The Aerospace Industry: a Descriptive and Prospective Empirical Analysis for Portugal

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Abstract – This paper aims at providing some key elements for better understanding the aerospace sector, particularly in Portugal. A characterization of the aerospace industry is therefore developed, with particular focus on a comparative analysis between the main key-players in the aerospace sector in Portugal and all the other companies that are trying to enter this competitive industry.

The main results suggest that major Portuguese firms with activity in the aerospace sector are more likely to develop R&D and marketing activities than the remaining companies. Moreover, core aerospace organizations seem to cooperate more with other companies or institutions.

Results on different characteristics and outputs among aerospace organizations bring contribution at different levels, namely, to the academic discussion on the topic; to organizational management and also to help guiding policy making and the design of specific public policies aimed at such a complex industry like the aerospace.

1. INTRODUCTION

Over the years, the aerospace sector has had a notorious impact on the emergence of new markets and, consequently, new goods and services that can fulfil consumers’ needs and improve the quality of life. In fact, the development and use of aerospace applications fostered knowledge spillovers, technological innovation and, consequently, have had an important socioeconomic impact worldwide (ACARE, 2008), (Goehlich, 2008), (OECD, 2007).

Aerospace is widely recognized as a leading sector regarding high technology and innovation (Loschky & Nuortila, 2009), due to its importance on enhancing and maintaining national security systems (Lorell & Levaux, 1998), as well as an integrator of innovative technologies. Moreover, the specificity of this sector contributes to a great extent to the onset of new companies and, as a result, more places for highly qualified jobseekers. For these reasons, the aerospace sector is considered to play a fundamental role on countries’ socioeconomic development (Diário da República, 2010) (Regeringskansliet, 2005) (Hollanders, et al., 2008).

Even though aerospace related activities are considered important for the economy and society in general, academic knowledge about this specific industry seems to be piecemeal mostly because the sector’s inherent specificity and numerous dimensions of the analysis involved (Gabbai, 2005). This article aims at contributing to address this gap in the literature by shedding new light on the main specificities and evolution of the aerospace sector across the last decade, with a special focus on the Portuguese case. Specifically, this encompasses the understanding of which companies are part of the sector and what is their contribution to the aerospace sector in Portugal, in order to provide both a descriptive and prospective analysis of the sector in Portugal.

Since data and statistics available for the aerospace sector are significantly underdeveloped in a vast group of countries (Gabbai, 2005) and, particularly, in Portugal (INTELI, 2005), an important goal for this article is to gather and analyse several sources of information (secondary data) and to design and implement a comprehensive questionnaire (primary data) in order to provide a detailed descriptive analysis of the sector’s evolution over the last 10 years, as well as a prospective analysis about the development of the aerospace sector in Portugal over the next 10 years. The notorious lack of knowledge about this sector, plus the dearth of structured information about the aerospace sector in Portugal, acts as a motivational factor to try to bring new empirical evidence about this research topic in Portugal, which can hopefully bring some contribution for further academic investigation.

After the introductory chapter, the remaining article proceeds as follows: the next chapter will provide a description of the aerospace sector, with special focus on the Portuguese case, Chapter 3 brings a clearer understanding about the data and methodology used throughout this article. In Chapter 4, research findings, drawing on quantitative and qualitative data, are presented and examined. Finally, Chapter 5 will conclude the present work by providing more detailed discussion of the main outcomes of the results, as well as, a set of suggestions and remarks regarding further research on the topic.

2. AEROSPACE SECTOR

The term aerospace is typically used to refer to the industry that develops and provides aeronautical and space products and services (OABAAC, 2010). Therefore, the aerospace sector is composed of two main and overlapping branches: aeronautics and space. While the former deals with craft that stay within Earth’s atmosphere, the latter deals with craft that operate outside it. However, the fact that both are intrinsically connected in terms of technology and knowledge-base explains why they are often presented as being one – the aerospace (Silva, et al., 2005).

