puglia (Brindisi), Canada (Montréal), Tunisia (Tunisi), where are located very important poles or cluster of the aeronautic industry. Since 1993, it has been operating in the aerospace field and is a top supplier of aerospace companies, such as Augusta Westland, Alenia Aermacchi (earlier operating as Alenia Aeronautica), Alenia Aeronavali, Bombardier, EADS CASA, Galileo Avionica. The core competencies of Dema SpA are relative to aero structures components design, fabrication and assembly, composites materials. It is considered in the industry supply chain an supplier of tier-2 supplier, but for some “prime contractors” (i.e.: Bombardier) it operates as tier-1 supplier (“small prime”), that is, as an integrator between the big international customers and the network of qualified SME, through an integrated offer – including engineering, manufacturing engineering, manufacturing and assembling – of complex aerostructures (www.demaspa.it). Dema gives great importance to R&D activities, and to collaboration agreement with national and international firms, Universities, Research centers to acquire, share and develop with them the technical knowledge and capabilities, to increase the competitive performance and enter in new markets. Company’s turnover went 4 million Euros in 2004 to 8 million Euros in 2005 to 37 million Euros in 2008. Dema S.p.A. can count more than 600 employees.

Geven S.p.A. is a leading force in the field of Passenger Seating and Interiors, striving to preserve at length the well reputed reliability and quality standards of its performance, products and after market support services and care. A vast number of seating product certifications for a very large number of varied applications has been acquired over the years, for a great array of configurations and LOPA's, covering most of the aircraft types flying the skies today.

Geven S.p.A. is also one of the primary companies in the design, manufacture and installation of isolation blankets for aircraft such as A380; A321; B767; B787; ATR 42 and 72; DC9/10/MD 80; B707; P180 Avanti; P68; and P68TP aircraft. A recent and successful addition to Geven's production output are flooring panels for ATR aircraft family. Geven has also established a leading position in the field of aerospace support by providing skilled Overhaul and Repair Services to some of the major MRO's.

2.3 The supply chain of aircraft industry and outsourcing relationships

The civilian aircraft industry is hierarchically organized in four main levels, in the form of a pyramid (Niosi & Zhegu 2005). First of all, at the top of the pyramid operate the so called Original Equipment Manufacturers (OEMs) or “prime contractors” - such as Boeing Co. and Airbus in the market of large and mid-sized commercial aircrafts, and Bombardier, Embraer, Alenia Aermacchi for regional jets - who carry out the design and the final assembly of aircrafts. These firms perform the role of system integrators into supply chain at worldwide; more specifically, they manage the relationships with the customers (marketing, sales and relationships capabilities), exploit the new market's opportunities (sense making capabilities), define the product concept of new aircrafts (innovation capabilities), design the whole aero structure of the aircrafts and prototype them (design capabilities), coordinate the activities of the “small prime” strategic suppliers or tier-1 suppliers of the aircraft industry's pyramid (project management and leadership capabilities), assembly the whole aircrafts with the parts or subassemblies designed and/or manufactured by the prime contractors (engineering capabilities for final assembling). Relatively to the airframe structures and subassemblies, in years past, the OEMs defined standards and technical specifications of production for the “small prime” contractors, who make the subassemblies in their care (operational outsourcing). In recent years, however, the “small prime” contractors have been directly involved for designing, building and delivering of complete airframe structure (for example, sections of fuselage, wings) and/or subassemblies (for example, landing gears), too; in addition, they assume the market risk for any new aircraft launched on the market, through a mechanism of risk sharing (risk sharing contract). In other terms, by contract, each involved tier-1 strategic supplier receives payments for its participation share to the program only when the aircrafts ordered by the customers (airlines) are actually completed and delivered, out the bans of scheduled. Obviously, the risk sharing model to be successful is indispensable (but not sufficient!) that the suppliers involved are responsible for the delivery of complete subassemblies of the aircraft (i.e.: fuselage sections, wings, etc.), instead of small single parts, to mitigate the suppliers financial risks by the opportunity of higher potential revenues and profits (Tang & Zimmermann 2009). The system integrators outsource innovation activities for new product development project for three fundamental reasons: 1. the innovation activities aren't strategic and have a low strategic risks (risk of knowledge and capabilities spillovers). In this case the OEMs have as aim to reduce the costs, because of the lower labour rates in other countries that are candidates to outsource work, and to enhance profits and flexibility of the innovation projects; 2. lack of technological capabilities and knowledge for innovation development. In this case the aim of

OEMs could be to integrate and/or absorb complementary and indispensable capabilities of suppliers to carry out innovation development programs; 3. opportunity for the outsourcee firm to growth the business in different countries and increase the market share over the world. Not infrequently, in fact, the choice of prime contractors is affected by so called “*offset*” strategies, indeed, the OEMs sign agreements with Governments of countries for the provision of aircrafts to the national airlines with the involvement of domestic suppliers in the designing and/or production of parts.

At the tier-1 of the pyramid, under the OEMs, operate the so called “small prime” contractors, companies which design and/or manufacture airframe structures, subassemblies, propulsion systems, on-board avionics, and other complex parts of an aircraft. They are co-design partners, because they work collaboratively with the OEMs since early design phase to develop and engineer new airplanes concepts. These firms of the supply chain have high technological and organizational capabilities to design and manufacture complex parts of an aircraft. The small prime contractors are medium-large global players but smaller than OEMs. They are the primary interlocutors of OEMs and, as we have already told, they assume the risk of innovation programs by sharing a portion of the costs of new aircrafts’ development (risk sharing partners). Some of the principal small prime contractors who have relationships with Boeing Co. on the 787 Dreamliner program are Alenia Aermacchi, Mitsubishi Heavy Industries, Dasa, Latecore, Kawasaki Havy Industries, Rolls-Royce, General Electric, Pratt & Whitney. The small prime contractors, in recent years, participate directly to the development, design and manufacturing of new aircrafts. They have assumed the role of strategic partner of OEMs because have, over the time, developed internally specific technological and organizational capabilities for product innovation.

