MIETE

MASTER IN INNOVATION AND TECHNOLOGICAL ENTREPRENEURSHIP

The historical evolution and the recent dynamics of the Portuguese Aerospace sector on new firm creation: a case-study analysis

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Master Dissertation

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Abstract

The present dissertation aims to bring more information to the discussion on the development of the Aerospace industry sector in Portugal and to explain the dynamics of creation of start-ups linked to this sector, in Portugal. Besides the fact that it is not a deeply developed topic, the knowledge about this cluster, which relies upon the Foundation for Science and Technology, as a link between the government and the Aerospace sector, remains fairly unknown when compared with other industrial clusters, in this country. The Aerospace sector in Portugal is a niche and a highly specialized sector, which has shown a high annual growth. This is also one of the few industry sectors that has witnessed an increase in terms of public investment with that investment being increasingly channeled to the development of the Aerospace cluster in the region of Évora, a city in the country's inland. This cluster is mainly characterized by an agglomeration of highly specialized firms and workers, where entry barriers are high and costly. The main focus of this study is to analyze the historical evolution and the current dynamics of the Aerospace sector in Portugal related with the creation of start-ups in the sector, while contextualizing this case-study with the vast literature on industrial clusters. For that purpose, this study begins with a literature review on the Aerospace sector, providing insights onto the Aerospace industry in Europe and finally on the Aerospace sector in Portugal. Then it will focus on the evolution of the sector in Portugal, presenting the case-study of the cluster in Évora, a municipality in the inland south of the country, in which the recent dynamics, together with international value-chain linkages, has led to the emergence of start-ups related to this sector.

A evolução histórica e as dinâmicas recentes do setor Aeroespacial Português na criação de novas empresas: uma análise de estudo de caso

Resumo

A presente dissertação tem como objetivo gerar mais informações para o debate sobre o desenvolvimento do sector da indústria aeroespacial em Portugal e explicar a dinâmica de criação de start-ups ligadas a este sector, em Portugal. Além do fato de não ser um tópico profundamente desenvolvido, o conhecimento sobre este *cluster*, que conta com a Fundação para a Ciência e Tecnologia, como elo de ligação entre o governo e o setor aeroespacial, permanece relativamente desconhecido quando comparado com outros *clusters* industriais, deste país. O setor aeroespacial em Portugal é um nicho e um sector altamente especializado, que tem mostrado um crescimento anual elevado. Este também é um dos poucos setores da indústria que tem assistido um aumento em termos de investimento público, com esse investimento a ser cada vez mais canalizado para o desenvolvimento do *cluster* aeroespacial na região de Évora, uma cidade no interior do país. Este *cluster* é caracterizado principalmente por uma aglomeração de empresas e trabalhadores altamente qualificados, onde as barreiras à entrada são elevadas e dispendiosas. O foco principal deste estudo é analisar a evolução histórica e as dinâmicas atuais do setor aeroespacial em Portugal relacionada com a criação de start-ups no sector, contextualizando este estudo de caso com a vasta literatura sobre *clusters* industriais. Para esse efeito, o presente estudo de caso começa com uma revisão da literatura sobre o setor aeroespacial, fornecendo informação sobre a indústria aeroespacial na Europa e, finalmente, sobre o setor aeroespacial em Portugal. De seguida, ele incidirá sobre a evolução do sector em Portugal, apresentando o estudo de caso do *cluster* em Évora, um município no interior sul do país, em que a dinâmica recente, em conjunto com as ligações a cadeia de valor internacionais, tem permitido o surgimento de novas empresas relacionadas com este sector.

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1. Introduction

Aerospace industry studies have predominantly relied on two research categories: engineering/ innovation studies and economics/ industrial clusters. Engineering studies mainly focus on innovation in structural design, guidance, navigation and control, instrumentation, communication and production methods (e.g., Kalawsky, 2013; Gruntman, 2014; Masood et al., 2014). On the other hand, studies on aerospace industrial clusters and their relationship with national and local economic growth have also been subject of a wide corpus of research (e.g., Niosi and Zhegu, 2005; European Space Agency, 2012; Dostaler, 2013; Elola et al., 2013).

Concerning the research branch on industrial clusters, it has been mainly composed by an extensive empirical literature which has gradually been recognizing the effects of globalization in parallel with more localized aspects (Beaudry, 2010). In this context, studies on Aerospace clusters tend to be focused on firm competitiveness (e.g., Elola et al., 2013; Dostaler, 2013) by taking into account the effects of government policies and incentives, usually made through national programs in the creation and development of these clusters (Beaudry, 2010; Elola et al., 2013). This literature also analyses the challenges faced by already established Aerospace clusters, namely in the North America and Europe (Beaudry, 2010; Dostaler, 2013; Elola et al., 2013). Besides that, a stream of empirical studies has also been developed around the emergence and growth of Aerospace clusters in emerging countries of Asia, namely China, India and South Korea, and in South America, namely, in Brazil and Mexico (e.g., Niosi and Zhegu, 2005; Niosi and Zhao, 2013; Dostaler, 2013; McGuirea and Islama, 2014).

Despite the growing interest of the topic, a brief search in the Scopus database allow us conclude for the relative scarcity of articles studying Aerospace clusters in the fields of economics and management. Within the published articles of Scopus, an advanced search using the keywords “Aerospace Sector” in the fields ‘title’, ‘abstract’, and ‘keywords’ yielded 1006 articles, where those related with Engineering represent about 49%. When restricting the search using as keywords “economics” or “business”, narrower results were obtained, namely 135 articles with the keyword “economics” and 270 articles with the keyword “business”, respectively, representing 13% and 27% of the number of articles obtained in the previous search.

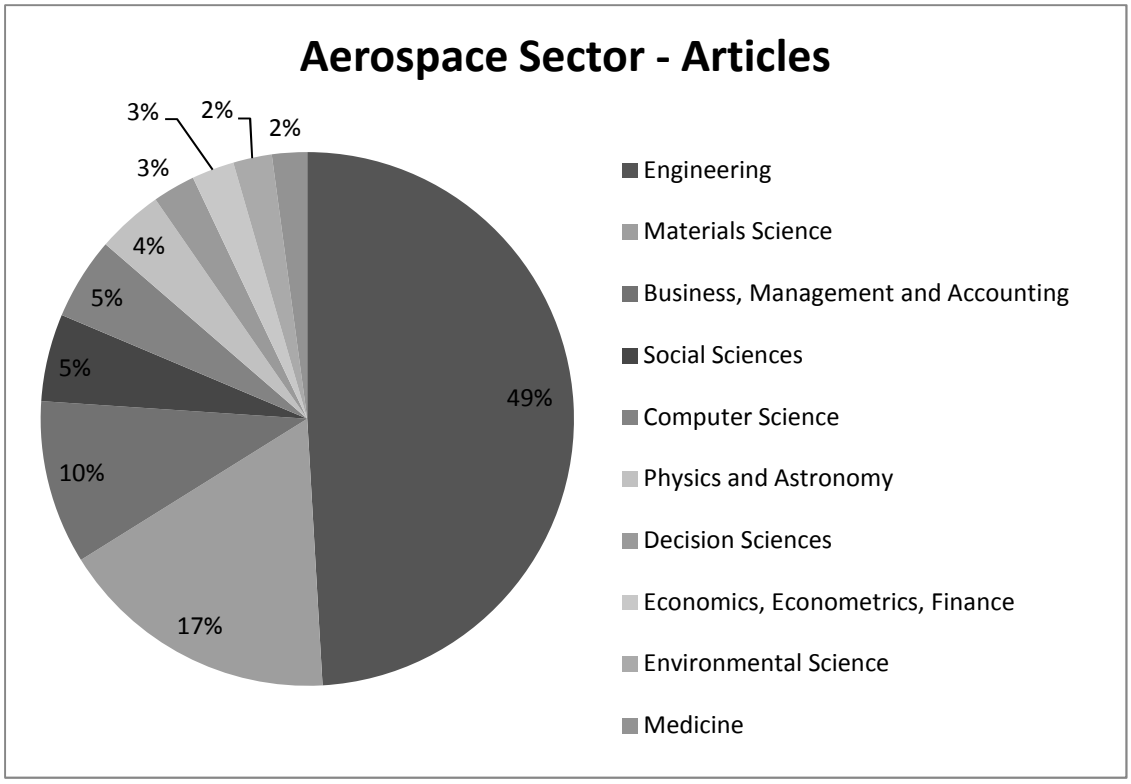


Figure 1 - Results from the search on the Aerospace Sector literature. Source: Scopus Database; Author's own computations.

Figure 1 allows observing that in terms of academic research, as object of study, the Aerospace sector is clearly dominated by engineering studies, mainly mechanic engineering (e.g., Fernandes et al., 2002; Ribeiro et al., 2009).

Regarding the Social Sciences (e.g., "Business, Management and Accounting", "Social Sciences", "Economics, Econometrics, Finance, "Environmental Science"), studies on the Aerospace sector represent about 20% of the whole literature on the topic (cf. Figure 1) and mainly consist of exploratory reports and surveys on the emergence and development of clusters and related firms (e.g., Niosi and Zhegu, 2005; Beaudry, 2010; Dostaler, 2013; Elola et al., 2013; Niosi and Zhao, 2013).

In what regards to Portugal, most of these reports or surveys have their origins in Portuguese public institutions such as the FCT (Foundation for Science and Technology) or the AICEP (Trade and Investment Agency), and they make a diagnosis of the growth of the Aerospace sector in Portugal, usually presenting a description of the established/ incumbent industries as a way to characterize this sector in Portugal. The major goal of these reports is to give information and to promote the sector to potential investors with the interest of attracting foreign investment. Besides that, there are also consulting and technical studies that are outsourced to firms outside the Public

Administration (e.g., Intell, 2005), particularly dedicated to the analysis of the results from the partnership of the Portuguese Aerospace sector with the European Space Agency, and to the assessment of the economic impact of this partnership in the Portuguese industry, focusing on its characteristics and challenges in Portugal.

These studies are also dedicated to provide potential suggestions to the constraints that the Aerospace sector has faced in countries like Portugal, such as the small size of the Portuguese market (of the companies; of the national space market), the scarce governmental incentives to this specific sector, the poor articulation between universities and private companies, the lack of specific technology/ know-how and the absence of partners and competition (Foundation for Science and Technology, 2011). The main purpose of these studies has been to support the work developed in the country within this sector, as a means to promote Portugal as a technological and attractive country for foreign investment (AICEP, 2010; Foundation for Science and Technology, 2011).

Despite the importance of these consulting reports, there is a noticeable lack of empirical and academic studies on the dynamics of the Aerospace industry and its relation with the emergence of new related firms in Portugal, that is mostly linked with the local development of this sector's partnerships and the influence of the European Space Agency in the start-ups' processes.

Portugal became a new member state of the European Space Agency (ESA) on November 14, 2000, thus establishing an important milestone in the development of its Space industry[1] (Foundation for Science and Technology, 2011).

The Aerospace industry in Portugal has registered its largest investment to date with the creation of an Aerospace cluster in 2008 in Évora, a municipality in the inland southern region of the country (about 130 kms far from the capital of the country, Lisbon), with an investment amounting to 177 million Euros (AICEP, 2010). The development of this cluster has been driven by the construction of two partner factories, the Embraer Metal and Embraer Composites, of the Brazilian aircraft company, Embraer (the most important Brazilian aircraft manufacturing company).[2] Indeed, this sector has created

[1] Aerospace and Space are terms used interchangeably to describe the same reality. Similarly, 'industry', 'industry sector' and 'sector' are used interchangeably to present the same concept throughout this study.

[2] Founded in 1969, Embraer (*Empresa Brasileira de Aeronáutica*) is a mixed capital company under governmental control, with headquarters in São José dos Campos in the State of São Paulo, Brazil. Privatized in 1994, Embraer continue to present solid growth and nowadays is the third largest commercial aircraft manufacturer in the world and the fourth largest aircraft manufacturer, when including business jets and military programmes. In 2008, Embraer announced the construction of these

strategic partnerships with other companies already established in the international market (e.g., Embraer; Pilatus Aircraft) which allowed access to consortia of major relevance in order to participate in projects of greater visibility and higher financial return. Without these partnerships, those projects would not have been possible.

Nowadays, the Portuguese Aerospace industry registered an important growth in the recent years: it observed a trade balance surplus of 85 million Euros, while a decade ago it witnessed a negative balance of 500 million Euros. The sector has adjusted its strategy, which allowed the evolution from only dealing with aircraft maintenance to producing manufacturing components (AICEP, 2010). Moreover, during the year 2014, it announced the creation of the first Business Incubator Centre (BIC) of the European Space Agency in the Portuguese cities of Coimbra (Institute Pedro Nunes, IPN), Cascais (DNA Cascais), in the Centre-Southern part of the country, and Porto (UPTEC - Science Park and Technology, University of Porto), in the North of the country.