2.1. Structure of the aerospace sector

According to the European Association of Aerospace Industries (AECMA, 2002), the organizational model of the aeronautical industry supply chain is stratified and hierarchically organized into “tiers”. At the top of the pyramid there are the product integrators, Original Equipment Manufacturer (OEM), who are responsible for product
development and supply-chain management. Therefore, these companies own the project and select the systems, structures and major components suppliers, from the second tier. At the third level one can find mainly a very concentrated group of Small and Medium Enterprises (SME) offering parts and components assembled by tier 2 and sometimes even by tier 1 firms. Even if these firms often get most of their revenues from the aerospace industry, they are also offering their products and services to a large range of other industries.

2.2. International Context

For many decades, the US aerospace industry was dominant worldwide. Today, the world civil market has evolved into the highly competitive duopoly of Boeing and the European Aeronautic and Defence and Space Company (EADS). Looking at the top 100 aerospace companies in the world (ranked by sales) can provide a picture of the aerospace sector performance over the past 10 years, see Figure 1.

Before proceeding, it is important to take into account several factors, which have had an impact in the aerospace sector during the last decade:

- September 11 attacks have had a tremendous impact in the aerospace sector since it increase people’s fear of flying, leading to a reduced use of airlines fleets and, therefore, causing a decline in maintenance requirements from airlines (Ito & Lee, 2004) (IATA, 2011);
- Deterioration of economic conditions due to the financial crisis in the end of 2008, which alongside with the rise of the volatility in fuel prices led to the growing pressure in defence budgets. These factors have contributed to an increasing search for efficiency, stronger promotion of exports, more selective investments and rationalization of products portfolios (ASD, 2010) (IATA, 2011).

2.2.1. Turnover

Figure 2 depicts the US and the European aerospace industry turnover across the last decade.

2.2.2. Exports

Aerospace exports are typically used as a major indicator of competitiveness among the aerospace industry since it reflects the ability of countries to create and sustain high-skilled and high-wage jobs. It is equally or even more important to recognize that exports are necessary to sustain and increase the capacity for cutting-edge innovation and to fund research and development that will underpin next generation aerospace technology. Figure 3 shows the EU and US aerospace exports evolution in the last decade, using ASD and Aerospace Industries Association (AIA), as source to the EU and US exports respectively.

As shown in Figure 3, the European aerospace industry has been reinforcing its position as a global actor serving markets all over the world and overcoming the US after the financial crises in 2008. As expected, the main downward was after the
September 11, 2001, due to a greater fall in European exports reflecting the difficulties incurred by the US airlines and the downturn in the world economy. After 2004, exports started recovering from the 2001 downturn. However, if on the one hand the European industry reaching its higher point in 2010, due to the rise in export opportunities outside Europe (in particular the Middle East and Asia), on the other hand the US exports have reached its highest point in 2008 and after that experienced a new decline. Since the US have the biggest defence market, the US industry can still remain competitive producing to its internal market and without exporting.

2.2.3. R&D Expenditures

Investment in R&D, as well as in new programmes, education and skills provision is of foremost importance for the sustainability and development of a technology-intensive industry such as the aerospace. Figure 4 shows the European and US R&D expenditure.

![Figure 4 - European and US R&D expenditure. Source: ASD Facts & Figures, OECD and AIA.](image)

It can be seen from Figure 4 that US R&D expenditure in the aerospace sector during the considered period of time has been significantly higher than European expenditure. However, since 2008 there is no available data for the US investment in R&D and in within a context of financial crisis, the figures for the US R&D expenditure might decrease significantly.

2.2.1. Employment

Figure 5 shows the number of employees for the US and European aerospace sector.

![Figure 5 - EU and US aerospace number of employees. Source: ASD Facts & Figures.](image)

Alongside turnover, employment also presents a downward trend after the September 11, 2001, followed by an ascendant trend after 2003. However, with the financial meltdown of 2008, while the European workforce has remained slightly the same, being marginally affected by the crises, the US workforce has decreased. Additionally, since the turnover has increased in this period of time, it is expected an increase in sector productivity.