The tier-1 strategic suppliers, moreover, coordinate, as small primes, the relationships and the activities of all other “subcontractors” operating downward of the supply chain (tier-2). At this level (tier-2) of the pyramid works a concentrated number of suppliers at global level, generally small and medium sized firms, that supply single component or parts. This subcontractors are called supplier of “second level”, too, because generally they haven’t direct relationships with OEMs, but just with the small primes. In fact, these latter can’t carry out alone all the designing and manufacturing activities of new orders by OEMs. The subcontractors are specialized in the engineering and/or manufacturing of parts, and components. Generally, the tier-1 small primes develop standards and technical specifications of production which tier-2 suppliers have to follow to engineer and/or manufacture the work-package assigned. However, some subcontractors, with specific technological and organizational capabilities, can collaborate to the development and design of parts and subassemblies of new aircrafts, under the coordination of small prime (outsourcing of innovation activities). Therefore, they are supplying integrators because collaboratively integrate the capabilities of tier-1 small prime for design, fabrication and assembly of airplanes components. They have, also, the capabilities for development of tools and manufacturing processes, and the industrial competencies to produce with innovative materials (i.e. composite ones). These suppliers, in some cases, have direct relationships with OEMs both on innovation-based activities and operational ones. Of course the number of subcontractors with these innovation capabilities is very narrow.

Finally, at the tier-3 of the pyramid operate a wide number of small suppliers (“*third level*” suppliers) that manufacture in outsourcing single and technologically simple components or parts. Generally, the components produced by tier-3 are assembled by firms of tier-2 and/or tier-2 (operational outsourcing). In recent years some tier-2 suppliers are trying to assume the role of small prime operating between OEMs and tier-3 SMEs of the supply chain (as the case of Dema S.p.A. and Geven S.p.A.).

As we have highlighted above, the outsourcing relationships in the aeronautic supply chain – both innovation-based ones and operational ones – are hierarchically collaborative, top-down like.

The role of tier-1 strategic suppliers is very important because they are business partners of innovative programs toward the OEMs, upward of the pyramid. The role of co-partner is increased over the last ten years. They, also, take place a strategic role because involve, coordinate and manage the innovative and operational activities of a numerous small and medium supplier operating downward of supply chain (the suppliers of “second” and “third” level). The tier-1 contractors have, also, the innovation capabilities to develop and manufacture internally own commercial aircrafts. This is the case of Alenia Aermacchi who is OEM, in collaboration with EADS France, for the regional aircraft family, ATR (Avion de Transport Regionale).

2.4 The Boeing 787 Dreamliner project: leveraging capabilities and knowledge of the strategic suppliers

Boeing 787 Dreamliner is a mid-sized, wide-body, twin-engines, highly fuel efficient commercial aircraft currently under development by Boeing Co. The program 787-8 was launched by Boeing Co. in January 2004. Using the words expressed by a manager of Alenia Aermacchi’s Engineering Department during the interview: *“this decision, however, was came before by a phase, started in 1998, during the which was developed the product concept. Alenia Aeronautica was involved in the concept development team, named «Partner Council», for its capabilities on the design and manufacturing of aero structures components. Similarly, other prime global contractors, such as the Japanese firms, were involved in the «Partner Council» for the specific organizational and technological capabilities they were able to bring into the program The logic of Boeing was to co-develop with its top-tier supplier partners the new frontier of aero structures material, systems and engines and to create a technological breakthrough. The innovation, therefore, was both a product concept innovation, in terms of new customers’ needs satisfied, and in the components, parts, systems used for manufacturing a new airliner. These latter changes created a huge innovation on the design and manufacturing processes, too. During the phase of the product concept development the aim of Boeing was to explore - on the global supplier market, not just aeronautical ones - the capabilities to design and work composite materials which was the new innovation focus of the program B787. On the field of aero structures Alenia Aeronautica brings to the starting program the designing and technological capabilities of a horizontal fuselage structure that minimize the number of assemblies on the base of «one-piece barrel section» technology and the competencies on the central stabilizer”*. Alenia Aermacchi, then Alenia Aeronautica, already was a consolidated global partner of Boeing Co. In 1998, when started the product concept phase of the Boeing 787 Dreamliner, Alenia Aeronautica (since January 2012 named Alenia Aermacchi) co-located at Boeing plant in Everett, Washington, about 100 people of engineering department to cooperate with the R&D people of Boeing to co-develop the new product concept. In terms of people, Alenia Aeronautica was the partner most involved on the program. The engineers of Alenia Aeronautica worked cooperatively and integrate with the Boeing’s R&D people for the development of the configuration, certification and tests on the new subassemblies assigned. The control of Boeing on the tier-1 strategic suppliers to protect itself by spillovers’ phenomenon has been always complete. In fact, all the top-tier partners - even when co-located at the Everett plant, in Washington - worked separately on the program Boeing 787 Dreamliner. The program organization was centralized and the system wasn’t permeable. Boeing Co. has maintained internally the core competencies and knowledge of

airframe and engineering for final assembling. All the tier-1 strategic suppliers team involved on the co-design of complete subassemblies of aero structures (fuselage sections, wings, stabilizers, etc.) develop calculus models coherent with the “design guides” defined by the same Boeing Co. These “guides” permitted Boeing Co. to have designed complete subassemblies coherently with the final design configuration of the whole aircraft, as developed by itself. The calculus model underlying the final design configuration of the airplane was known only by Boeing Co., and not by the other partners. This concept was expressed, with the following words, by a manager of Alenia Aermacchi’s engineering department during the interview: *“The participation of the top-tier suppliers into «Partner Council» gave a horizontal visibility on who was involved on the program, but not on the object of the collaboration of any partner. In this phase we didn’t know what the Japanese firm were working - in terms of technological solution and calculus model - and what they should produce when the final product concept was «crystallized».* In April 2005, a year after the decision to launch the program, the final and more conventional external design was set. Boeing Co., then, decided to launch a program exploring new product architecture and using materials radically new for the aircraft industry (carbon fibre, titanium). Boeing featured its first B787 in a roll-out ceremony on July 8, 2007¹¹, at its Everett assembly factory. Originally scheduled to enter service in May 2008, production has been delayed more times, and in August 2009 the scheduled service entry date was pushed back to the fourth quarter of 2010. The first flight test, originally planned for September 2007, occurred in December 2010 (the airplane has to do six flight tests before to be manufactured and fulfil the orders of airline companies). Boeing 787 Dreamliner will bring the economies of large jets transports (i.e.: Airbus 380) to the middle of the market. It features a wing and structure optimized for mid-range flights. This jetliner is a revolutionary answer to the preferences of airlines over the world which required super efficient airplanes with an higher fuel efficiency (Boeing 787 Dreamliner uses 20 percent less fuel than similarly sized airplanes for comparable missions), lower maintenance and replacement costs (30% less), less environmental impact (20 percent fewer emissions than similar sized airplanes) and an increased comfort for the passengers (in the passenger cabin is allowed higher humidity and pressure). The Dreamliner allows airlines to offer “point-to-point” flights, reducing the operational costs and satisfying better the needs of international passengers. According to the original operation plan, Boeing 787 Dreamliner would have to be assembled at final assembly plant of Boeing in Everett, Washington, within three days, unlike the 30 days indispensable for the final assembling of 737 program (Tang & Zimmerman 2009). The expected performances of the 787 program are supported by a set of new technologies and design methods which involve several aspects of the aircraft (materials, systems, manufacturing and logistics processes) and are co-developed by Boeing and 43 of the world’s most skilled top-tier partners¹², responsible for designing, manufacturing and delivering complete subassemblies (fuselage sections, wings, etc.), which are assembled at the final assembly plant in Everett, Washington (Figure 3). B787 program is a breakthrough innovation for some fundamental motives. First of all, 50% of primary aero structures (80% by weight) – including fuselage and wings – on Boeing 787 Dreamliner is made of