As a way to document the evolution of this sector and to contribute to a literature with scarce empirical studies assessing the importance of this sector in the entrepreneurial efforts and in the creation of new firms and related businesses in the country, the present study attempts to thoroughly explore the economic and business dynamics of this sector and its influence in creating and developing a cluster of firms and start-ups in Portugal.

The present dissertation is structured as follows. In the next section, we undertake a literature review on key concepts and on the Aerospace industry, focusing on its characteristics as an industrial cluster, grounded on the bulk of research already developed. In Section 3, we present a case-study on the analysis of the emergence, development and the characterization of the Aerospace sector in Portugal. We also explore the linkages between this specific sector and the creation of start-ups related with the Aerospace value-chain. Finally, in Section 4, major findings and conclusions from the case-study are discussed in terms of policy implications.

two new factories in Portugal, both based in the city of Évora. The units are dedicated, respectively, to manufactured machinery, metal structures and composite material assemblies.

2. Aerospace clusters: a review of literature on the topic

2.1. Concept of Industrial Cluster

Most definitions that are found in literature for industrial districts or industrial clusters are deeply influenced by the economist Alfred Marshall, who pioneered a study on these phenomena in the beginning of the twentieth century. In his *Principles of Economics* (1922), the author describes the event as the concentration of specialized industries in particular localities. Marshall (1922) stresses not only the established business inter-connectivity in the district's environment but also the importance of exploiting other socio-cultural aspects, such as the flexibility of the local labor market and the mobilization of individuals from firm to firm within the district, highlighting the fact that emigration outside the district is considered as residual and that the individuals show a greater dedication to the district itself instead of to the firms where they are operating. These aspects facilitate the creation of a solid district culture identity and a shared industrial knowledge. Originally, when referring to industrial districts, Marshall (1922) envisages a locality where the business composition is constituted of small regional owned firms that make investment and production decisions on a local basis. Trade between firms is considerable, transactions among buyers and sellers often involve long-lasting contracts or pacts.

Marshall's (1922) explanation of what makes the industrial district model so important relies on the characteristics and the quality of the local input sharing and the local labor market, which is intrinsic to the district and highly adaptable to firms' needs. The mobilization of workers from firm to firm which contributes to knowledge diffusion and the spread of ideas within the industrial district is also a characteristic of these complex *milieus*. In the end, the "industrial atmosphere", as Marshall (1922) points it, derives from the co-location and the regular and frequent interactions of inter-related firms in the same area of an industrial system and from the society grown around and for the purpose of that industry. Marshall (1922) also highlights the role of the workers' loyalty, which appears to be more related with the district itself rather than to the firm, with low emigration flows. Thus, the district benefits from a balanced and stable community that allows a strong evolution of the local cultural identity and the sharing of industrial knowledge over time.

Industrial districts characterized by Marshall (1922) are often described at the light of the theory on agglomeration economies, which suggests that the rigidity of a place resides not in the regional mass of firms or workers, but in the external economies available to each firm from its spatial co-location with other firms and suppliers of services (Marshall, 1922).

In this line of thought, Becattini (1990: pp. 38) is one of the first authors to provide a Marshallian definition for the Industrial District: "[…] a socio-territorial unit which is characterized by the active presence of both a community of people and a population of firms in one naturally and historically bounded area" (Becattini, 1990). This is a broadly accepted definition as a renewed version of Marshall's (1922) concept of industrial districts or clusters, in which economies of agglomeration (from localized knowledge, share of common inputs, skilled labor and know-how) are the main fundaments for the clustering of firms in the same geographical area.

During the 1990s, with the seminal work of Krugman (1991) on the effect of agglomeration economies in the clustering of firms, there was a deep resurge of interest in the topic of industrial clusters. The geographic concentration also appears as an essential element for pinpointing firms' clusters in the work of Redman (1994: pp. 307): "a cluster is a pronounced geographic concentration of production chains for one product or a range of similar products, as well as linked institutions that influence the competitiveness of these concentrations".

In a study dedicated to firms' competitiveness and clusters' strategy, Jacobs and De Man (1996) identify five pivotal characteristics that can be used to conceptualize clusters: the first, related with the location of the cluster economic activity; the second, concerning the interactions (upstream, downstream or across the same level of the value-chain) and the relationships among industry sectors within the cluster; the third, on the usage of usual/ communal technology and knowledge; the fourth, on the value of the company's network; and finally, the fifth, on the presence of a main protagonist which can be a leading company, an industry or both.

However, and despite what was previously mentioned, there is still no unanimity in the definitive concept of Industrial Clusters, particularly regarding its iterations within the cluster. As previously stated, a common denominator across all the existing definitions is Marshall's (1922) "agglomeration theory", described in his *Principles of Economics* (e.g., Porter, 1998; Newlands, 2010), and that relates the firms' clustering mechanism - location of firms nearby each other - with the agglomeration economies accruing from

their co-location and the benefits of the flexible specialization of each firm in the local production value-chain. Regarding Krugman's (1998) theory on economic growth, this author has stressed the relevance of the industrial clustering in increasing returns as a beneficial requirement for the expansion of firms' scale and their external economies with consequent effects in the clustering of firms and in the economic growth of regions.

In other perspective on firms' competitiveness, Newlands (2010) mentions that if firms compete with each other, the risks involved in the enterprises' collaboration and in the creation of common inputs may lead to a weakening of their competitiveness, thus the clustering of firms may result in higher benefits.

In a socio-economic perspective, other definitions and features of industrial clustering have been put forward, most of them focusing on the importance of the set of inter-relations and the type of interdependencies among firms within the cluster for their growth strategy and competitiveness. For example, Morosini (2004) states that within a cluster, the knowledge exchanges are not arbitrary, but rather deliberate, socially developed and essential to ensure the competitiveness of the cluster. He then presents his own definition for Industrial Cluster as a "socio-economic entity characterized by a social community of people and a population of economic agents localized in close proximity in a specific geographic region" (Morosini, 2004, pp. 307).

Very popular in the management and socio-economic literature, Porter (1998, pp. 32) provides a definition to industrial clusters, describing them as "geographic concentrations of interconnected companies and institutions in a particular field [which] encompass an array of linked industries and other entities important to competition", which later on, in 2000 (pp. 16), are more integrally defined as "geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions in a particular field that compete but also cooperate". A cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities" (Porter, 2000, pp. 16). The location of clusters varies from regions, countries or cities, and by being more than a mere grouping of industries or firms, clusters hold a set of highly interdependent firms, industries and support institutions that develop, on a daily basis, a complex network of inter-linkages and exchanges (of intermediary inputs, knowledge, labor, technology, etc.) and play a key role on the cluster's competitiveness. Clusters include governmental and other support entities

(e.g., universities, think tanks, vocational training providers, standards-setting agencies, trade associations) that provide specialized training, research and development as well as technical support to all the firms in the cluster (Porter, 2000).

On a similar perspective, another concept of Industrial Clusters is provided by Bergman et al. (1999), where these structures are defined in terms of the linkages existing among specific firms and industries that present a set of aspects and behaviors in common such as the location, the origins of innovation and shared suppliers.

According to Rosenfeld (1997, pp. 1), in a sociologically-based perspective, an industry cluster is referred to be "a geographically bounded concentration of similar, related or complementary businesses, with active channels for business transactions, communications and dialogue that share specialized infrastructure, labor markets and services, and that are faced with common opportunities and threats." This concept noticeably highlights the relevance of social interaction and firm cooperation at the core of the cluster and the importance of specialized infrastructures in developing the precondition for the constitution of an industrial cluster (Rosenfeld, 1997).

Besides those authors, the work of Rocha and Sternberg (2005) also presents an interesting debate on the relation between entrepreneurship and clusters, envisaging entrepreneurship as the creation of new companies and clusters as a set of geographically located companies interlinked with each other and with associated institutions in related industries. In this debate, they particularly mention that an evaluation of the impact of clusters on entrepreneurship is both theoretically and empirically hard to perform due to conceptual, theoretical, and methodological constraints.

Actually, both clusters and entrepreneurship are complex phenomena that challenge those who attempt to conceptualize and to analyze them at the light of empirical theories of building and testing. Despite those challenges, from the definitions of industrial clusters provided by all the presented authors and expressed in the literature, it is possible to draw some common elements on the conceptualization of these structures, such as the characteristics of the value chain (e.g., Graham and Ahmed, 2000; Elola et al., 2013); types of constituent firms and actors included in the cluster (e.g., Niosi and Zhegu, 2005); ties and types of interactions amongst local economic agents (e.g., Sinha et al., 2004;); industrial specialization/ firms' agglomeration benefits (e.g., Porter, 1998; Martin and Sunley, 2003); the share of common inputs and production factors within

the cluster (e.g., O'Sullivan, 2006; Biggiero and Sammarra, 2010); the policy mechanisms that are employed at the cluster level, and the level of aggregation of the industries that compose industrial clusters (e.g., Rabellotti, 1995; Chiaroni and Chiesa, 2006).

2.2. Concept of Start-up: a brief reflection

Multiple views have been expressed on the role of the entrepreneur in the economy (Lucas 1978; Kihlstrom and Laffont, 1979; Evans and Jovanovic, 1989) but possibly the most prominent is Joseph Schumpeter's vision of the entrepreneur in his *Theory of Economic Development* (1912).

In the words of Schumpeter (1912: pp. 492), "the function of entrepreneurs is to reform or revolutionize the pattern of production by exploiting an invention or, more generally, an untried technological possibility for producing a new commodity or producing an old one in a new way, by opening up a new source of supply of materials or a new outlet for products, by reorganizing an industry".

Later on, Schumpeter presents in the *Theoretical Problems of Economic Growth* (1947), a new conceptualization for entrepreneurship. In this definition, there is less focus on "individualism", and the author states that the entrepreneur does not have to be one person. The entrepreneur can be an organization, a firm, a government or a country itself, which is a detachment from his earlier recognition of an entrepreneur as an individual agent (Schumpeter, 1947).

As a result of the entrepreneurial effort and its influence in the economic growth of a country, the concept of 'start-up' has been increasingly recognized in the economics, business and policy spheres as well as in terms of academic debate (e.g., Audretsch and Fritsch, 2010; Audretsch, 2012).

Start-ups are new companies attempting to enter or to develop a market with innovative products or services. Initially, their growth is hampered by the high need for financial capital and management capacity of its founders and these two factors become central to the survival of the start-up (Stubner et al., 2007), due to the complex process to access the financial capital and to the need of human resources endowed with knowledge, skills and experience required to solve management and technical problems along the production and business cycle (Jovanovic, 1982; Stubner et al., 2007; Clercq and Arenius, 2006).

The above definition contrasts with the view of other researchers that highlight start-ups as firms that serve as stream suppliers of technology to already established companies instead of the potential disruption of supplies in the market structure (Gans et al., 2000).
According to Clarysse and Moray (2004), start-ups are defined as a heterogeneous set of enterprises that comprises distinct firm types that vary from technology developers to technology adopters, mainly early adopters. In this kind of firms, revenues come over the long-term. This contrasts with the individualistic perspective of Korunka et al. (2003) that brings the entrepreneur to the front line. In his perspective, the start-up process begins with the first actions from a person, the entrepreneur. He is the driving force in the whole process.
A more general definition comes from Black (2010) to whom a startup is an organization created to explore a business model that can be duplicated and scalable. In the perspective of this author, the major objective for the business model is related with who is going to use the product or service or the amount of profit, depending on what was agreed with the stakeholders of the start-up. The development of the market, of the product or service thus must be flexible and fast, facilitating the process through which start-ups can rapidly test their chances in what concerns to their business model.

2.3. A recent literature review on the Aerospace Clusters

The existing literature on Aerospace Clusters is predominantly composed by empirical literature, which has gradually been recognizing the effects of globalization in parallel with more localized aspects (Beaudry, 2010; Clifton et al., 2011). In this context, studies on this topic tend to be focused on firm competitiveness (e.g., Calabrese et al., 2013; Dostaler, 2013; Elola et al., 2013) and on the analysis of the effects of government policies and incentives usually undertaken by means of national programs in the creation and development of industrial Aerospace clusters (e.g., Beaudry, 2010; Clifton et al., 2011; Elola et al., 2013). This literature also analyses the challenges faced by already established Aerospace clusters, namely in the North America and Europe (e.g., Beaudry, 2010; Dostaler, 2013), and the rising competition from emerging countries not traditionally connected to this sector, like Brazil, Mexico, China, Russia and South Korea. These countries have gained relevance in this sector by providing services at a lower cost, when compared with the traditional countries operating in this sector (e.g., Beaudry, 2010; Dostaler, 2013) which allowed an increase of their market shares in the international market. Also the impact of technologies' transfer in the

creation of start-ups within the Aerospace Clusters is studied or referred in the recent literature on the topic (e.g., Rocha and Sternberg; 2005; Audretsch, 2012; Del Giudice et al., 2013). In the case of Rocha and Sternberg (2005), they mostly focus on the impact of the creation of clusters on entrepreneurship at the regional level, analyzing the possible benefits from the creation of linkages within clusters that would positively influence regions and that allow the establishment of sale and distribution agreements in addition to processes of technology transfers.