2.3. An outlook for Portugal

2.3.1. Public Policies

In the last years, the governments’ approach to the aerospace industry has been marked by a change from direct financial support to a stronger commercial relation. This has happened due to the reduction of available budgets for defence. Consequently, governments have encouraged mergers so that they can benefit from important synergies, which enable them to obtain higher values, lower costs, reducing the development costs and the associated risk. Therefore, the aerospace manufacturers have pursued partnerships and sharing of costs and development risks. This is important because the results, although solid, take long term development cycles. It is therefore crucial to define adequate public policies in order to assure stability in this sector. In this sense, the Portuguese government had taken two important steps in the last decade, namely:

- Portugal’s participation in European Space Agency (ESA) (November 2000);
- Portuguese Aeronautical Cluster Development (October 2010).

2.3.1.1. Portugal’s Participation in ESA

Space activities are characterized by their highly complex, multidisciplinary, technological and scientific challenging and international nature. Consequently, and similarly to what happens in the European partners, whose activity in this sector have started long time ago, Portugal’s participation in space activities can greatly benefit Portuguese society, as long as based on clear decisions, reasonable funding levels and appropriate management. Therefore and, in accordance with the R&D national strategy for space (2004), these benefits can be translated in: internationalization, highly qualified employment, knowledge transfer, social impact, national recognition.

2.3.1.2. Portuguese Aeronautical Cluster Development

The Portuguese government has assumed the need to develop a national aeronautical cluster in order to promote national competencies and to integrate important aeronautical project supply chains. Therefore, in order to achieve this goal, the following tasks were defined by the Portuguese ministers’ council (Diário da República, 2010):

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, on the consolidation of this specific cluster;

3. Promote the effective, rational and complete utilization of the opportunities that arise from defence acquisitions to develop the aeronautical sector.

2.3.2. Market Structure and Evolution

The leading Portuguese aerospace companies are OGMA – Indústria de Portugal, S.A. and TAP Maintenance and Engineering (TAP M&E). These two companies operate in the aeronautical sector, mainly in the maintenance field. In addition to these companies, there are several high qualified SMEs, as well as small subsidiaries of international groups, positioned in tier 3, which manufacture aerospace products and provide relative services. The majority of these companies already have a significant record of participation in international supply chains.

2.3.2.1. Turnover

The Portuguese aerospace turnover was calculated based on the INE’s available data for the indicator Statistics of Industrial Production. This indicator provides information about the total sales volume for companies, whose main activity is characterized for manufacturing of aircraft, spacecraft and related equipment, as well as, repair and maintenance of aircraft and spacecraft, see Figure 6.

![Figure 6 - Portuguese aerospace turnover. Source: INE.](image)

As shown in Figure 6, the Portuguese turnover slightly increases from 2002 until 2004, where it marginally decreases to 2005. In 2006, there was a steady increase in the turnover, which might be explained by the state capital injection in OGMA’s capital, after its privatization, boosting its turnover. Notice that 2006 is the first year after OGMA privatization that the firm has profit. However, the state capital injection does not explain the continuity of this effect after 2006. Therefore, the steady increase may also be caused by a big company change of CAE. After that, the trend was upward until 2008, when the financial crises occurred, leading to a decrease in 2009.

2.3.2.2. Exports

The evolution of the Portuguese aerospace exports were calculated from INE’s Statistics of Industrial Production by adding the sales to EU with sales to third countries, see Figure 7.

![Figure 7 - Portuguese aerospace exports. Source: INE.](image)

As it can be seen from Figure 7, the Portuguese exports have been growing slightly until 2005, which was followed by a steady increase, rising to more than double. This might be caused by a company change of CAE in order to establish the main activity as manufacture of aircraft, spacecraft and related equipment. After that there was a sharp rise in the exports characterized by adding of repair and maintenance to the sector activity. It is therefore important to notice that OGMA maintenance activity accounts with 80% of its activity (INTEL, 2005).