¹¹ The first designation of the program was 7E7, changed later into 787, namely July 8th, 2007, the date defined for the roll out.

¹² The principal prime contactors involved on the Boeing 787 Dreamliner program are: Saab (Sweden), Mitsubishi Heavy Industries (Japan), Fuji Heavy Industries (Japan), Kawasaki Heavy Industries (Japan), Alenia Aermacchi (Italy), Rolls-Royce (United Kingdom), Messier-Dowty (United Kingdom), Goodrich (USA), Spirit (USA), Dasa, Latecore France, General Electric (USA), Pratt & Whitney (USA), Kal-ASD (South Korea). All these strategic suppliers are risk sharing partner.

composite material (carbon fibre) and 15% of titanium. The traditional materials make up the residual part of aero structures (20% aluminium, 10% steel, 5% other). This material breakout configuration is completely different from the precedent Boeing's commercial airplanes families (i.e.: 737) because only 12 percent of aero structures was made up of composites and 50% of aluminium. Secondly, the design and the manufacturing process has been based on the innovative logic of "one piece-barrel sections", namely, the fuselage is designed and manufactured just in five sections, and not in many single parts. Instead of building the complete aircraft from the ground up in the traditional manner, Boeing joins at its factory in Everett, Washington, the complete sub-assemblies and integrated systems delivered by tier-1 suppliers. This technique reduces the final assembly to only three days (a quarter of the time traditionally indispensable for Boeing's final assembly process) and the number of employees at the final assembly plants. So, with B787 Dreamliner program, Boeing decided to change its basic assembly approach. Rather than receive different single parts by hundreds of suppliers and assemble them at its assembly factories in USA, it assigned its top-tier suppliers to do more assembly themselves and deliver complete subsystems.

To tier-1 suppliers selected for the B787 Dreamliner was asked to have responsibility for providing a higher level of systems and structures and bringing it in their own suppliers network (tier-2 and tier-3). The agreement with the tier-1 suppliers was supported by a risk sharing contract. It is a strong strategic change in the supply chain management, sharing the risks and benefits of building a new airplane, paying their own up front related to engineering, facilities, equipment and tooling. The change of the approach is best expressed in the words of a Boeing's top manager (www.boeing.com): *"outside suppliers have always been an important part of what we do and how we build airplanes, and they are becoming more so For our other airplanes, outside suppliers provide 55% to 60% of the content with the rest built in-house. For the 787 Dreamliner, we are pushing 70% They are really becoming a true extension of our engineering and manufacturing system"*. The outsourcing has been always a common practice at Boeing Company and in the airplane industry. Airbus, instead, has been more conservative on outsourcing. It contracts 52% of the airframe to outside suppliers.

Thirdly, a web-based open architecture permits to apply the concurrent engineering model on global scale in the supply chain, coordinate the suppliers' development activities and their visibility, and provides the advantages of the "24 Hour Knowledge Factory" model (Mahmoodi 2009), granting time saving compared to the sequential or concurrent engineering acting on local or internal base.

Fourth, Alenia Aermacchi designs and produces in outsourcing the central fuselage (sections 44 and 46) and the horizontal stabilizer of the Boeing 787. It has the role of tier-1 small prime and share with Boeing the risk of the project (risk sharing partner). Alenia Aermacchi, in its turn, outsources part of the production of components to subcontractors (tier-2 of the supply chain) and suppliers of "third level" (tier-3), assuming the role of main contractor toward Boeing. Generally the outsourcing concerns operational activities; just a few number of subcontractors – with strong and specialized technological capabilities – are involved by Alenia Aermacchi both for the co-designing of components and its manufacturing (the so called "vertical work packages"). That's the case of Dema S.p.A. The relationships between Alenia Aermacchi and this kind of aeronautical tier-2 subcontractor is based on a partnership based hierarchical-cooperative governance mechanisms.

Figure 3. Boeing 787 workflow sharing.



In general, this small group of subcontractors (5-6 firms), in a first phase of the program Boeing 787 Dreamliner' was evaluated and selected on the base of mechanical skills able to be applied to composite materials. As said a supply chain manager of Alenia Aermacchi during the interview, *“the selected suppliers were admitted to a tender; the best ranked suppliers have been assigned «vertical work packages» which foresee the design and manufacturing of fuselage's and stabilizer's parts. These components were, then, delivered and assembled at Grottaglie plant (near Foggia, Puglia, South Italy) of Alenia Aeronautica”*. Over the time, the collaborative relationships on the Boeing 787 Dreamliner program has enabled these suppliers to increase the own skills on the composite and titanium technology, on the design and manufacturing processes with these kind of materials, and the designing and manufacturing of facilities construction. Their role for the product innovation development has been crucial. To use the words of a manager of the supply chain department during the interview in Alenia Aermacchi, *“the tier-3 supplier involved on the Boeing 787 Dreamliner program which design and built the facility construction (mould tooling) enabled us to develop the new process «one-piece barrel» used to produce the entire central section of the fuselage”*. The process of evaluation and selection of tier-3 suppliers involved in the program Boeing Dreamliner 787 was modified over time. As said a supply chain manager of Alenia Aeronautica during the interview, *“when the monthly number of series produced of Boeing 787 Dreamliner increased, Alenia Aeronautica changed the evaluation and selection approach of its subcontractors. Indeed, beyond the mechanical skills applied for the design and manufacturing of aero structures parts in composite materials, were considered other aspects: process and logistics capabilities, organizational and financial strength, competitiveness on costs (exploitation potential of learning curve)”*.