Due to the particular characteristics of the Aerospace sector as a strategic determinant in the formation of new firms/ businesses and in national entrepreneurial efforts, firm competitiveness plays a central role in this literature. In the words of Dostaler (2013, pp. 32), "the aerospace industry is considered a highly strategic sector in all advanced and developing countries of the world." In her study, the author attempts to assess the impact of the emerging Aerospace clusters from countries not traditionally related to this sector (e.g., Korea, Mexico, China) and analyzes the strategies developed by the Canadian Aerospace Industries to increase their competitiveness, checking whether those strategies are adequate to turn the Canadian aerospace cluster into a competitive sector within the set of new emerging players at the global scale, such as China, Mexico, South Korea, Russia and Brazil. The study of Dostaler (2013) provides a contemporary analysis in order to identify if the Canadian aerospace cluster shows conspicuous signs of competitiveness. The interviews undertaken during the study conclude that the key success factors required to win contracts in the Aerospace sector mainly focused on offering lower prices (Dostaler 2013). The emphasis on costs appears as a natural strategy, mainly due to the emergence of other countries in this sector, like China, Mexico and South Korea that provide services with a lower cost. Nevertheless, other aspects appear to have also importance as key elements to the companies in this sector to achieve success. Other priorities are stressed such as the confidence required between suppliers and the production process, in order to allow delivery-on-time and just-in-time strategies; the quality in relation to the product or service provided/ the perceived quality/ reputation in the aerospace sector; the reaction speed on providing solutions to solve clients' demands; and the ability to expand product awareness in the market and in the flexibility of the industrial process. Another conclusion from the study was that since the aerospace sector is widely distinguished as an industry with high technological content, the companies interviewed stated they were "proud" of their

technological capabilities, as a way to differentiate them and to survive in this sector. Thus, although the sector was more cost sensitive, technology still played an important role (Dostaler 2013).

In turn, in Elola et al. (2013), the research is performed in order to assess if the Basque Aerospace cluster (in Spain) has been able to maintain its competitiveness throughout the past decades. In their article, the authors explore how clusters are created as well as how they have developed over time and in what way the development of new specializations by local companies plays a key role in the competitiveness of this cluster within the global value chain. This historical analysis starts with two firms who are the first/ primary driving forces in the emergence of the Aerospace cluster, and demonstrates how critical was the government support in the formation of this cluster, both at an economic and a financial level. In this case, the major competitiveness factors of this cluster are the pre-existent knowledge in materials, engines and structures. The knowledge and know-how in producing these components is mostly drawn upon the experience of local industries. The other major factor in the cluster's developments was the diversification and growth strategies of large Original Equipment Manufacturers (OEMs), firms that are particularly dedicated to designing planes and helicopters, prospecting markets and order subassemblies from the second tier that benefited this sector. The aerospace sector consisted of a scarce number of large multinationals with a high level of vertical integration. Nevertheless, the technological shift modified the modus operandi of this sector. It needed new and complex capabilities that the incumbent aeronautical firms did not had, it enabled the modularity of this sector, by facilitating the entrance of new firms that started making new types of airplanes, subcontracting a varied amount of the work to other specialist firms and setting up international value chains comprising a high number of specialized companies (Elola et al. 2013).

Contrasting with the Basque Aerospace cluster, that Elola et al. (2013) describes as major competitive factors the already established knowledge and the diversification and growth strategies of large Original Equipment Manufacturers (OEMs), Calabrese et al. (2013) stress the role of innovation as a way to achieve firm competitiveness in this particular sector. In this case, the research focuses on the Italian region of Lazio, and according to Calabrese et al. (2013, pp.1) "the innovative behavior of companies is one of the main sources of competitiveness, business survival, economic growth and

employment in a territory". The Aerospace industry located in Lazio is structurally focused on two sectors, civil and military, that are interconnected. Indeed, the existence of these sectors allows a deep combination of competencies and technologies, and also the exploration of economies of scale and scope. A considerable group of SMEs (Small and Medium Enterprises) of high technological and innovative capacity have strengthened ties around the large companies in the cluster. These SMEs have a thriving entrepreneurial character, which offers an important support to the Aerospace sector which is composed by a number of companies dedicated to industrial research, formation, technology transfer, enabling innovative projects, research activities, business creation and/or growth and support for developing business networks, venture capital support, developing and operating laboratory infrastructures and large-scale demonstration projects. The cooperation between companies and/or research institutes in the use of innovation indicates a strong reliance on networking (Calabrese et al. 2013). The existence of this dense network of companies that includes complex relationships of supply and sub-supply is presented by the authors has having positive effects on the performance of the Italian aerospace sector (Calabrese et al. 2013). Significant factors on the development of this cluster also reside on the efforts carried out to innovate with the information diffusion about grants and funding opportunities that enables the companies to get more contracts in public and private spheres. Companies' competitiveness are primarily guaranteed by the companies' capacity to develop an ample network favoring technological transfer and R&D (research and development) partnerships, as well as their ability to protect the results of their innovative activity (Calabrese et al. 2013).

Like Dostaler (2013) and Elola et al. (2013), Calabrese et al. (2013) also emphasizes the changes that occurred with the globalization, where knowledge became a valuable asset and innovative behavior has turned a crucial determinant of firms' competitiveness within the Aerospace clusters.

Thus, the major characteristics of Aerospace clusters that have been expressed in literature are related with characteristics of the companies that compose those clusters and their continuous innovation efforts, reliant on the search for information on funding, on how to protect their innovations, on gathering more contacts by creating a network with investors and suppliers, that will permit the development of linkages between companies and that will allow a more effective participation in the global value chain of the Aerospace industry at a worldwide level (Calabrese et al. 2013; Elola et al., 2013).

Governmental support has been in many cases, essential to the creation and sustainability of the cluster, through the diffusion of the existent knowledge in the area where the cluster is to be established allowing the adaptation of local knowledge and the redirection of information to the sector (Elola et al., 2013).

This was the case of Portugal with the creation of the Aerospace Cluster in Évora where the governmental strategies and the promotion of knowledge diffusion encouraged a shift in the national industry which was previously centered on the automobile industry, and that is currently diversified in a myriad of activities related to the Aerospace sector, with a business developing perspective in straight relation with the public programs, such as the education and formation of highly skilled workers in the University of Évora or in the local vocational training centers of the Employment and Vocational Training Institute (IEFP). In the case of Portugal, there have been also high investments in technology transfer and knowledge from international global investors to the Portuguese units and to local suppliers, stimulating knowledge diffusion and spillovers to the smaller firms, which has boosted the business development and the creation of a qualified Portuguese network of suppliers (AICEP, 2011).

2.4. Aerospace Clusters in literature: concept and characteristics

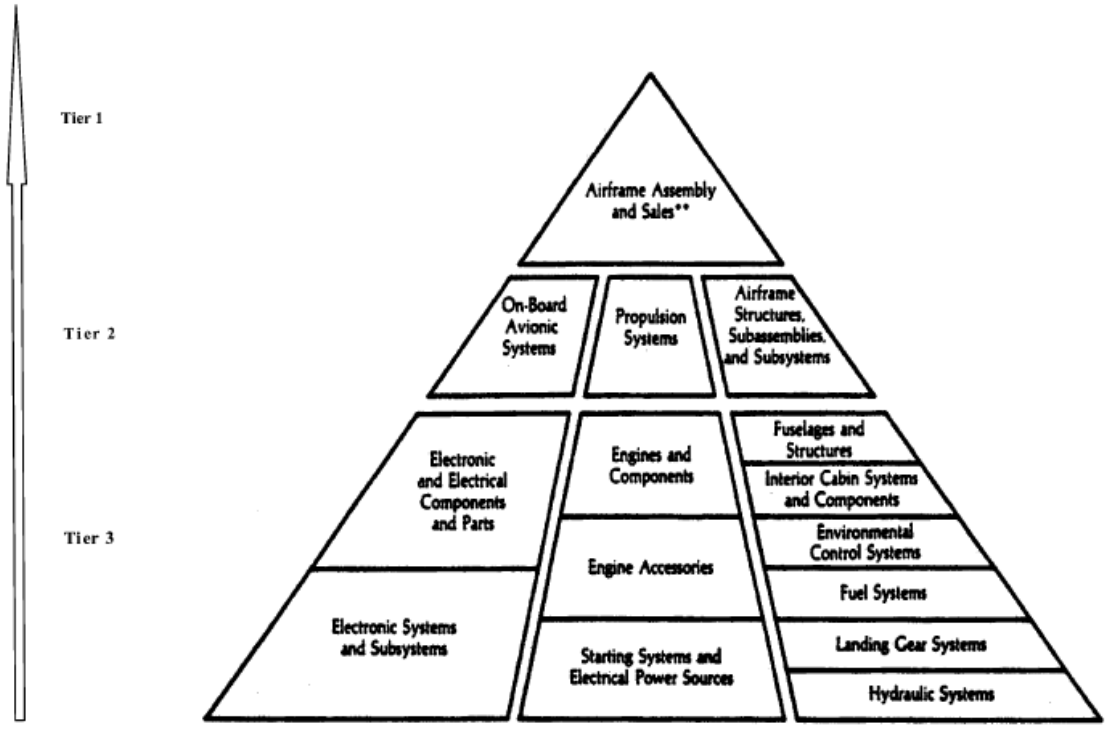
In literature, the Aerospace Cluster is characterized by the Aerospace Industries Association (AIA) (2009) as a group of firms, researchers and governmental entities of the aerospace manufacturing, maintenance, and repair industry, often tailored to benefit from the strengths of aerospace companies already located in a region (AIA, 2009). This strengths are the already established knowledge in the region, the expertise on materials, and the indigenous technological capabilities, of a certain region that can be beneficial to the Aerospace industry (Elola et al. 2013; Niosi and Zhegu, 2013; McGuire and Islam, 2014).

Aerospace Clusters are predominantly constituted by OEM's (Original Equipment Manufacturers), having several small and medium sized suppliers of aircraft and aerospace components and related modules (Niosi and Zhegu, 2005). At the top of the hierarchical pyramid of the Aerospace Cluster are the OEM's belonging to *Tier one* (cf. Figure 2) related with the prime contractors and assemblers, which are also responsible for the design and marketing (e.g. Airbus; Boeing; EMBRAER; Bombardier) (Elola et al. 2013). The second level of the pyramid is composed by the *Tier two* suppliers (e.g. General Electric; Rolls-Royce) - these suppliers are mostly manufacturers of propulsion

systems on-board avionics and airframe structures/ they can also be assemblers of parts and components that are developed on the third and fourth tier levels. *Tier three* suppliers are producers of electronic, hydraulic systems and fuselage parts, and they are a highly concentrated group of producers at the global level with a dense set of firms dominating each segment. At the base of the pyramid lies the *Tier four* - suppliers which are the manufacturers of components and parts that afterwards will be assembled by the second, third or even by the first Tier (Niosi and Zhegu, 2005; Bawa et al., 2013; Elola et al. 2013) (cf. Figure 2).

As employer units, Aerospace Clusters consist in large agglomerates of highly skilled labour (Niosi and Zhegu, 2013), predominantly composed by Engineers (Software; Systems; Mechanics; Electrical; Materials; Industrial; Aerospace), with a component of

Figure 2- Value Chain of the Aerospace Cluster
Source: Niosi and Zhegu (2013, pp. 12)



highly technical and specialized knowledge embodied in them (Regional Technology Strategies, Inc., 2009). The mobilization of workers and the diffusion of specialized knowledge/ learning practices across firms is crucial to the development of the Aerospace industry. On this particular issue, Rebolledo and Nollet (2010) explain that inter-firm learning is a critical issue for all firms in the industry, due to the level of

accuracy needed in the production, in assembling all the parts of the product and due to the complexity and diversity of the technologies used.

The Aerospace industry is a network with a high degree of interconnected companies that are progressively shifting to modular subcontracting, meaning that nowadays large companies tend to focus on their core capabilities by outsourcing parts in the production process, like, design and manufacture. Together with the reduction of the supplier base, this turned companies gradually more dependent on efficient suppliers to continuously provide competitive subsystems and subassemblies which combine state-of-art products and technology processes. Under these conditions, the know-how about the finalized products is scattered throughout the supply chain and each supplier specializes in the particular knowledge needed to produce a module, enabling the creation of more knowledge by the other suppliers (Smith and Tranfield, 2005). This particular characteristic reminds the industrial clusters' features well expressed in the literature, in Marshall's (1922) "agglomeration theory", that associates the firms' clustering mechanism with the agglomeration economies accruing from their co-location and the benefits of the flexible specialization of each firm in the local production value-chain.