2.3.2.3. Employment

Since there is no available data in INE on the number of employees working in the Portuguese aerospace sector, data from ASD Facts & Figures is used for the purposes of the present analysis. However, this publication only provides the number of employees working in the aerospace and defence sectors, considering also the naval, land,ammunitions and other equipment sectors.

It is also important to notice that the value used for the number of employees in 2008 was corrected in accordance to DANOTEC information. According to DANOTEC, in 2008 the approximately 1900 employees of TAP M&E had not been accounted in ASD Facts & Figures since this value was not available at the time. Therefore, out of the 2700 employees for the aerospace and defence sector provided by ASD were added 1900 from TAP M&E in 2008.

![Figure 8 - Number of employees working in the aerospace and defence sectors in Portugal. Source: ASD Facts & Figures & Danotec.](image)

As detailed in Figure 8, there were some fluctuations in the number of employees, but the trend was upward until 2007. In 2008, the late delivery of the employee data of other companies might have caused the downward trend. After that and with the global economic crises the number of employees working at the aerospace and defence sector have slightly
3. DATA AND METHODOLOGY

3.1. Research Design

Information about the most important economic indicators is usually collected by taking into account the type of economic activity. In Portugal, the aerospace sector is registered with CAE-Rev.3 30300 – manufacture of aircraft, spacecraft and related equipment, or with CAE-Rev.3 33160 – repair and maintenance of aircraft and spacecraft.

An assessment of the scientific literature on the topic, revealed an evident lack of knowledge about the aerospace sector in Portugal. Therefore, since there is no complete and updated list of the organizations (companies and institutions) which constitute the aerospace sector in Portugal, the first step in order to overcome this problem is to identify the organizations which have contributed or aim to contribute to one or more phases of the lifecycle (since R&D until dismantlement) of aeronautical and space equipment and systems.

3.2. Data Collection

3.2.1. Secondary data

An exhaustive research on the topic revealed the fact that there is no complete and updated list of the organizations which constitute the aerospace sector in Portugal, being such information disperse through various entities. Therefore, in order to identify the universe for analysis, information was collected through several sources, namely: INE, PEMAS, Proespaço, Space Office, AeroPortal Project, INAC, Relatório nacional do projecto europeu EADS: Estratégias Territoriais do Sudoeste Europeu, Estratégia nacional de investigação e desenvolvimento tecnológico para o espaço, Take-Off magazine, CORDIS, report prepared by Comissão Executiva da Especialização em Engenharia Aeronáutica do Bastonário da Ordem dos Engenheiros.

As a result of this data collection, a directory of organizations which have contributed to one or more phases of the equipment and systems lifecycle of aeronautical and space applications was built.

At this point, with a complete and updated list of organizations, one can carry out an empirical analysis, defining the population as the organizations, which have been operating in the aeronautical and space sectors in Portugal since 2000 until 2010.

To sum up, data collection elapsed a target population of 140 companies and 32 institutions.

3.2.2. Primary data

While creating the questionnaire particular effort was put on its methodological validation. Therefore, a specific literature review was made in order to find similar studies on sectorial analysis and innovative trends, which have also recurred to survey analysis.

The decision to include a group of questions regarding the aerospace entrepreneur relies on the increasing need of empirical investigation on the various professional groups (Marques, et al., 2011). This is justified by the importance of entrepreneurs for the economy development (Fragoso, 2008).

Thus the questionnaire includes a group of questions about innovation in enterprises, which were adapted from the Community Innovation Survey1 (CIS). Hence, for the case of the present study, the CIS questionnaire was adapted to two questionnaires, one aimed at firms and another to institutions. Both questionnaires have been structured into six groups, see Figure 9.