Dema S.p.A. is one of a few subcontractors involved by Alenia Aermacchi early designing phase on the Boeing 787 Dreamliner program. In accordance with the words expressed by a manager during the interview, *“for the program 787 Dreamliner we worked on parts of fuselage and horizontal stabilizer with «vertical works packages». Also, we had 10-12*

people for repairing activities at the Charleston-South Caroline plant, where there is the second final assembly factory of Boeing 787 Dreamliner. For some work packages, we have relationships directly with Boeing Co., on the others we work in Italy as small prime subcontractor of Alenia Aeronautica". The involvement of this small group of skilled tier-2 subcontractors enabled Alenia Aermacchi to pursue the objectives of 787 Dreamliner program set by Boeing: *a. leveraging the technological and process capabilities of the subcontractors' network; b. sharing the operational risk along the supply chain obtaining high performance in terms of productivity; c. trying to meet the scheduled time-to-market.*

Geven S.p.A. is in the list of qualified suppliers of Boeing. On Boeing 787-8 program Geven S.p.A. receives from Alenia Aermacchi the Boeing specifications for the design, manufacture and installation of "blankets" on the two central sections (44-46) of the fuselage on which the last is involved with Boeing.

This is the system of thermal and acoustic insulation (primary and secondary insulation). Received from Alenia the design specifications of the "blanket" then they share through the digital platform ENOVIA the engineering of the part numbers and manage the entire process until the delivery and the installation of them. The property rights of the final design is of course of Boeing.

It provides blankets for sites of sub assembly. Boeing is arranging a second assembly site in Charleston along with the historic one of Seattle. A site where it is realized the assembly of the barrels, the installation of barrels and also the installation of blankets. For Section 46 Geven S.p.A. provides the whole body or fuselage assembling of the blankets even the underside of the floor. For section 44 instead since it is the one with wings it assembles blankets from the ground up. Even in Grottaglie are installed over blankets and blankets from the floor up.

The Geven S.p.A. staff, however, is often called at Boeing in Seattle for the cabling, or to check the actual size of the specification and it proceeds to a sampling on site rather than through the digital or CATIA estimation.

The unconventional outsourcing strategy of Boeing on 787 Dreamliner program has determined a highest involvement of 43 tier-1 suppliers on R&D activities for the product innovation development. These top-tier partners, in turn, have developed partnerships with the most skilled tier-2 subcontractors and involved it on the innovation activities. This outsourcing strategy for Boeing 787 Dreamliner highlighted the following objectives: *1. leveraging best-in class supplier is a strategic way to perform product innovation programs; 2. the strategic outsourcing of innovation activities requires to design a relationships system, inside and outside of the firm, to exploit all the vantages of the choice; 3. Boeing Co. instituted with the tier-1 strategic suppliers a risk sharing contract to require an higher involvement of the partners, reduce the financial and business risk of the program. These strategic suppliers, in fact, pay their own up-front costs related to engineering, facilities, equipment and tooling; 4. tier-1 strategic suppliers, and tier-2 subcontractors of the supply chain design parts of the plane as well as build them; 5. strategic partners tier-1 supply complete subassemblies rather than single parts; 6. logistics visibility, communication and transferring data and design are supported by web-based planning platforms which enable interactive and synchronized relationships end-to-end supply chain globally across the partners. It allows a continuous demand/supply coordination.*

In summary, the new strategic logic, about the outsourcing choices, has profoundly and radically changed the business model of Boeing Co., and of the entire aeronautic supply chain. The point is clearly synthesised in the following words of the Chief Operating Officer of Alenia North America: *"Over the past few years the concept of working together within prime, first, second and third tiers has changed radically. In the 60's, design was centralized and collaboration consisted mostly of the external manufacture of some*

elements. Parts were defined by a single design team, they were occasionally built elsewhere but, in every case, parts were assembled by the prime manufacturer. This was the case when Aerfer (as Alenia was formerly known) began building the fuselage panels for the DC-9 in Pomigliano d'Arco near Naples. Forty years later this approach is no longer valid. The metamorphosis of the major aircraft manufacturers into system integrators has brought radical changes in the industry. Today's suppliers are expected to be «vertical» partners, collaborating on all industrial process from design to manufacture as well as sharing strategic decisions with the prime manufacturer. The difference between partners and suppliers is the ability to create complete systems, a consolidation of efforts that enables a group of partner companies to act as «small prime contractors» capable to design and produce complete systems to be delivered to the final integrator, such as Boeing and Airbus, that tend increasingly to act as system integrators on large scale. This ability to create complex systems has allowed companies like Alenia Aeronautica to participate in some of today's largest commercial programs, including the Boeing 787 and the Airbus A-380 programs. The changes taking place in the supply chain are characterized by a transfer of responsibilities and activities from the prime manufacturer to a smaller number tier-1 manufacturers. The partnership model, as utilized by Boeing for the 787 airframe, changes dramatically the traditional relationships between various entities in the supply chain. The number of first tiers as compared to the prime is reduced from 50 players of previous Boeing programs to 7 of that number. This is a model that creates new opportunities of growth for the entire supply chain because the activities they are engaging in are on a much bigger scale than in the past. The small primes operate on a higher level by taking on activities and responsibilities that were performed in the past by the prime manufacturer. Boeing is transforming itself from a jet manufacturer into a large-scale systems integrator, a company that project, sells and supports new aircraft, but actually defines and produces very few of the components that go into them. With the 787, Boeing has taken a huge step in that direction moving all the assembly of major subassemblies to the suppliers, keeping only a light final assembly line. Major suppliers, such as Alenia, are taking responsibility for designing, producing and delivering fully equipped sections of the airplane to the Boeing 787 final assembly line”.