Large companies are adjusting to fewer but more competent suppliers, consequently, there is a growing pressure for large companies to learn from their suppliers (Smith and Tranfield, 2005). Inter-firm learning is related with all knowledge outputs (i.e. knowledge creation, retention, transfer and application) taking place in a firm as a result of the interaction with another firm. Therefore, developing a strong inter-firm knowledge network becomes pivotal in the production and assembly process in order to have an effective exchange of knowledge among the industry's firms. Besides, Aerospace firms tend to develop in the same fashion of high-technological firms, which have the propensity to cluster around knowledge creating organizations (Braunerhjelm and Feldman, 2006). In this vein, most of the existent Aerospace clusters are often located in the perimeter of R&D Institutions, R&D Laboratories, Industrial Specialized knowledge associations, laboratories which are generators of patents and high-tech think tanks that spawn the diffusion of knowledge that is transferred to the cluster of high-tech companies (Niosi and Zhegu, 2005). This aspect is well explored in the Industrial Cluster literature, by Morosini (2004) to whom knowledge diffusion and knowledge spillovers are crucial in the development of the competitiveness of the cluster and also by Jacobs and De Man (1996), that identifies as one of its five pivotal features of clusters, the usage of usual/ communal technology and knowledge.

As mentioned earlier, one aspect with major relevance in the literature of Aerospace clusters has been the governmental support. As stated by Elola et al. (2013), the governmental aid in the creation of the Aerospace Cluster is crucial at both economic and financial levels. Without this support, the emergence of this cluster would have been jeopardized, mainly because that there was no tradition or industrial specialization on this sector in the region. In the case of the Basque Aerospace Cluster, the financial support came from both regional government and the State government that were imperative in the initial stages of development. This cluster has also benefited from the general policies of the regional government for education and specialized training, plus from a wider convergence with the universities accompanied by the introduction of specific courses on aeronautics (Elola et al. 2013; Elola et al. 2013). The Basque Country (Northern Spain) come to be one of the first European regions, to implement a cluster-based competitiveness policy in the 1990s, directly following Porter's study, which established and validated the positive effects of R&D, innovation on cluster development and on the competitiveness and growth of regions (Aranguren and Navarro, 2003; OECD, 2011). This particular aspect has been widely addressed in the Industrial Cluster literature where the governmental support, as well as from other entities (e.g., universities, think tanks, vocational training providers, standards-setting agencies, trade associations) allow specialized training, research and development as well as technical support to all the firms in the cluster (Porter, 2000).

Another author stressing the governmental role in the emergence and development of these clusters is Clifton et al. (2011), in his study on the Welsh Aerospace Clusters, where government sponsorship is considered as a key element in order to tackle with market vulnerabilities, mainly concerned with external competitors, and to provide better assistance in order to encourage the aerospace firms to develop more balanced decision-making processes.

Networking efforts and the interactions of firms along the value-chain within the Aerospace Cluster and at a worldwide, globalized scale has also been significantly stressed in this literature. It is a high value-added sector that is affected by scale and timing (Niosi and Zhegu, 2013) thus, the industry's success is reliant on rapid technological development, and even though inter-connected manufacturing and maintenance firms are geographically clustered, their activity highly depends on components and parts that are widely dispersed in terms of industry sectors and

locations around the world (Zuliani, 2008; Niosi and Zhegu, 2013). The European Commission's report "Competitiveness of the EU Aerospace Industry" (2009) depicts Aerospace Clusters as having a high technological level, with complex technology, where development costs are high and large investments are required for the development of new technologies, which explain the importance of pertaining to the global/ international value chain that allows the main firms of the cluster to become essentially the final assemblers of the parts that come from around the world (Elola et al, 2012, Dostaler, 2013, McGuire and Islam, 2014). On the characterization of the Aerospace sector in Spain, Elola et al. (2012) also describe the geographical firm spread within the aerospace sector by analyzing the competitive positioning of the Basque Aerospace Cluster in the international value chain, which is particularly pertinent in the aerospace industry, controlled by a small number of multinationals with production networks composed by numerous companies and firms distributed worldwide (Elola et al, 2012). Beaudry (2010) describes Aerospace industries as "a pertinent example of the beneficial effects of clustering" alongside with the importance of globalization, due to the fact that firms are clustered and benefit from being localized, but at the same time are increasingly sub-contracting on a value-chain and worldwide buyer-supplier logic, which encourages a high collaboration not only at the local level, but at the various levels of contractors industry sectors and other locations around the world (e.g., Graham and Ahmed, 2000; Elola et al., 2013).

From all that has been reviewed, important features related with the Aerospace clusters clearly arise. The first lies in the high flow of innovations and industrial knowledge creation, which is diffused among the firms in the cluster. Second, these clusters benefit from a pool of highly skilled and specialized workers due to their specific requirements in terms of know-how and industrial knowledge. Third, these clusters are highly reliant on governmental incentives and benefits, due to their particular needs of financial and technical support mainly in the first stages of development. Forth, Aerospace clusters are geographically bounded through a myriad of local synergies and inter-connections among the clustered firms, also relying upon a globalized, worldwide network of supplier-buyer and value chain interdependencies.

3. The Aerospace sector in Portugal: a case-study analysis

Described as an aggregator of knowledge and science, the Aerospace sector has been considered as a driver of innovation in the economy (Hollanders et al., 2008).

It is also a highly value-added industry, influenced by its dimension and the importance of its value-chain that is not only locally enrooted but also is spread worldwide by a globalized network of interactions. The success of this industry is dependent on an intense technological development and governmental support for the continued development of research and development (Niosi and Zhegu, 2010). At international level, as mentioned above, studies that have discussed the aerospace sector are mostly empirically-based works (e.g., Niosi and Zhegu 2005; Dostaler, 2013; Venturini and Verbano, 2014), official reports (ESA, 2012) and case-studies (e.g., Bach et al., 2002; Beaudry, 2010; Elola et al., 2013).

Given the particular features of this sector, we present a methodology to describe the Aerospace sector in Portugal and its linkages with the emergence of new firms, on the basis of a case-study analysis.

Case-study analysis is to a greater extent more than just an analysis on an individual or a particular situation. This method allows the researcher to present answers to the "how" and "why" questions, always taking into consideration the impact of a certain phenomenon in its surroundings. Case-study analysis also potentiates the collection of data from different sources and the merging of that data to bring new knowledge to the case (Yin, 2003; Baxter and Jack, 2008). It presents the possibility of turning complex science and technology projects in understandable and compelling information to a non-scientific audience. The scope of this method is flexible and vast, allowing variations from succinct descriptive synopsis to more lengthy and comprehensive descriptions. With the potential to gather all sorts of information, the case-study analysis presents itself as a practical tool for exploiting the various aspects of the case and draw important conclusions based on the particular features under analysis (Yin, 2003).

Notwithstanding what was previously said, the case-study analysis is also seen as having some weaknesses as an assessment tool. Either it being qualitative or quantitative, case-studies are usually connected to individual, particularized projects, and due to that reason, the final conclusions of case-studies are not generalized as they are mainly associated to the project for which they were designed for. Despite being

envisaged as a method that can not be generalized as it happens with theoretical or formal analysis, within the scientific community the case-study analysis has assumed an important role in appreciative studies and has been a highly common used tool for its pertinence and adequacy to analyze local and particular phenomena (Yin, 2003). For this reason, this is a usual method applied in social sciences, in policy research and management studies.

In the case of the Aerospace sector, there are several examples of authors who have used this method in the description and characterization of their cases (e.g., Petroni and Verbano, 1999; Jackson, 2004; Beaudry, 2010; Dostaler, 2013; Elola et al., 2013; Venturini and Verbano, 2014).

In the present study, the main purpose is to analyze the historical evolution, the local and international dynamics and the emergence of new firms and start-ups related with the Aerospace sector in Portugal, which thus explains the suitability of a case-study approach. In the words of Yin (2013, pp.1), “in general, case studies are the preferred strategy when 'how' or 'why' questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context”. For those reasons, this study attempts to provide a useful analysis of the Aerospace sector in Portugal from the methodological perspective of a case-study analysis.

3.1. Historical Evolution of the Portuguese Aerospace Cluster

3.1.1. Emergence and historical evolution of the Aerospace cluster

The first flight made in Portugal was in a machine baptized with the name of “Passarola” in 1709, invented by the priest Bartolomeu de Gusmão. The true characteristics of the “Passarola” are unknown, because the documents with that information were lost in time, but the small amount of existent information allows for a description of the machine that shows some similarities to hot air balloons, with an ignition source on a boat shaped equipment that enabled the heating of air and the ascension of the machine. It is recognized that the huge balloon was launched from the Castle of São Jorge in Lisbon, having landed at the Terreiro do Paço, a central part of the capital city. By 1922 it took place the first flight that crossed the South Atlantic from Portugal to Brazil by the Portuguese aviators Gago Coutinho and Sacadura Cabral. Their expedition took about 79 days, but the flight time was only sixty-two hours and

twenty-six minutes, having covered a total of 8,383 kilometers. The voyage took place in four stages due to unforeseen problems with the expedition and the requirement of devices, in total, three aircraft to complete the crossing.

The foundation of Parque de Material de Aeronáutica, later named *Oficinas Gerais de Material de Aeronáutica* (OGMA), in June 29th, 1918, demonstrates that with the end of the First World War, the aeronautical sector in Portugal was subject to a strong governmental commitment and its use on both military and civilian level was stimulated. By this time, Portugal followed the trend of other countries, especially those having a similar industrial specialization, like Spain, Greece and Belgium, and that encouraged Portugal on the development of the aerospace industry when it was still in its initial stage.

Despite earlier efforts, the most significant landmark in the sector occurred after the Second World War, with the foundation of TAP, then called the Secção de Transportes Aéreos (Air Transport Section), on March 14th, 1945 by Humberto Delgado, who was Director of the Civil Aviation Office at the time. That was also the year when the first aircrafts was acquired, two Dakota DC3s (Douglas Commercial), with room for 21 passengers. In the following year, the company was finally able to begin operations after setting up the General Pilots Course. This meant it could launch its first two air routes, the first commercial Lisbon-Madrid service began on 19 September 1946, while on 31 December the "Imperial Airline" was launched, flying between Lisbon, Luanda and Lourenço Marques, a journey of 24,540 kilometres that took a total of 15 days and included 12 stopovers. Other routes launched before the end of the 1940s included Paris (1948), London (1949) and Seville (1948).

In the early 1990s, Portugal took a vital step in the development of the Aerospace industry, with the launching in 1993 of its first low altitude micro-satellite, the PoSAT-1. This release was made possible by the European Ariane launcher, and allowed a successfully accomplished project that had been initiated in 1992 in partnership with the University of Surrey, England. But it was in 1996 that the country registered its most relevant milestone in ensuring the survival of the Portuguese aerospace industry by the establishment of a cooperation agreement with the European Space Agency (ESA). This arrangement assured special status collaboration with that organization and allowed the participation of R&D institutions and Portuguese companies in the optional programs of ESA, such as ARTES (Advanced Research in Telecommunication Systems), the ASTE

(Advanced Systems & Telecommunication Equipments) and the GNSS (Global Navigation Satellite System). This cooperation agreement with ESA also allowed specialized training and the mobilization of Portuguese engineers and researchers in the various research centers of ESA across Europe, facilitating the diffusion of specialized knowledge among firms in the sector.

This agreement paved the way for the full membership of Portugal to the ESA, on 14th of November in 2000, becoming the fifteenth member of this organization. Portugal gave a major step forward in the development of the Portuguese Aerospace sector, which together with the public investment in international organizations like EUMETSAT (European Organization for the Exploitation of Meteorological Satellites) and ESO (European Southern Observatory), has had a significantly contribution on the creation of scientific and technological competences in the aerospace field including over 50 companies, universities and research institutes.