![Figure 9 - Questionnaire survey flowchart.](image)

Data collection has had a target population of 140 companies and 32 institutions, from which 48 companies and 17 institutions have replied, accounting for 34% and 53% respectively.

3.3. Sample

Two groups of analysis were created. One composed by the most representative organizations in Portugal and another one which accounts with the remaining organizations. In order to define which are the most representative organizations to the aerospace sector in Portugal one had to select the ones which importance is most significant for the Portuguese aerospace sector, namely: organizations which belong to PEMAS and Proespaço, organizations which have participated in EU Commission framework projects for R&D (from CORDIS database), OGMA and TAP.

As a result, Group 1 accounts for 50 organizations and from those, the ones that have answered the survey represent 64% of the G1. Group 2 accounts for the other organizations that have answered the questionnaire survey (these organizations have attested their connection to the aerospace sector).

4. RESULTS

4.1. Data Analysis

4.1.1. Respondents Profile

In order to study the respondents profile in terms of their professional category and position held in the organization, the univariate analysis was used. The great majority of the respondents were the top managers of the company (88%).

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Therefore, the responses obtained are more likely to provide accurate data about the company.

### 4.1.2. Entrepreneur

Since the main purpose of this section is to characterize the profile of the entrepreneur in the aerospace sector and since the great majority of the institutional respondents are not institution founders, the present analysis only considers the answers of the company respondents.

Among the respondents, 41% (20) are the founder or at least one of the founders of the company.

The entrepreneur is usually a male (95%), whose average age is 36 years.

More than 80% of the entrepreneurs in the aerospace sector have tertiary background, mainly in engineering. Notice also that entrepreneurs whose background is aerospace engineering only accounts for 5%

More than half of the founders had a job before having created the company. Furthermore, the majority of them have no previous experience in companies’ creation.

Almost 80% of the companies’ founders have had some previous experience in the same sector of activity and for most of them that experience was for more than 5 years.

Also, more than half of the founders have a relative who is an entrepreneur and most of them have also had an international experience.

![Figure 10 – Important factors for creating a business in the sector.](image)

From the Figure 10, one can notice that the most important factors for the entrepreneur’s decision of creating a company are professional fulfillment and the opportunity of taking a good business. Otherwise, founders have stated that dissatisfaction with previous employment is not an important factor.

This highlights the fact that entrepreneurship in the aerospace industry is, apparently, much more opportunity-based than necessity-based (see, for example, GEM (2010) for additional insight on this classification), meaning that instead of being pushed into entrepreneurship from unemployment or lack of good conditions on their previous occupation, businesses are driven by individuals’ capability to identify and explore new entrepreneurial opportunities.

### 4.1.3. Organizations’ main characteristics

From the inquired organizations, about half of them have been created on last decade and the district where most of them are located is Lisbon, followed by Porto and Leiria.

The most common CAE among the inquired companies, which are CAE-Rev.3 25734, CAE-Rev.3 30300, CAE-Rev.3 33160 and CAE-Rev.3 71120, which stands for metal mould manufacture; aircraft, spacecraft and related equipment manufacture; aircraft and spacecraft repair and maintenance; engineering and related activities, respectively. And, more than half of the queried institutions have R&D as main activity, which is a clear indicator of the knowledge intensity that characterizes this particular sector in Portugal.

From the respondent organizations, one can verify that firms are more likely to be a Sociedade Anónima or a Sociedade por Quotas, whereas one finds that a variety of institutions are: research centres (44%), laboratories (19%), associations (12%) and others, which is in accordance with the main activity carried out by the institutions.

Although most of the queried firms belong to a group of companies (54%), most of them are not the headquarters of the group. However, group headquarters are situated mostly in Portugal. On the other hand, institutions usually are integral parts of another entity, for example research institutions, like research centres and laboratories are very often integrated in a university campus.