The Boeing 787 Dreamliner is a technological discontinuity of both product and process. In fact, as we said above, this all-new airplane is able to offer significant advantages in terms of performances and operating costs comparatively to the commercial aircrafts of the same category (mid-sized aircraft) already existing on the market. The Boeing 787 Dreamliner, however, is even a technological discontinuity of process because it's the first and nowadays unique commercial aircraft whose primary aero structures – including fuselage and wings - are manufactured for 50% with composite materials (carbon fibre) and 15% in titanium, materials absolutely new in the commercial aircraft industry. This technological discontinuity for the aero structures, compared to the standards established in the industry, has changed the processes of design, manufacturing and assembling the components and subassemblies. The new technologies of materials permit to increase the quality and the performances of the aircrafts (lower environmental impact, increased comfort for the passengers), as well as decrease the operating costs for the airlines companies during the whole product's life cycle (higher fuel efficiency, lower maintenance costs, fewer emissions), comparatively to similarly sized airplanes. Therefore, the all-innovative project Boeing 787 Dreamliner is a breakthrough or radical innovation (Henderson, Clark, 1990), because it has deeply redefined both the dimensions of technological innovation (product and process) rather than to be a simple reinforcement of the existing technological paradigm of the one or other dimensions. Therefore, it's useful to analyse the technological discontinuity created by B787 Dreamliner in terms of two further dimensions: 1. the changes

in the product's key components or subassemblies; 2. the changes in the architecture of product engineering, namely, in the technical configuration of interdependencies among the product's key components or subassemblies, namely as their assembling is organized. Boeing 787 Dreamliner can still be considered a radical or breakthrough innovation, because: *a.* for the aircraft's aero structures are used materials completely new for the technological state of the industry; *b.* the structure of the links between the key components and/or subassemblies (product architecture) used for designing and assembling the aircraft is fundamentally changed. The same conclusion highlights if the innovation of B787 is analyzed in terms of changes in the product architecture and changes in product concept. In conclusion, B787 has completely redefined the competencies and the interdependencies of the product architecture consolidated in the industry for designing and producing commercial mid-sized aircrafts. These factors of strong technological discontinuity have affected, in our opinion, the decision of Boeing Co. to make a wide use of the outsourcing for develop and manufacture the B787 Dreamliner, even considering the need of company to arrive on the market with the new aircraft as soon as (short lead time), develop and manufacture it with competitive costs, and regain the market leadership lost against the rival Airbus.

The first flight test of Boeing 787 Dreamliner was delayed for three years behind the schedule. The interviews of managers involved in the study have highlighted different causes: *a.* the radical innovativeness of materials used for produce parts and subassemblies. Nobody supplier had a sufficient experience to work these material for the production of a commercial mid-sized aircraft. So, during the program happened design and manufacturing problems (incorrect installation of parts, structural breaks), delivery delays of foreign and domestic supply chain, caused by parts shortages (one of the most relevant was the fasteners shortages), lack of documentation with complete and precise specifications for the parts and subassemblies; *b.* the high number of tests on single parts, conducted by the same suppliers. It isn't clear if these delays and problems were a matter to design, communication, execution or something else.

3. Discussion

On the basis of the theoretical background which has informed this paper, and the findings derived from the empirical longitudinal study, we offer the following discussion about the research questions (RQs) which we pointed out to explore.

RQ 1: would be possible to produce an aircraft like Boeing 787-8 Dreamliner without leveraging so much on strategic outsourcing of R&D?

"It would have been very difficult in the timescale. The numbers of aircraft to produce and the scale of investments were too large to be managed internally also because the delivery times were very close. Perhaps with a five-year rather than a three year program Boeing could centralize more activities. Certainly, in terms of engineering skills Boeing could handle it all inside. Among other things, the formulation of the outsourcing model, as it is well known, also responded to a goal of industrial off-set as well as of strategic outsourcing. There was also a country risk assessment related to the centralization of production", that was the opinion of a Geven's manager expressed during the interviews.

In our opinion the answer to the question is negative because Boeing Co. has leveraged the best in class R&D capabilities disposable in its supply partners' network all over the world, even to reduce the total amount of the investment in R&D program for 787-8 Dreamliner. The Boeing Company 2010 Annual Report highlights that the total R&D expenditure did not

exceed, on average, 4,3 billion dollars per year, the budget furthermore is distributed on all innovation projects of the firm. It is estimated that the B787 program has reached from 16,3 to 23 billion Euros of investment (R&D) at the date (Gates 2011a). It demonstrates that an investment of this magnitude would have absorbed the entire budget of the company, about 4 billion a year from 2005 to 2010, leaving a few residual resources for other strategic investments.

Even if the top management of Boeing Co. is thinking, for the next model B787-9 (the current model in delivery phase is 787-8), to change the supplier outsourcing approach, it doesn't cease to leverage the best technologies existing all over the world regardless of their location. To use the same words of a Boeing's manager recently interviewed by Reuters (Peterson 2011): "*.... It is true that supplier involvement in the development and design of the 787 is significant.....Suppliers helped us develop and understand technologies and options for the airplane as we went through the early phases of concept development. Suppliers have also provided more of their own development, design and manufacturing funding*".

RQ 2: Has the outsourcing model adopted by Boeing increased the total cost of production and the time to market rather than decreased them?

We have to distinguish, in our opinion, three configurations of cost for answering this specific research question: 1. the planned cost of the program (R&D budget cost); 2. the total cost of development to the date; 3. the opportunity cost referring to the size of the project cost that could be reached into the competing hypothesis of a more centralized program development of B787, in accordance with the consolidated outsourcing model adopted traditionally in the commercial aircraft industry. In relation to the first configuration of cost it was estimated a budget of about US\$ 10 billion (with an allocation of 5.8 to Boeing and 4.2 to the supply partners'). According to more recent sources (Gates 2011b), the project would have exceeded the budget and reached a size of about US\$ 16 billion (32 if you consider the investment in production facilities and the managerial acquisitions to overcome the difficulties arisen in supply chain). No one can say what might be the project cost in case of internal development. But we can definitely say that the internal development of technologies and production processes existing somewhere in the supply network, would have to be realized by Boeing at an higher cost compared to external leverage of the same technologies, expertise and know how. This cost would be raised by the supplementary costs in terms of longer time of delivery and therefore also of indirect impacts in terms of lost sales.

Therefore, our consideration is this: surely the real project total cost exceeded the budget but it is still verified a theoretical statement that the strategic use of outsourcing lead to savings of cost related to knowledge and experience development and aiming to implement a difficult to achieve innovations, also reversing some of the R&D total cost on the external network of suppliers.