Software development remains the main core business of the Portuguese companies, but the evolution of technological competences have been extended to space-related hardware, especially after 2008, when it benefited from a noteworthy growth. Portugal is already the base for important ESA infrastructures, including a station in Santa Maria, located in the Islands of Azores, operating since 2008. It was the first ESA station in the country, in addition to monitoring the telemetry activities of Ariane launchers, it was also a processing station of Earth Observation data. With an estimated investment of 2.5M € by the ESA and approximately 1M € by the Regional Government of Azores, it allowed the mobile station conversion to permanent station telemetry, which was the third mission in which the Santa Maria station has participated. Other important infrastructures can be also found in the meteorological data processing station of LSA SAF (Land Surface Analysis Satellite Applications Facility), as part of EUMETSAT, located in Lisbon and incorporated in the national Instituto Português do Mar e da Atmosfera (Portuguese Sea and Atmosphere Institute), with the objective of taking full advantage of remotely sensed data on land, land-atmosphere interactions and biosphere applications. A strong emphasis is also put on developing and implementing algorithms that allow an operational use of data from EUMETSAT satellites. Also operating in Portugal is the ESTHER (European Shock-Tube for High Enthalpy Research), located in the outskirts of Lisbon (Sacavém), the biggest Space facility in Portugal, with the aim to provide support to the design of ESA planetary entry vehicles study and the atmospheric reentry phenomena. This facility has the capability of simulating the

atmosphere of Earth, Mars and Venus (CO2–N2) by reproducing shock-waves for speeds of about 4–12km/s and gas mixtures of non-terrestrial environments.

The Aerospace production sector in Portugal is constituted by two major companies: Oficinas Gerais de Material Aeronáutico (OGMA) Indústria de Portugal, S.A. and Transportes Aéreos Portugueses (TAP) Maintenance and Engineering.

With a total turnover of 166.8 million euros in 2014, OGMA is a national private and public-owned firm, dedicated to the production and maintenance of aircraft components, located in the capital Lisbon. This company was considered a strategic agent to the Portuguese Government mainly due to its connections to the Defense sector in Portugal and to the Portuguese Air Force until 2005, when was partially acquired by Embraer, a Brazilian aerospace conglomerate of specialized firms that produces commercial, military, executive and agricultural aircraft and provides aeronautical services, in an operation that was seen as an incentive to the development of the Aerospace sector in Portugal (see Figure 3). Working together with several Original Equipment Manufacturers (OEM's), like Lockheed Martin, Rolls-Royce and Airbus, among others, OGMA has capabilities in the Aeronautical sector, being a *tier 2* supplier competent in assembling parts that come from other tier suppliers.

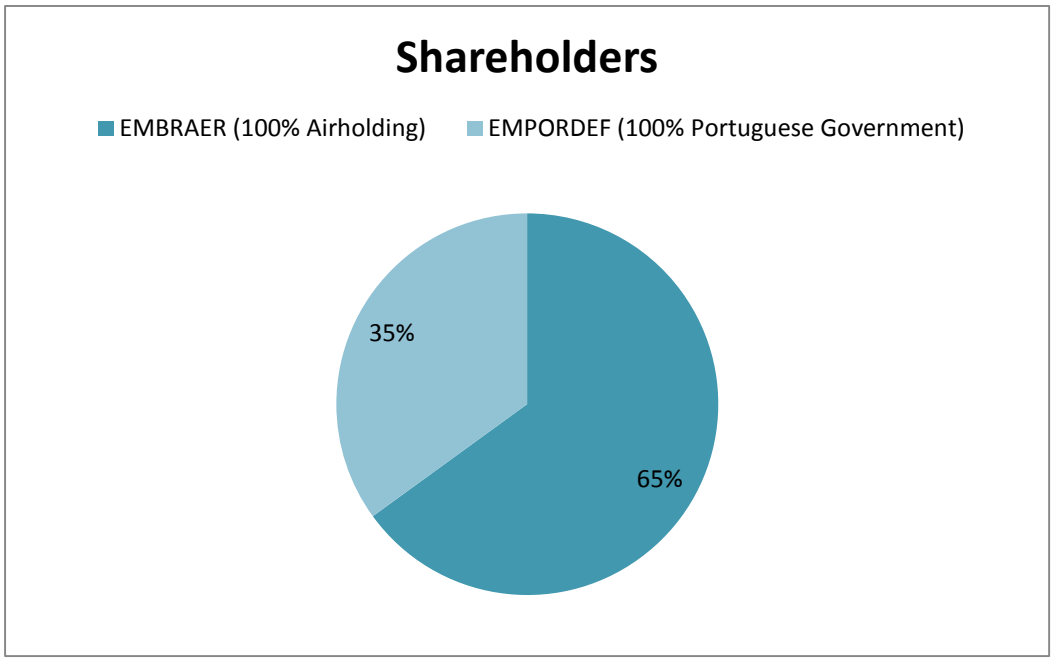


Figure 3 – Shareholders of OGMA (Indústria de Portugal, S.A.), 2015.

The other important company in this sector in Portugal is Transportadora Aérea Portuguesa, S.A. (TAP, S.A.), and more precisely its unit TAP Maintenance and Engineering (TAP M&E), a public-owned firm dedicated to the maintenance of aircrafts

located in the capital Lisbon, which has presented a turnover of 76 million euros in 2013. TAP Maintenance and Engineering (TAP M&E) is a leading global maintenance, repair and overhaul solution provider for Airbus, Boeing, Embraer and Legacy fleets, that managed to accomplish international recognition from both customers and manufacturers such as Airbus, FedEx, and NATO in a competitive sector where safety is presented as an essential cornerstone for any company that wants to operate in this sector. It is mainly positioned in the aftermarket industry (Maintenance, Repair and Overhaul) which handles with the maintenance and up-gradation of an airplane and employs a specialized workforce of about 4,000 workers that includes highly qualified technicians and engineering staff. The company TAP Maintenance and Engineering (TAP M&E) operates in one main center in Portugal, located in the capital Lisbon, and in two operation centers in Brazil, in the cities of Rio de Janeiro and Porto Alegre.

Besides these two large companies, there are also a number of SMEs operating in the Aerospace sector in Portugal, such as Edisoft, Tekever, Active Space Technologies and Evoleo Technologies, specialized in activities such as thermal architecture for aerospace applications, flight solutions, mission control tools testing tools and support, and that, together with subsidiaries of global companies established in Portugal, such as Thales (France), Indra (Spain) and gmv (Spain) have developed a dense network of *tier 3* suppliers, allowing them to gain important expertise in the Portuguese Aerospace sector as well as in the global supply chains.

Yet, despite all the advances in the sector, the Portuguese aerospace industry remains a niche of market, with the activity in this sector being practically confined to the two major companies: OGMA and TAP Maintenance and Engineering.

In this context, a significant event for the aerospace industry in Portugal was the acquisition of OGMA by Embraer in 2005 which enabled the prospective of spillovers to other firms in the aeronautics sector and to the overall economy. This enabled the entrance in the Portuguese market of one of the major Original Equipment Manufacturers (OEM's) in the world and the Embraer's presence in Portugal enhanced the critical mass needed for the creation and development of its Aerospace sector. This was pivotal for the strategic development of the sector, allowing the improvement of competences and stimulating the production of innovations in the Aerospace-related firms.

The investment was particularly channeled to the cluster development in an inland municipality near the capital of the country that is Évora (about 130 kms far from Lisbon), with the interest in the regional development of this location and also to benefit from the local conditions and infrastructures of the region, such as the proximity to Lisbon and Madrid, and to the Beja (a nearby municipality) airport. The direct investment of Embraer allowed the Aerospace sector in Portugal to develop from maintenance to the manufacture of airplanes, a crucial factor in the development of countries, due to the high technological content involved in these stages of the process and also for exportation purposes where Portugal assumed a higher positioning in the commercialization of high-value added products in the international environment. As stated by the Portuguese government at the time, this investment played a crucial role in the development of the technological know-how at a localized level while allowing a deeper integration of Portugal in the global economy, based on a sector featured by a high level of specialized knowledge, research and development. The emergence of the Aerospace cluster in this inland region of Évora was also important to the regional employment and to the local dynamics of the region, which has also placed Portugal into a new stage of the Aerospace industry, related with the manufacturing and assemblage of aircraft key parts and components.

It also promoted the development of already established competitive and innovative firms in Portugal through strategic partnerships with the Aerospace industry, like the agreements established between Airbus and the Portuguese Automobile group of Salvador Caetano (which led to the creation of the Salvador Caetano Aeronautics, in 2015) in the production of mechanic parts, mainly for the military airplanes of Airbus and potentially in a second phase, to produce structural composite parts. This was also the case of the projects developed between Embraer, Almadesign (Design in technologies and ergonomics), Amorim Cork Composites (Cork producer), Couro Azul (Leather Producer), Inegi (Instituto de Ciência e Inovação em Engenharia Mecânica e Engenharia Industrial) and Iberomoldes (supplier of engineering services and value-added prototyping moulds and thermoplastic products for automotive, electronics and aerospace sectors), that led to the creation of Project LIFE (winner of international Crystal Cabin Award 2012 in “Visionary Concept” category and used as a case study of Green & Eco-Innovation Growth, by OECD). Other projects developed are found in the PAIC (Portuguese Aerospace Industry Consortium), as a result of 14 Portuguese companies partnership with Lockheed Martin for an air system development and the

Compass consortium associated to KC 390 Program, the military airplane, currently being developed in the Évora Aerospace Cluster.

These partnership projects led to the expansion of companies like OGMA; Edisoft - a Portuguese company, based near Lisbon, that offers solutions for software engineering and development, system integration and technology consultancy; and Tekever, dedicated to the Information Technology and the Aerospace, Defense and Security activities (e.g., developing innovative technology, systems and sub-systems for the space sector). Tekever is based in Lisbon, Portugal, but already has offices in other European countries, Asia, South and North America. These projects are a contributing source for the continuous reinforcement of the national Aerospace cluster and to its international awareness and linkages around the globe.

As described in the literature concerning industrial districts, the Aerospace sector in Portugal can be described much in the light of the Marshallian arguments (1922), envisioning localities where the business composition is constituted of small regional owned firms that make investment and production decisions on a local basis, but also interconnected with global networks of suppliers that take part in the worldwide value chain.

Also, a key determinant on the development of clusters with the specificities of the Aerospace sector lies in the set of highly interdependent firms, industries and support institutions that develop, on a daily basis, a complex network of inter-linkages and exchanges (Porter, 2000). A further step forward was also the creation of industry associations in the Portuguese Aerospace sector. This was the case of PEMAS (Portuguese Aerospace Industry Association), that was created in 2004, as an association of Small and Medium Enterprises (SMEs) and research and development institutions and that has actively contributed to the promotion of initiatives and projects in the Aerospace sector among members and in collaboration with enterprises outside the association. Examples are the project VULCAN for the creation of new materials and aircraft design strategies, with the role of PEMAS as partner and Work Package leader; or the constitution of the Consortium CSEG (Security Consortium) for the consolidation of a national network of research and development in the area of security, in an attempt to combine the technological and scientific knowledge with the practical knowledge of the industry. The experience gained in projects born within PEMAS has proven that cooperation in integrated projects contributed to the evolution of the Portuguese Aerospace industry towards more significant projects including assemblage

incorporated in the upstream segments of the value chain. This sector was once largely dominated by maintenance companies and manufacturing firms of small components to be assembled in other segments of the value chain. These cooperation projects and agreements had a crucial role in overcoming the difficulties of the integration in complex supply chains around the world such as air transportation networks, and aeronautics in particular. Ultimately, they turned possible the assemblage of an entire aircraft (KC-390), for the first time in Portugal, in the year of 2013 in the Évora Aerospace Cluster.

Other important associate organization for the development of the Aerospace cluster is the CEIIA (Center for Excellence and Innovation in the Automotive Industry), created in 1999, due to the identification of a gap in the Portuguese aeronautical market, with the purpose of development, generation and retention of skills in product design and support services to this industry. This organization assumed the role of a competitiveness Center for mobility industries, which includes the Aeronautics industry and the Automobile industry, in order to promote excellence references and skill development in terms of the research, design, development, manufacture and the testing of products and services in the Aeronautics and the Automobile industries. It is in this context that the aeronautics sector has developed, in order to materialize one of the strategic axes of the intervention of CEIIA, which emphasizes the diversification of activities in the supply chain of the aviation industry, namely by developing the strategic sectors through the integration of national technology in new products with a high added value. Some projects currently being developed by this Center are AgustaWestland, on the domains of full Aircraft Modeling, Analysis and Optimization, composite and aluminum Monolithic Structures and a partnership with Embraer, on the engineering and development of composite and metallic structures for the aircraft model KC-390. Other important company is EEA (Aeronautical Engineering Company), is located in Maia, Porto, Portugal, and is dedicated to the design, promotion and implementation of engineering projects, testing, developing and delivering products or aeronautical structures. The EEA has been appointed the managing body of the Portuguese participation in the program with Embraer, with the role to mobilize companies in the areas of aero structures and software around the technological consortium KC-390. Partially owned by the Portuguese state through EMPORDEF (Portuguese Defense Company), that is the holding company of Portuguese defense

industries whose business is the management of shareholdings held by the State linked companies directly or indirectly to defense activities as an indirect form of performing economic activities.