It is advanced an original hypothesis during the interview to the Geven's managers. Boeing knew that cause the introduction of technological innovation in materials and supply chain processes would have impacted on development costs considerably and would go through huge time to market delays. However probably it was primarily a marketing strategy: to launch a program as ambitious and fast (3-4 years) to capitalize on the orders of the airlines, The aim was to gain a critical mass program (1.000 airplanes) and developing contracts that transferred on the small primes the risks of delays. In fact Boeing negotiated global contracts for such an aim. Therefore, the increased costs and time delays were predictable. Also because in the past, programs were launched with a strong U.S. government support, so the time to delivery wasn't always a critical variable of the program.

Furthermore should not be confused the effective time of new product development (2005-2011, seven years), the scheduled time to market (2005-2007, three years), the time to market

indispensable for Boeing to develop in home the all-new aircraft B787-8. As mentioned earlier, the concurrent engineering model on global scale provides the opportunity to implement a “24 hour Knowledge Factory”, granting time saving compared to the sequential or concurrent engineering acting on local or internal base. By the “24 Hour Knowledge Factory” approach the output of an engineer on one side of the world could be verified by its present alter ego on the other side of the world who provides a testing of the effectiveness of the calculation models developed by the counterpart without design process delay time. If properly designed a system of this type of outsourcing makes conceptually and theoretically the development process of the all-new aircraft B787 a continuous flow process with obvious savings in time (and therefore of costs).

In accordance with the interviews of managers involved during the field research, for the 787-8 most of the delays have also been determined by the certification process. Too many new materials used at the same time, in the high number of cases there were missing procedures and certification rules for composite fiber parts and assembled. Another of the main reasons that led to the time to market delay was the management of the digital platform and delays due the learning curve for the partners having to adopt it.

With regard to the improvements introduced by Boeing in the 787-9: 1. the 787-9 is longer than 787-8 and therefore the availability of more seats impacts on the convenience for the customer airlines; 2. on 787-9 Boeing is trying to solve some design problems of the earliest model (787-8). For instance there has been the replacement with only one part (One-Piece Frame Shorty) of the housing of the section 44-46, which, was previously for 787-8, made of two separate but linked parts; 3. a major innovation introduced in the 787-9 is the concurrent co-design of the structure and systems, while the systems in the commercial aircraft industry are traditionally designed soon after the structures; 4. another radical innovation introduced is that the use of aluminum is almost prohibited. It is significantly increased the percentage of use of titanium and composite, for obvious reasons to further reduce the weight of the aircraft; 5. for the 787-9 Alenia Aermacchi and the others small prime contractors, in order to reduce the total cost of the program, are recurring in wide measure to contract base relationships with second and third tier suppliers rather than to order ones. It is not risk-sharing contract model, but a guarantee of continuity of the job during the aircraft life cycle.

RQ 3: Had the outsourcing model adopted by Boeing changed the structure of supply chain relationships in the aircraft industry?

According to Geven's informants, *“the model of digital co-design will be the new model for managing relationships in the supply chain pyramid adopted by Boeing. Boeing is transferring know-how on aero-structure, and specific knowledge about the processes of production and co-design. It is also driving the growth of technology partners on the composite material, digital platform management and procedure. In general it is true that the 787-8 has led to some flattening of the supply chain pyramid. ENOVIA has imposed a sense of disintermediated relationship between tier- 2 and Boeing, but as we said before virtual on digital platform and sometimes even off line and on site direct relationship. It is also a true design system in a continuous cycle.”*

As showed during the interviews, Alenia Aermacchi and its partners were forced to model their supply chain on requirements of Boeing. In other words a project like the 787-8 Deamliner is a breakthrough innovation for the whole industry reshaping vertical relationships in the supply chain. Also, for this in the next future the relationships model also operational that binds Boeing to its supplier network in a very close manner will not

necessary evolves except in a very limited extent for the difficulties to redefine the entire supply chain.

Boeing with the new 787-9 model, at the present in designing phase, has entered fully into the supply pyramid scheme, no longer trusting in the small prime contractors suppliers (tier-1) ability to manage their networks. It doesn't want to leave too much space to small prime contractors and has started to interact at the sub contractors (mainly tier-2) level. Boeing managers and engineers want to be close to those who physically does the work. They want to impose their methods and organizational processes of design and production. Drastic change of direction to achieve the total visibility of the entire supply network. For example, at the plant in Grottaglie (Puglia, Italy) of, there are about 100 Boeing American employees, Alenia Aermacchi Pomigliano (Napoli, Italy) dedicated a building to Boeing engineers which is almost of the same size of that dedicated to the Italian engineers.

Boeing facing with the difficulties of Alenia Aermacchi and the other tier-1 partners in coordinating their network of suppliers has decided to recur to disintermediation and direct control by the presence of its employees in subcontractors (mainly tier-2) plants. Alenia Aermacchi, for instance, had major problems in the realization of the stabilizer and in the fuselage assembling.

Probably this is due not only to delays but also the awareness (expressed by the managers of Boeing in several journals) of the absolute importance of technology in the construction of "one piece barrel" of the fuselage for the competitive advantage of the company and the entire network in the long run.

Thus, even leveraging on Alenia Aermacchi and some other small primes difficulties (like Mitsubishi, for instance), Boeing has entered firmly in the supply network probably with the purpose of ensuring compliance with the efficient standard and scheduled deliveries but also in order to absorb skills and critical production processes routines.

It can be said that the use of a web-based concurrent co-design enhances the ability of coordination of the central firm on the supply network and limited the small prime contractor partners contribution to the single aero structure project management and the necessary control and check activities. The technology transfer is realized through the platform and with the direct physical interference of the employees of Boeing at the various tiers of the value system (mainly at tier-1, tier-2 levels).

In this sense, in fact, this brings to a sort of a collapse of the traditional pyramidal tiers of supplier relationships in the aviation industry. A radical innovation of the final structure of supply chain relationships mainly for 787-9 Dreamliner.

Boeing is calling into question the entire project first of all forcing Alenia Aermacchi and the other partners (tier-1 small prime) to recur on key parts to American subcontractors (tier-2 and tier-3). So while in the past for the 787-8 program Alenia Aermacchi and the other Boeing partners (small prime contractors) have great freedom and absolute power for their network selection, on the 787-9 program, Boeing is trying to shift the focus back home (USA). So the effect for second and third tiers is that they are forced to compete with American subcontractors operating with a different operational size and therefore are very stressful on costs and delivery timing. With the latest 787-9 model, Boeing put the whip their suppliers who have made huge investments but not yet fully exploited them.