Since the Aerospace sector depends on a dense network of supportive associations, other relevant organization in this sector is INTELI (Intelligence in Innovation - Innovation Centre), with an actuation field on business intelligence, data collection, and on the treatment of information and its subsequent conversion into knowledge. This organization plays a decisive role in supporting decision-making processes of public and private actors in the sector as well as in terms of policy research, by developing pioneering and innovative solutions to governance problems and in the formulation of public policies from the definition of the agenda the design and implementation of local policies, to the respective monitoring and business evaluation, through a systematic reading, identification and exploitation of opportunities offered by the market.

Finally, the association ProEspaço (Portuguese Association of Space Industries), designated to provide support in the promotion of the activities related to Space and concerned aspects, has been playing an important role as an interface between the national governmental bodies and the international governments for all the matters related to the Space industry. It works with all the levels of government (local, regional, national and supra-national) in order to substantially increase the participation of the Portuguese Aerospace industry in the activities at a national, European and at a global scale. Both providing information on the Aerospace industry in Portugal and acting as a research, development and related support association, this entity has contributed to the enhancement of the domestic industry, under the scope of the Portuguese Space Policy, and to the strengthening of cooperation between companies, universities and public research institutions aimed at developing new technologies and products for use in Space. It has also developed studies, analyses and reports to the institutions and bodies responsible for the preparation of the Portuguese Space Policy and related plans of industrial development of the Portuguese Government.

Thus, the intense network linkages between firms in the cluster and between strategic firms and R&D entities thorough project collaboration and cooperation agreements has been a key element of development in the Portuguese Aerospace sector. This topic has been widely discussed in literature related with Industrial clusters, in the sense that project interaction and firm cooperation conjointly with the importance of specialized

infrastructures are essential factors to the cluster development, due to the share of information and knowledge spillovers. Besides, the mobility of employees from firm to firm provides an opportunity for knowledge diffusion and know-how within the cluster.

3.1.2. The Portuguese Aerospace cluster today

The most significant event for a potential Portuguese Aerospace Cluster occurred in the year of 2012 with the Embraer's investment of 148 million euros in the implementation of two manufacturing plants for aircraft structures/ components in the southern municipality of Évora: *Embraer Portugal Estruturas Metálicas, S.A.* and *EC Estruturas em Compósitos S.A.*, with the metal structures unit, receiving 100 million euros of the total investments and with the composite materials factory accounting for the remaining, 48 million euros. The investment is extended over 6 years and it aims to create 570 direct job posts.

The Brazilian Embraer has chosen Portugal as a pivotal location, mainly due to its relation to European markets, mainly Spain, and to the North African international relations. The choice of this country also appears as a corporate strategy to diversify the regions in which Embraer is present and due to the historical and diplomatic inter-relations between Brazil and Portugal. Here, diplomacy is envisioned as a complement to entrepreneurship and the cultural affinity between Portugal and Brazil has been also an aspect in the decision of Embraer's business implementation. Locally, the selection of the Industry Park for Aeronautics in Évora was the result of a thorough evaluation by the firm. Many relevant features behind this location choice can be explained in the light of the industrial clusters' literature, that highlight the agglomeration economies as attraction forces of the foreign direct investment, such as the potential access to a highly skilled workforce present locally (a local labor market), a dense network of supplier-user firm operators, logistical infrastructures (such as hangars), the existence of a technology park devoted to aeronautics, with a set of supportive entities and R&D centers, in conjugation with a municipal director public plan, aiming to promote the development of the Aerospace sector in the region of Évora. Also the proximity to transports infrastructures such as the airfields of Évora and Beja and the railway infrastructure of the surrounding areas allowing easy and fast access to the capital, Lisbon, to the seaports and connections with neighboring regions, including the Spanish territory, which has developed some of the most relevant Aerospace clusters in Europe - the Aerospace clusters in Madrid and in Andalucia.

The integral development of the aircraft KC-390 is the anchor project for the consolidation of the Aerospace cluster in Évora and for the whole Aerospace sector in Portugal. In terms of industry specialization within the cluster, Embraer produces the metal vertical stabilizers of the aircraft, the horizontal stabilizers in composite material and also the wing panels are manufactured in their factories, in Évora. The other two major contributors to this project are OGMA that manufactures the aircraft center fuselage, right and left sponsons and elevators, while it also assembles the sponsons, components that assure the stabilization of the aircraft. The contribution of OGMA started at the very first stage of the aircraft planning and design, as a result of partnership with Embraer. The company participated in the initial phase of product development (Joint Definition Phase) and on the development and management of a competitive and flexible sustainable supply chain. The other contributor is CEIIA, the Center for Excellence and Innovation in the Automotive Industry, with the project Engineering and Development of Composite and Metallic Structures (EDCMS) for Embraer aircraft KC-390. CEIIA involvement in the project comprises two major design and development products for the KC-390 - the Sponson and the Elevator. Like CEIIA, EEA (Aeronautical Engineering Company) is a direct supplier of Embraer in engineering, and makes the design and structural design of three modules: Rudder deep, the belly of the plane and the central fuselage, that thereafter in the production chain, are provided to OGMA who manufactures and assembles these parts of the aircraft.
Also, at the level of employment and skilled labor in the sector, important developments have been recently taken place. The education and training of highly skilled human resources by institutions like University of Beira Interior (UBI), Technical Institute of Lisbon (IST) and the Portuguese Air Force became an important factor in attracting foreign investment to the sector, either in aeronautical engineering or on more traditional engineering fields like informatics, mechanical and electronics.

The developments in the sector during the 2000s led to a clear change of strategy at the governmental level, with the responsibility of developing and consolidating a national Aerospace cluster on the part of the Portuguese government. In this context, the national Executive assumed a set of actuations in order to promote national competencies and the specialization of the Aerospace industry and to incorporate future aeronautical projects in the worldwide supply chains. With this purpose, the following directives were implemented by the Portuguese Ministers' Council (Diário da República, 2010:

pp. 1) Promote the aggregation of the key players associated with the aeronautical cluster and boost the creation of new technological players in order to foster the evolution of the sector; 2) Promote the growth and training of the national industrial and technological base, with special focus on the creation of new technology-based companies, on the attraction of foreign investment and finally and on the consolidation of this specific cluster; 3) Promote the effective, rational and complete utilization of the opportunities that arise from Defense acquisitions to develop the aeronautical sector."
With these directives, the government intends to maximize the potential of the sector and of the investments already done, channeling them to the creation and consolidation of the Aerospace sector in Portugal.

3.2. Firms and Start-ups in the Portuguese Aerospace sector

The membership of Portugal in the European Space Agency has resulted in a relevant impact on the development of the Aerospace sector, namely in the creation of new businesses that have acted as enabling agents to the entry of small and medium Portuguese companies in this sector's value-chain, predominantly as *Tiers 2* and *3* suppliers. In this process, it was very important the Emits (Electronic Mail Invitation to Tender System), which aims to guarantee the principle of fair competition and fair access to ESA's procurement at all levels. This allowed many small Portuguese companies to have access to projects that otherwise would be impossible, either by the financial capacity needed to work in these projects or by the difficulty of competing with already established companies in this sector in Europe, like Telespazio Spa, an European spaceflight services company, headquartered in Rome, or the Thales Group, a French multinational company that designs and builds electrical systems, headquartered in Paris.

Other decisive momentum that the Aerospace Sector in Portugal had towards the creation of firms and start-ups related to the sector had been promoted by the government support by strengthening the participation of Portugal in the optional programs of ESA, amounting to 10 million euros over the coming years, distributed by the major national interest programs, particularly in the areas of Technology (GSTP), Telecommunications (ARTES), Viewing land (GMES) and in Launchers (PRIDE) and Exploration (MREP). These programs are of particular interest for technological development and national business entrepreneurship. Additionally to those programs,

the inclusion of Portugal in the International Space Station (ISS) project has been contributing to the entrepreneurial efforts in the sector, as well as the installation of two factories of the Brazilian Embraer group in Évora, with governmental intentions of developing an Aeronautics and Aerospace cluster in the region, that has been fostering the installation and creation of new companies and the creation of a significant number of jobs at a localized level.

According to the catalog of 2013 (latest data available) provided by the Foundation for Science and Technology (FCT) on the Portuguese firms operating in the Aerospace sector, there are 21 specialized firms in Portugal, divided by five segments: Software, Hardware, Ground Segment, Space related services and Space Segment (cf. Figure 4).

Critical Software	Software		Ground Segment	Space Segment	Space Based Services
Deimos Engenharia	Software		Ground Segment		Space Based Services
Edisoft	Software		Ground Segment	Space Segment	Space Based Services
Eixo Digital	Software		Ground Segment		
Evoleo	Software	Hardware		Space Segment	Space Based Services
GMV	Software		Ground Segment	Space Segment	Space Based Services
Holos	Software		Ground Segment	Space Segment	
Spin.Works	Software	Hardware	Ground Segment	Space Segment	
Tekever	Software	Hardware	Ground Segment	Space Segment	Space Based Services
Ydreams	Software	Hardware	Ground Segment	Space Segment	
Visionspace	Software		Ground Segment		
Active Aerogels		Hardware		Space Segment	Space Based Services
ActiveSpace		Hardware		Space Segment	
CEiiA		Hardware	Ground Segment		
Efacec		Hardware		Space Segment	
Fibersensing		Hardware	Ground Segment	Space Segment	
HPS Portugal		Hardware	Ground Segment	Space Segment	
ISQ		Hardware	Ground Segment		Space Based Services
Kemet		Hardware		Space Segment	
Lusospace		Hardware	Ground Segment	Space Segment	
Omnidea		Hardware		Space Segment	

Figure 4 - Catalog Aerospace companies (2013). Source: Data provided by Foundation for Sience and Technology (2013).

All of them operate in several segments, but it is interesting to observe that is very rare for a firm to operate on both the software segment and the hardware, and also that the majority of the firms operating in this sector are present in three segments at maximum.

Tekever is the only one that operates on all the segments presented in the previews board. This indicates that all the firms are highly specialized in a particular stage of the production process. The majority of these firms' headquarters are located in the metropolitan area of Lisboa (Lisboa, Oeiras, Palmela, Caparica), most of them integrated in Technological parks (Oeiras), or established near the Palmela Automobile sector of AutoEuropa. Other important Aerospace hub in Portugal is the metropolitan area of Porto (Porto, Maia, Matosinhos). Here, the technological park, situated in Maia, is one of the most influential in the northern region of the country. Coimbra, a municipality in the center of Portugal, also constitutes an important hub for the sector, where have been developed companies like Critical Software and ActiveSpace, both with their headquarters in the Industrial Park of Taveira, Coimbra.

Lisbon appears as the major hub in the Software segment, with seven of the total eleven companies operating in this sector in Portugal. It should also be noted that a total of nine companies that operate in the Aerospace sector in Portugal have their headquarters in Lisbon, therefore only two of the companies headquartered in Lisbon do not operate in the software segment (ISQ and Lusospace).

On other hand, Porto is a hub for the Hardware segment, with six of the fourteen companies that work in that segment. Also important is that those six firms are also the total of companies headquartered in this region.

Coimbra appears as the third strongest Aerospace hub in Portugal with two of the total three companies operating in hardware segment and then Aveiro, Évora and Viseu only present one firm related to the sector.

Ground segment and the Space segment are the two strongest segments in Portugal, having respectively fifteen and sixteen firms operating in their segments. In the case of these segments they are more transversal to the entire country, but in the Ground segment, Lisbon has a dominating presence with nine companies operating in this sector, followed by Porto with four. In contrast, the Space segment shows a more even geographical distribution, where Lisbon has six companies working in this sector, while Porto has four, Coimbra has three companies. Additionally Space related services is the segment with the smallest number of companies operating in Portugal, with a total of eight, being five of them located in Lisbon, two in Coimbra and one in Porto.

Due to the specific requirements of this sector in a highly qualified labor force, in the presence of knowledge spillovers and the reliance on project cooperation, the

geographical location of Aerospace-related firms is directly related with the presence of higher-education institutions, innovation and research centers. The three cities with most firms in the sector have a strong academic tradition with the University of Lisbon, University of Porto and the centenary University of Coimbra, as well as with R&D institutions. University of Porto has one of the most noted research outputs in Portugal, being in 2013, the Portuguese University with more patent requests, backed by international relevant research centers like INESC (Research Institute of Computer Systems) and CEMUP (Materials Center of University of Porto). The city also harbors CEIIA (Center for excellence and Innovation for the Automotive Industry), an active player in the development of the KC-390 airplane of Embraer, and that was also essential in the creation of the Évora Cluster. However, the biggest catalyst and incubator of start-ups in Porto is UPTEC (Science and Technology Park of University of Porto), which has been promoting the development of technology-based companies and has been attracting innovation centers of national and international companies, by stimulating transference of knowledge between the universities and the market. Since the beginning of its activity in 2007, the UPTEC has supported the development of more than 300 business projects.

Lisbon is the other relevant pole of development for firms and start-ups related with the Aerospace sector. It is in the metropolitan area of Lisbon that TAP M&E and OGMA have their headquarters, they are the two biggest Portuguese companies in this sector in Portugal. It also is the only city out of the three that actually offers an academic degree specialized in the Aerospace sector, in the Technical Institute of Lisbon: the Master degree in Aerospace Engineering.

In turn, Coimbra is home to the IPN (Institute Pedro Nunes), that seeks to promote innovation and technology transfer by establishing a link between the scientific and technological environment and the productive fabric. Additionally, these three cities where chosen to receive the European Space Agency business incubator centre in 2014 with the goal of adapting space technology for non-space industrial and commercial uses.

These R&D centres have had an important role as firm incubators especially through the diffusion of knowledge that is generated by them and then transferred to new companies. In Porto, the most relevant cases in this context were the creation of Fibersensing, a company that monitors aircrafts structural integrity and building solutions for space, that was born of INESC, and the formation of Tekever, that

develops and delivers advanced technology and products that improve the quality of communication, information, and execution capabilities in the organizations. Tekever is present in the UPTEC incubator in Porto. In Lisbon, from the Technical Institute IST, technology-based companies linked to the Aerospace sector have been created in areas such as information and communication technologies. Driven by the possibility of accessing the equipment and laboratories of the Institute, this has allowed the emergence of companies like Lusospace, that operates from the concept definition, preliminary design, through the development, integration, testing and qualification stages; Spin.Work, a company dedicated to the development and manufacturing of aerostructures and unmanned systems for the Aeronautics, Space and Defense markets; and Omnidea, an aerospace technology and energy systems company, that also provides solutions to the challenges involved in any R&D activity. Another key center for the creation of companies in this sector is the IPN (Instituto Pedro Nunes) in Coimbra, whose incubator contributed, for example, to create the company Active Aerogels, Ltd., working on the development of innovative, high performance, heat insulation, based on aerogels and their derivatives.

Also, the foreign investment and the increasing linkages to the international value chain have also constituted crucial elements in the creation of new firms related to the sector in Portugal. The establishment of two factories of the Brazilian aircraft group, Embraer, in Évora mitigated one of the weaknesses of the Aerospace sector in the country, which was the lack of an Original Equipment Manufacturers (OEM) based in Portugal. Furthermore it has stimulated the creation of new businesses or new subsidiaries of other companies in the surrounding areas, as it was the case of the Mecachrome Aeronautics, a Portuguese company created in 2014 in Setúbal and owned by the French Group Mecachrome, that has announced the investment of 30 million euros in the construction of a new factory of metal components for the aeronautical sector that will be installed in the Évora Aeronautical Industrial Park. This was also the case of Air Olesa that is currently in the installation phase of a new plant also for the production of components for aircraft in the Évora Aeronautical Industrial Park.

All the Portuguese companies (already established and start-ups) can be included within the Tier 2 and Tier 3 of the Aerospace value chain (cf. Figure 2), where the specialization is highly focused on composite materials, like the case of the companies Amorim Cork Composites or the Salvador Caetano Aeronautics, both located in the Porto district (Santa Maria da Feira and Vila Nova de Gaia).

The active presence in consortiums and international cooperation agreements has allowed the related firms and start-ups such as Tekever, Active Space Technologies and Critical Software, to have access to several projects, with other Portuguese companies and international ones, like the project LIFE (Lighter, Integrated, Friendly and Eco-efficient Aircraft Cabin), with the aim of creating skills for design, development and industrialization of functional and technical solutions for aircraft interiors, and the project Paic Imperio UAS Project - Portuguese Civil UAS Development Programme, a consortium of Portuguese companies with the cooperation of Lockheed-Martin's, to build and provide a competitive civil Unmanned Aerial System (UAS).

The participation on European level consortiums constituted by one or two Portuguese firms and Aerospace firms from other countries allowed a dynamics of creation of related projects, firms and start-ups specifically related to the Tiers 2 and 3, such as the cases of Airbus and Salvador Caetano Aeronautics that emerged in Porto in 2015, producing machine parts of aluminum and titanium and components of composite material, or Tekever Space, also located in Porto, with the mission of designing, developing and commercializing cutting-edge systems for the Space market. Through these cooperation agreements and consortiums, the Portuguese firms have had access to knowledge and projects that would not be reachable to these firms, due to their small scale and dimension. Other important projects have been the participation of Portuguese companies in the European Aerospace Cluster Partnership (EACP), a platform of mutual trust and cooperation for European aerospace clusters that operates in three working groups: internationalization, strategy, and skills and innovation; and the Portuguese involvement in the European Skills Hub for Aerospace program, that aims to develop a connection between the different vocational education and training systems in Europe and the RUE AERO Project (Reaching Up to Excellence in Aerospace Cluster Management), which provides the means to improve the suppliers quality. This last project has been particularly relevant in the development of the Évora Aerospace Cluster, where the geographic proximity of specialized suppliers and the local availability of skilled labor and a trained young labor force are preponderant factors for the selection of Portugal as partner of big international aircraft players, such as Embraer.

The networking effect and the linkages with the international value-chain have also promoted the development of new related services in the sector. In 2005, the installation of Embraer has brought other companies to join the Aerospace cluster in Évora, which were attracted by the possibilities to do business with this third biggest airplane maker in the world. This was the case of the subsidiaries of international or national companies, like CapGemini, which is present in 44 countries and is one of the world's foremost providers of consulting, technology and outsourcing services; Air Olesa, a company operating on Aeronautical systems and components; and a myriad of Portuguese technological start-ups that have flourished in the Évora Cluster, like Flyeye, a company working in the Unmanned Aerial Vehicle (drones), or Mainsystems, a firm providing high performance technological solutions.

Despite the existence of these companies, the total number of start-ups in the Évora cluster is still low, which may be a consequence of the cluster's still recent development. In this context, the raising dynamics in the Aerospace cluster of Évora has been mainly sustained by the efforts promoted by the AICEP (Agency for Investment and Foreign Trade of Portugal), the ADRAL (Alentejo Regional Development Agency) and the CME (Municipality of Évora) in order to attract companies and worldwide suppliers to the cluster. The CME has accompanied these efforts with incentives for companies to settle in the Aviation industry park, together with the Government support to locate other services and relevant public institutions related to the sector in the region, on the basis of the new packages of Structural Funds - Partnership 2020 and Partnership Alentejo 2020 - with a prioritization to the development of the Aerospace Industry for the next decades. Also on the governmental efforts on the local cluster of Évora, it is relevant to notice the creation of specialized infrastructures by the City Municipality, namely the creation of the Aviation industry park, and the development of the technological Employment Center and Vocational Training of Évora (IFPE), providing specialized technical training in the areas of aeronautics and production processes. Another important aspect of the governmental support has been the direct investment made through EMPORDEF (Portuguese Defense Company) - a holding of the Portuguese Defense industries whose business is the management of shareholdings held by the State companies related with Defense activities - as an indirect form of performing economic activities, for example, with the creation of the Edisoft or EEA (Aeronautical Engineering Company).

In this context, the start-ups creation process within the Aerospace sector is also useful to explain the creation of start-ups in other related sectors of activity such as the Defense sector. Aerospace and Defense are two well connected sectors with companies that operate in both sectors, such as Tekever (Portugal), Lockheed Martin (United States of America), Holos (Portugal), Active Space Technologies (Portugal) and Critical Software (Portugal). Other sectors with a strong dependence on innovation and technology development will be able to correlate to this process of developing start-ups, where the influence of Government support and Foreign Direct Investment has been essential in their sustainability.

4. Concluding Remarks

This dissertation has its major aim in providing a deeper analysis and information on the development of the Aerospace industry sector in Portugal as well as in explaining the increasing dynamics of the Aerospace sector and the creation and development of firms and start-ups linked to this sector, in Portugal. In this context, this study contributes to the literature on a topic that remains fairly unknown when compared with other industrial clusters, in this country.

This study allowed to verify that the Aerospace sector in Portugal shares features of an industrial cluster with global connections to the worldwide value-chain. The firms in the sector share high benefits from the existing knowledge spillovers in terms of software development, hardware or in the production of composite materials. They also show requirements of a qualified labor force and of specific infrastructures of education (Universities, specialized vocational training centres), with a strong focus on mechatronics, a combination of systems engineering, mechanical engineering, electrical engineering, telecommunications engineering, control engineering and computer engineering. Another important feature on this sector is the support from internationally recognized institutions like EEA (Excellence in Engineering Aeronautics), that strives to improve the level of competitiveness of this sector in Portugal, allowing it to participate in the worldwide value chain of this sector, and the CEIIA (Center for Excellence and Innovation in the Automotive Industry), aiming to promote the growth of Portuguese companies in the international supply chains of Aerospace industries, through innovation and quality. The development of the Portuguese Aerospace sector has been also reliant on the efforts of R&D institutions, that research for innovative solutions and technologies with a strong connection to the industry, transmitting the knowledge there generated to the industry and thus creating value. These are the cases of INESC in Porto and the IST (Technical University) in Lisbon, which have been dynamic agents in promoting entrepreneurship in the Aerospace sector and enabling the creation of technological start-up companies in areas such as Information and Communication Technologies.

Additionally, the dependence on governmental support is also a highly noticeable feature of the Portuguese Aerospace sector. Being this sector constituted by small and medium firms, a constant support by the national government has been essential to the

history of this sector in Portugal and to its sustainability over the past decades. In this context, the membership of Portugal to the European Space Agency represented a first effort of the government to potentiate this sector; also important at this level, was the recent increase of the participation of Portugal in the ESA budget, which provided more opportunities of business to the Portuguese small and medium companies. Another important aspect was the international agreement between the Portuguese government and Embraer, that enabled the installation in Portugal of two factories by the Brazilian aircraft manufacturer, allowing the country to be closely involved in the production of an aircraft project and to participate as supplier in the international value chain. All the governmental support comes as crucial to the companies operating in this sector, that otherwise would not be able to compete at a worldwide level, either for financial capacities or due to their scale and dimension.

This study also allowed to understand that the effect of consortiums (e.g. COMPASS - Portuguese Consortium of Aeronautics Systems and software) with international suppliers (e.g., Embraer) along with the governmental support and the local efforts of regional policies (e.g. development of an aeronautical industrial park) has led to the development of a dynamic Aerospace cluster in Évora. It also demonstrated the existing vulnerabilities that this cluster faces, due to the high dependence on governmental support in order to assure its sustainability and growth.

Another feature that became clear was the necessity of networking and project cooperation (through the establishment of consortiums) with a net of highly specialized suppliers, nationally and foreign-owned, both at the level of knowledge transfer and trust among the suppliers and the OEMs' allowing the creation of a national value chain that is boosting the competitiveness of the sector. These facts highlight the important need that this sector has in terms of attracting foreign capital and to be involved in worldwide projects to achieve an international dimension.

In particular, it is essential to pursue policies to encourage the development of the sector in the region and attract more foreign suppliers, while it is also important to actually do the planned investments in improving the training capacity of the region, in fostering entrepreneurship, in attracting qualified people and in encouraging networking services (networks) to develop a national value-chain that can promote the competitiveness of the cluster, allowing it to expand and grow.

The future existence of a cluster in the Évora region involves the development of strategic partnerships between the government and the various companies that can stimulate the dynamics of competition and cooperation within the sector.

With the critical business and technological mass in place, it is necessary to encourage a dynamics of competition and cooperation among the companies, including the creation of joint brands, associations of producers and suppliers, purchasing platforms and contracting, partnerships or sharing services.

The Aerospace sector as a hub of innovation and technology should be the continuous recipient of investment by the Portuguese State, as this is a sector with spillovers of know-how and technologies that enable the creation of new companies, new products and services, benefiting the economy and creating skilled jobs. A country with a solid Aerospace sector is considered as developed at both economic and technological levels, but also developed in terms of its human capital. In this particular case, the efforts that have been channeled to the inland region of Évora have been able to create a cluster with the potential to stimulate the regional growth, the awareness of the region, the qualification of its human resources, the knowledge diffusion and the development of industrial skills that have been, up to the moment, mainly promoted in more developed, coastal regions.

Since this study has focused primarily on the historical evolution and recent dynamics of the Aerospace sector in Portugal, it lacks information on important topics that were beyond the scope of this dissertation and that can be properly developed in terms of future research, such as the impact of legislation by the Portuguese Government especially directed to this sector, in a final definition of a common national strategy for the development of a AED (Aeronautics, Aerospace, Defense) cluster, be it at national or at a local level, in this case, Évora. Another important topic would be to calculate the future impact of the installation of the two Embraer factories in Évora and its relation to the creation of new companies specialized in this sector namely the potential enhancement in the creation of business-related start-ups at the local level. These will constitute new challenging grounds to be explored in the future.