For the 787-9 model Boeing has decided to negotiate with small prime to implement the program in subsequent packages to assign separately to tier-2: design or manufacture or installation one. The first deliveries of 787-9 are scheduled for January 2013. Surely that decision is the result of a dialectic between the parties. Boeing is now re-engineering the entire process. Temporarily the partial internalization of some processes is only justified by the need to control especially the cost. This appears to relate to production packages, not design ones continuing to be assigned to the 787-8 program partners who have demonstrated

skills and by the way have acquired not a secondary experience. In essence, Boeing: 1. is reducing the small prime negotiating of vertical integrated packages with tier-2; 2. is imposing its U.S. suppliers for production packages; 3. is promoting contracts that allow the Small Primes not having to suffer alone the costs of delays and inefficiencies but to share them with the tier-2.

4. Conclusions, managerial implications and limits of the research

This paper recognizes the main findings of a ongoing research project began at the end of 2009. The empirical analysis are based on aeronautic industry through a longitudinal case study of three firms operating at the first three tiers of the aeronautical supply chain. The study has been focused on the development of the most innovative airplane never produced in the commercial aviation industry, until now: Boeing 787 Dreamliner.

This study has highlighted the high innovativeness of the 787 Dreamliner program and of organizational supply chain model. However the program had three years delivery delays in respect to the scheduled time, order shrunk and several billion of dollars over budget. Summarizing, Boeing, despite the delays and difficulties encountered with the program 787-8 Dreamliner, has been capable to leverage external supply network sharing development costs of new product development with its partners (mainly small prime), using the best existing technologies and know-how in the world aerospace supply chain, reducing most of the new product development process time, costs and time to market of the all-new aircraft. This has required the sharing with small prime of know-how relating the obsolete models of calculation of individual aluminium sub-assemblies and acquiring know-how related to the composite aircraft design and assembly and of individual composite aero structures. The expertise in the production of composite aero structures and organizational routines remain the prerogative of the small prime and of tier-1 and tier-2 suppliers. This organizational model of strategic outsourcing for innovation activities adopted by Boeing for the 787 Dreamliner has substantially altered the traditional supply chain in the aviation industry. Thanks to the web-based platform of concurrent co-design (ENOVIA) Boeing first succeeded in centralizing dominion over the entire value system, i.e. selecting the best practices existing and identifying the key supplier partners they possess them, and in a second phase, moving to physically interact with more dynamic firms in the value system regardless of their location in the value system (tier-I or tier-II or tier-III). The small primes in fact have lost some of their power to become the coordinators of the field activities and responsible for the project (in terms of complete sub-assemblies) monitoring. This methodological approach for work imposed by Boeing through the virtual platform to the entire supply chain has determined an impressive adoption of best in class processes at every level of the supply chain determining an acceleration in the learning curve mainly of the tier-2 and tier-3 suppliers, not traditionally used to have direct relationships with prime contractor and its procedures.

Recently, with the 787-9 Dreamliner, Boeing is trying to solve the engineering problems and organization ones emerged with the previous version (787-8) and to centralize where possible the core competencies crucial for its competitiveness in the long run. So under this perspective can be considered the acquisition of Global Aeronautica LLC, the South Carolina fuselage subassembly facility for the 787-8 by Boeing and the choice to try to move again the centre of gravity of the supply chain back to America by the imposition to the small prime of recurring to tier-1 and tier-2 American suppliers.

The study highlights some limits. Therefore, in the next future the aim will be to extend the case study approach to the other firms, both OEMs, international tier-2 and tier-3 suppliers of aircraft supply chain. So, we might absorb better the variety of outsourcing relationships on innovation activities deployed in the aeronautical supply chain. In fact, some

subcontractors of Alenia Aeronautica, in the last years, have developed direct relationships with the OEMs, stand alone or in consortium with other SMEs. It will, also, take place interviews directly to management of Boeing Co. (as we said above, Boeing has refused to answer our questionnaire) to better understand the future of outsourcing relationships on the Dreamliner, relatively to the design and manufacturing of the new version of the airplane currently in phase of design (Boeing 787-9 Dreamliner), and to deep the motives of three years delays from the time scheduled.

Surely the model of outsourcing adopted by Boeing could be improved, but some decisions related to the strategic outsourcing of R&D activities are irreversible as confirmed by the top management of Boeing. A Boeing executives declined to be interviewed for this story said (Peterson 2011): *"In retrospect, our 787 game plan may have been overly ambitious, incorporating too many firsts all at once -- in the application of new technologies, in revolutionary design-and-build processes, and in increased global sourcing of engineering and manufacturing content"*. But he also reiterated the company's faith in the Dreamliner. *"While we clearly stumbled on the execution, we remain steadfastly confident in the innovative achievements of the airplane and the benefits it will bring to our customers"*. Boeing Company replied to written questions submitted by Reuters: *"The sourcing decisions made on the 787 are a natural evolution of the work done at Boeing Commercial over the years," the company said. "We've said in the past that for the most part, we are satisfied with the general direction. However, there are a few things we would change, and you've seen us make changes on the 787 over the years."*