References

AICEP, Agência para o Investimento e Comércio Externo de Portugal, (2010), "Aeronáutica Portuguesa", *Revista Portugal Global*, pp. 1-35.

Audretsch, D. (2012), "Determinants of High-Growth Entrepreneurship", *OECD/DBA International*, pp. 1-27.

Audretsch, D., Fritsch, M. (2010), "Linking Entrepreneurship to Growth: The Case of West Germany", *Industry and Innovation*, Vol. 10, Nº. 1, pp. 65-73.

Audretsch, E. D., Santarelli B., Vivarelli, M., (1999), "Start-up size and industrial dynamics: some evidence from Italian manufacturing", *International Journal of Industrial Organization*, Vol. 17, pp. 965–983.

Aranguren, M. J., Navarro, I., (2003), " La política de clusters en la comunidad Autónoma del Pais Vasco: una primera valoración," *Ekonomiaz*, Nº53, pp. 90-113.

Bach, L., Cohendet, P., Schenk, E. (2002), "Technological Transfers from the European Space Programs: A Dynamic View and Comparison with Other R&D Projects", *Journal of Technology Transfer*, Nº. 27, pp. 321–338

Bawa, Y., Etxebeste, I., Konialian, M., Martin, J., Ruiz-Taboada, H., (2013) "Aerospace Cluster in the Toulouse Region", *Microeconomics of Competitiveness*, pp. 1-30.

Baxter, P., Jack, S., (2008), "Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers," *The Qualitative Report*, Vol. 13, Nº4, pp. 544-559

Becattini, G., Pyke, F., and Sengenberger, W, (1990), *Industrial Districts and Inter-firm Cooperation in Italy*, International Institute for Labour Studies, pp. 37-51.

Beaudry, C., (2010), "Entry, Growth and Patenting in Industrial Clusters: A Study of the Aerospace Industry in the UK", *International Journal of the Economics of Business*, Vol. 8, Nº. 3, pp. 405- 436.

Bergman, E. M. and Feser, E. J. 1999 Industrial and Regional Clusters: Concept and Comparative Applications. Web Book in Regional Science, Regional Research Institute, West Virginia University, accessed at 15 of March, 2015. http://www.rri.wvu.edu/WebBook/Bergma n-Feser/contents.htm

Biggiero, L., Sammarra, A., (2010), "Does geographical proximity enhance knowledge exchange? The case of the aerospace industrial cluster of Centre Italy", *International Journal of Technology Transfer and Commercialisation*, Vol. 9, Nº 4, pp. 283-305.

Black, S., (2010), "What's A Startup? First Principles", accessed at 3 of April, 2015. http://steveblank.com/2010/01/25/whats-a-startup-first-principles/

Catalog Aerospace companies (2013), *Foundation for Science and Technology*, pp. 1-47

Braunerhjelm, P., Feldman, M., (2006), "Cluster Genesis", *Oxford Press*, Nº1.

Calabrese, A., Campisi, D., Capece, G., Costa, R., Di Pillo, F. (2013) "Competiveness and Innovation in High-tech Companies: an Application to the Italian Biotech and Aerospace Industries", *International Journal of Engineering Business Management*, Vol. 5, Nº. 40, pp. 1-11.

Clifton, N., David, R., Ehret, O., Pickernell, D. (2011) "An Analysis of Actual and Potential Clustering Structures, Stakeholder Governance Activities and Crosslocality Linkages in the Welsh Aerospace Industry", *European Planning Studies*, Vol. 19, Nº. 2, pp. 279-309.

Chiaroni, D., Chiesa, V., (2006), "Forms of creation of industrial clusters in biotechnology", *Technovation*, Nº. 26, pp. 1064–1076

Clarysse, B., Moray N. (2004), "A process study of entrepreneurial team formation: the case of a research-based spin-off", *Journal of Business Venturing*, Vol. 19, pp. 55–79.

De Clercq, D., Arenius, P., (2006), "The Role of Knowledge in Business Start-up Activity", *International Small Business Journal*, Vol 24, Nº. 4, pp. 339–358.

Del Giudice M., Peruta, M. R. D. and Maggioni, V. (2013), "Spontaneous processes of reproduction of family-based entrepreneurship: an empirical research on the cognitive nature of the spin-offs", *Journal of Innovation and Entrepreneurship*, pp. 2-12.

Dostaler, I., (2013), "Competing in the global aerospace supply chain: The case of the Canadian aerospace industry", *Operations Management Research*, Vol. 6, pp. 32-43.

Elola, A., Valdaliso, J.M., López, S., (2013), "The Competitive Position of the Basque Aeroespatial Cluster in Global Value Chains: A Historical Analysis", *European Planning Studies*, Vol. 21, Nº. 7, pp. 1029-1045.

Evans, David S., and Boyan Jovanovic, 1989. "An Estimated Model of Entrepreneurial Choice Under Liquidity Constraints," *Journal of Political Economy*, Vol. 4, pp. 808-827.

European Space Agency (ESA) (2012), "ESA: Boosting Europe's Competitiveness and Growth", ESA Communication Production, pp. 1-36.

Fernandes, J.C.S., Ferreira, M.G.S., Haddow, D.B., Goruppa, A., Short, R., Dixon D.G., (2002), "Plasma-polymerised coatings used as pre-treatment for aluminium alloys", *Surface and Coatings Technology*, nº154, pp. 8-13.

Foundation for Science and Technology, (2011), "Survey of the Economic Impact of Portugal's Participation in ESA from 2000 to 2009", pp. 1-18.

Gans, J.S., Hsu, D. H., Stern, S. (2000), "When does Startup innovation spur, the Gale of creative destruction?," *National Bureau of Economic Reasearch*

Graham, G., Ahmed, P. (2000) "Buyer supplier management in the aerospace value chain", *Integrated Manufacturing Systems*, Vol. 11 Iss: 7, pp.462 – 468.

Gruntman, M., (2014), "Advanced degrees in astronautical engineering for the space industry", *Acta Astronautica*, nº103, pp.92-105.

Hollanders, H., Van Cruysen, A., & Vertesy, D. (2008). "Sectoral Innovation Systems in Europe: The Case of the Aerospace sector", *Maastricht: Europe Innova*.

Intell, (2005), "Diagnóstico do sector aeronáutico em Portugal", pp. 1-32.

Jacobs, D., de Man, A.-P. (1996), "Clusters, industrial policy and firm strategy: a menu approach.", *Technology Analysis and Strategic Management*, Vol. 8, Nº. 4, pp. 425-437.

Jovanovic, B., (1982), "Selection and the Evolution of Industry", *Econometrica*, Vol.50, Nº3, pp.649-670

Kalawsky, S. R. (2013), "The next generation of grand challenges for systems engineering Research", Conference on Systems Engineering Research (CSER13), pp. 834-843.

Kihlstrom, Richard E. and Jean-Jacques Laffont, 1979. "A General Equilibrium Entrepreneurial Theory of Firms Formation Based on Risk Aversion", *Journal of Political Economy*, Vol. 4, Nº. 87, pp. 719-748.

Korunka, C., Frank, H., Lueger, M., Mugler, J., (2003) "The Entrepreneurial Personality in the Context of Resources, Environment, and the Startup Process - A Configurational Approach", *Entrepreneurship Theory and Practice*, pp. 23-38.

Lucas, Robert, 1978. "On the Size Distribution of Business Firms", *The Bell Journal of Economics*, Vol. 9, pp. 508-523.

Krugman, P. (1991), "Increasing returns and economic geography", *Journal of Political Economy*, Chicago, USA: University of Chicago Press, 99 (3): 483-499.

Krugman, P., (1998), "What's new about the new economic geography?", Oxford Journals, Vol. 14, Nº2, pp. 7-17.

Marshall, A. (1922), *Principles of Economics*, Vol. 8, pp. 6-627.

Martin, R., Sunley, P., (2003), "Deconstructing clusters: chaotic concept or policy panacea?", *Journal of Economic Geography*, Vol. 3, Nº 1, pp. 5-35.

Masood, T., Erkoyuncu, J. A., Roy, R., Harrison, A. (2014), "Integrating design attributes, knowledge and uncertainty in aerospace sector", CIRP Journal of Manufacturing Science and Technology, N.º 7, pp.83-96.

McGuire, S., Islama, N. (2014), "Indigenous technological capabilities, emerging market firms and the aerospace industry", *Technology Analysis & Strategic Management*, pp.1-20.

Morosini, P. (2004), "Industrial Clusters, Knowledge Integration and Performance", *World Development*, Vol. 32, N.º 2, pp. 305–326.

Mulotte, L., Dussauge, P., Mitchell, W. (2013), "Does pre-entry licensing undermine the performance of subsequent independent activities? Evidence from the global aerospace industry, 1944-2000", *Strategic Management Journal*, Vol. 34, N.º 3, pp. 358-372.

Newlands, D. (2003) "Competition and Cooperation in Industrial Clusters: The Implications for Public Policy", *European Planning Studies*, Vol. 11, N.º. 5, pp. 521-532.

Niosi, J., Zhao, J.Y., (2013), "China's catching up in aerospace", International Journal of Technology and Globalisation, Vol. 7, Nº1-2, pp.80-91.

Niosi, J., Zhegu, M. (2005), "Aerospace Clusters: Local or Global Knowledge Spillovers?", *Industry and Innovation*, Vol. 12, Nº. 1, pp. 5–29.

Venturini, K. Verbano, C. (2014), "A systematic review of the Space technology transfer literature: Research synthesis and emerging gaps", *Space Policy*, N.º 30, pp. 98-114.

OECD, (2001), "Special Issue on Fostering High-tech Spin-offs: A Public Strategy for Innovation", *OECD Publications*, Nº. 26, pp. 7-171.

O'Sullivan, A., (2006), "Why tense, unstable, and diverse relations are inherent in co-designing with suppliers: an aerospace case study", *Oxford University Press*, Volume 15, Nº. 2, pp. 221-250.

Petroni, G., Verbano, C. (1999), "The development of a technology transfer strategy in the aerospace industry: the case of the Italian Space Agency", *Technovation*, No. 20, pp. 345-351.

Porter, E. M., (2000), "Location, Competition, and Economic Development: Local Clusters in a Global Economy", *Economic Development Quarterly*, Vol. 4, Nº.1, pp.15-34.

Porter, M. (1998), "Clusters and the new economics of competition", *Harvard Business Review*, Nº11, pp. 77-98.

Rabellotti, R., (1995), "Is there an Industrial district model: Footwear districts in Italy and Mexico compared", *World Development*, Vol. 23, pp. 29-41.

Rebolledo, C., Nollet, J., (2010), "Learning from suppliers in the aerospace industry", *Int. J. Production Economics*, Nº. 129, pp. 328–337.

Redman, J. (1994) "Understanding State Economics through Industries Studies", *Washington DC: Council of Governor's Policy Advisors*.

Ribeiro, H., Oliveira, M., Ribeiro, N., Cruz, A., Ferreira, A., Machado, H., Reis, A., Abreu, I., (2009), "Pollen allergenic potential nature of some trees species: A multidisciplinary approach using aerobiological, immunochemical and hospital admissions data", *Environmental Research*, nº109, pp. 328-333.

Rocha, H., Sternberg, R., (2005), "Entrepreneurship: The Role of Clusters Theoretical Perspectives and Empirical Evidence from Germany", *Small Business Economics*, Vol. 24, pp.267–292.

Rosenfeld, Stuart A. (1997) “Bringing Business Clusters into the Mainstream of Economic Development”, *European Planning Studies* Vol. 5 No. 1, pp. 3-23.

Sinha, P., Whitman, L., Malzahn, D., (2004) "Methodology to mitigate supplier risk in an aerospace supply chain", *Supply Chain Management: An International Journal*, Vol. 9 Nº. 2, pp.154-168

Schumpeter, J.A. 1912. “The Theory of Economic Development”, Cambridge: Harvard University Press, Vol.2.

Schumpeter, J.A. 1947. “Theoretical Problems of economic Growth”, *The Journal of Economic History*, Vol. 7, pp. 1-9

Smith, D.J., Tranfield, D., (2005), “Talented suppliers? Strategic change and innovation in the UK aerospace industry”, *R&D Management*, Vol. 35, Nº 1, pp. 37-49.

Stubner, S., Wulf, T., Hungenberg, H. (2007), “Management Support and the Performance of Entrepreneurial Start-Ups – An Empirical Analysis of newly founded companies in Germany”, *Management Support*, pp. 138-159.

Yin, R. K. (2003). “Case study research: Design and methods”, *Sage Publications*, Vol.5, Nº.3, pp. 1-108.

Zuliani, J.M., (2008), “The Toulouse Cluster of On-board Systems: A Process of Collective Innovation and Learning” *European Planning Studies*, Vol.16, Nº5, pp. 711-725.