References

- Anderson, P. & Tushman, M. L. 1991. Managing through cycles of technical change. *Research Technology Management*, Vol. 34, Nr. 3, pp. 26-31.
- Aron, R. and Singh, J. V. 2005. Getting Offshoring Right, *Harvard Business Review* 83:12, December, pp. 135-140.
- Arnold, U. 2000, "New dimensions of outsourcing: a combination of transaction cost economics and the core competencies concept", *European Journal of Purchasing & Supply Management*, November-December, pp. 23-29.
- Baden-Fuller, Ch., Targett, D. & Hunt, B. 2000, "Outsourcing to Outmanoeuvre: Outsourcing Redefines Competitive Strategy and Structure", *European Management Journal*, Vol. 18, No. 3, pp. 285-295.
- Barney, J.B. 1991, "Firms resources and sustained competitive advantage", *Journal of Management*, Vol. 17, pp. 99-120.
- Boeing Company 2010, *The Boeing Company 2010 Annual Report*, www.Boeing.com.
- Calantone, R.J. & Stanko, M.A. 2007, "Drivers of Outsourced Innovation: An Exploratory Study", *Journal of Product Innovation Management*, Vol. 24, No. 3, pp. 230-341.
- Cantone, L. & Testa, P. 2009, The outsourcing of innovation activities in supply chains with high-intensity of research and development, in *Esperienze di Impresa*, Università degli Studi di Salerno, Dipartimento di Studi e Ricerche Aziendali, Facoltà di Economia, Anno XVII, N°2, dicembre, Salerno.
- Capaldo, A. 2004, "Accesso alla conoscenza del partner, trasferimento e co-produzione di conoscenza: la collaborazione tra imprese in una prospettiva knowledge-based", *Finanza, Marketing e Produzione*, Vol. 22, No. 1, pp. 80-118.
- Carson, S. 2009, "The Markets: Aerospace", *Composite World Gardner Publications*, January.
- Carson, S. J. 2007, "When to give up control of outsourced new product development", *Journal of Marketing*, Vol. 71, No. 1, pp. 49-66.
- Cohen, W.M. & Levinthal, D.A. 1990, "Absorptive capacity: a new perspective on learning and innovation", *Administrative Science Quarterly*, Vol. 35, March-April, pp. 128-152.
- Cizmeci, D. 2005, *Is Boeing's 787 the New Camery*, Boston, Harvard Business School.
- Coase, R.H. 1937, "The nature of the firm", *Economica*, No. 4, Novembre, pp. 386-405.
- Doz, Y. & Hamel, G. 1998, *Alliance Advantage. The Art of Creating Value through Partnering*, Harvard Business School Press, Harvard-Massachusetts.
- Dyer, J.H. & Singh, H. 1998, "The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Advantage", *Academy Of Management Review*, No. 4, pp. 660-679.
- Freeman, C. 1991, "Networks of Innovators: a synthesis of research issues", *Research Policy*, Vol. 20, pp. 499-514.
- Garcia, R. & Calantone, R. 2002, "A critical look at technological innovation typology and innovativeness terminology: A literature review", *Journal of Product Innovation Management*, Vol. 19, pp. 110-132.
- Gates, D. 2006, "Converted 747 super freighter marks major change in how Boeing produces aircraft", *The Seattle Times Company*, September 17, Seattle.
- Gates, D. 2011a, "A 'prescient' warning to Boeing on 787 trouble", *The Seattle Times*, February 5, Seattle.
- Gates, D. 2011b, "Boeing celebrates 787 delivery as program's costs top \$32 billion", *The Seattle Times*, September 24, Seattle.
- Grant, R.M. 1991, "The resource-based theory of the competitive advantage: Implications for strategy formulation", *California Management Review*, Vol. 33, N° 3, pp. 114-135.
- Griffith, D.A., Harmancioglu, N. & Droge, C. 2009, "Governance decisions for the offshore outsourcing of new product development in technology intensive markets", *Journal of World Business*, Vol. 44, No. 3, pp. 217-224.
- Hagedoorn, J. 2002, "Inter-firm R&D partnerships: An overview of major trends and patterns since 1960", *Research Policy*, Vol. 31, No. 4, pp. 477-492.
- Hamel, G. 1994, "The Concept of Core Competence", in Hamel G., Heene A. eds., *Competence-based Competition*, Chichester, Wiley & Sons.
- Hamel, G. & Prahalad, C.K. 1996, "*Competing for the future*", Harvard Business Press Books.

- Howells, J. 1999, "Research and technology outsourcing", *International Journal of Technology Management*, Vol. 11, No. 1, pp. 591-603.
- Liebeskind, J.P. 1996, "Knowledge, strategy and theory of the firm", *Strategic Management Journal*, Vol. 17, pp. 93-107.
- Lorenzoni, G. & Lipparini, A. 1999, "The leveraging of interfirm relationships as a distinctive organizational capability: a longitudinal study", *Strategic Management Journal*, Vol. 20, pp. 317-338.
- Marshall, A. 1920, *Principles of Economics*, London. Macmillan.
- Mahmoodi, D. 2009, "Outsourcing of the Boeing 787", University of Arizona Education, http://next.eller.arizona.edu/courses/outsourcing/Fall2008/student_papers.
- Niosi, J. & Zhegu, M. 2005, "Aerospace Clusters: Local or Global Knowledge Spillovers?", *Industry and Innovation*, Vol. 12, No. 1, March, pp. 1-25.
- Nonaka, I. & Takeuchi, H. 1991, "The Knowledge Creating Company", *Harvard Business Review*, Vol. 69, November-December, pp. 96-104.
- Peteraf, M.A. 1993, "The cornerstones of competitive advantage. A resource-based view", *Strategic Management Journal*, Vol. 14, No. 3, pp. 179-191.
- Peterson, K. 2011, "A wing and a prayer: outsourcing at Boeing", *Reuters*, Jan 20, EVERETT, Washington, Special Report. <http://www.reuters.com/article/2011/01/20/us-boeing-dreamliner-idUSTRE70J2UX20110120>.
- Prahalad, C.K. & Hamel, G. 1990, "The Core Competence of the Corporation", *Harvard Business Review*, May-June, pp. 79-91.
- Quinn, J.B. & Hilmer, F.G. 1994, "Strategic outsourcing", *Sloan Management Review*, Vol. 35, Summer, pp. 339-350.
- Rundquist, J. 2008, "World-Class or Good Enough. The Choice of Partner when Outsourcing New Product Development in Medium-Sized Firms", *International Journal Of Innovation and Technology Management*, Vol. 5, No. 4, pp. 423-445.
- Tang, C. S. & Zimmerman, J. D. 2009 Managing New Product Development and Supply Chain Risks: The Boeing 787 Case. *Supply Chain Forum: An International Journal*, Vol. 10, pp. 74-85.
- Teece D.J. & Pisano G. 1994, "The Dynamic Capabilities of the Firm: An Introduction", *Industrial and Corporate Change*, Vol. 3., No. 3, pp. 537-556.
- Teece D.J., Pisano G., & Shuen, A. 1997, "Dynamic Capabilities and Strategic Management", *Strategic Management Journal*, Vol. 18., No. 3, pp. 509-533.
- Vittachi, I. 2003, "Boeing Outsourcing Gives Wings to Concern", *Alderman & Company The Chicago Tribune*, Vol. 42, November.
- Williamson, O.E. 1981, "The economics of organizations: The transaction cost approach", *American Journal of Sociology*, Vol. 87, pp. 548-577.
- Yin, R. K. 2003. Case study research, design and methods, 3rd ed. Newbury Park: Sage Publications.
- Zhao Y. & Calantone R.J. 2003, "The trend toward outsourcing in new product development: case studies in six firms", *International Journal of Innovation Management*, Vol. 7, No. 1, March, pp. 51-56.