### 4.1.4. Organizations’ socioeconomic information

As mentioned earlier, more than half of the queried companies were Sociedade por Quotas and since the minimum amount of money to constitute a company of this type is 5 000€, while to constitute a Sociedade Anónima the minimum amount of money is 50 000€. Therefore, it is expected the former category predominates. As expected, there is a high incidence of cases where the initial investment for start-up creation was of between 5000 and 9 999 €.

It is evident from the results that most of the companies’ capital is private, whereas on institutions there is no such distinction, capital is mainly public. On the other hand, the great majority of aerospace institutions in Portugal have nonprofit purposes. However, they might have profit purposes in order to invest in R&D activities.

Also, both companies and institutions have, in average, grown since the establishment year until 2010. Therefore, the number of personnel has risen significantly, as well as the female personnel and the pay level. Furthermore, one can observe that, as expected, the higher is the education level, the higher will be the remuneration level. Moreover, females and employees with PhD studies or more advanced educational level are, in general, more likely to work in institutions than in companies.

Most of the surveyed organizations have already had some activity in the aerospace sector. The reason for some organizations answering “no” to this question might mean that they aim to start activity in the aerospace sector in the future.

Most of the organizations have started its activity in the aerospace sector at 2000 or after that, which can suggest that after Portugal had joined ESA in 2000, more companies that develop activity in the aerospace field were created in Portugal.

The most underrepresented domain of activity in the aerospace sector is the military spatial. It is also important to
notice that most of the organizations accounts with less than 5% of its activity in the aerospace sector, which might suggest that the aerospace sector only represents a small percentage of their business. Data suggests that in the aerospace sector products from the inquired companies are composed by both goods and services, while in institutions’ products are mainly services, which is expected since the inquired institutions are mainly investigation centres.

Although most of the inquired organizations do not have any certification to operate in the aerospace field, companies are most likely to have one.

4.1.5. Innovation in the aerospace sector

This section aims at providing some insight about innovation in the aerospace sector. Since the answers between companies and institutions do not differ significantly, responses will be analysed together.

Most of the organizations have introduced innovations in the aerospace sector and that these innovations were mostly developed by the organization itself or by the organization group.

Furthermore, while the great majority of the innovations introduced in the aerospace sector were new to this sector the same is not true for the organization itself, what may suggest that organizations apply knowledge coming from other areas of expertise to the aerospace sector, introducing innovations in this sector of activity.

Only 21% of the inquired organizations have introduced a patent in the aerospace sector.

Most of the organizations have already developed the mentioned activities oriented to innovation in this sector of activity. Moreover, it seems that R&D is the most popular innovation activity in the aerospace sector, accounting for more than 80% of the organizations.

In the establishment year almost half of the companies have invested less than 5% of its turnover in innovation activities in the aerospace sector, which is expected since it was mentioned before that most of the companies do not see the aerospace sector as their main activity. Therefore, it comes with no surprise that the percentage of companies which applied less than 5% have been reduced in 2010 and the companies that apply between 5 and 25% have increased.

It is also important to notice that companies which applied more than 75% of its turnover in innovation activities in the aerospace sector in the establishment year have decreased in 2010, moving to the 50 – 75% category. This might suggest that companies, which initially dedicated entirely to the aerospace sector, have moved to other sectors of activity or that the products that they developed are being sold.

More than half of the organizations receive funds to develop activities in the aerospace sector. Although the funds are mainly from national and EU sources, other funds seem also to play an important role in funding the organizations, since it accounts for more than 30%. The most common financial funds originate – or are related with – Quadro de Referência Estratégico Nacional (QREN), FP7, FCT and ESA.

Figure 11 - Factors’ importance for innovation activities in the aerospace sector.

It can be observed from Figure 11 that the inquired organizations stated that the most important factor for innovation in the aerospace sector is clients. Nevertheless, organizations appear to play a very important role in innovation activities.

The great majority of the organizations cooperate with other companies or institutions. Apart from cooperating inside the organizations, the inquired companies and institutions are most likely to cooperate with national universities and R&D public institutions.

4.1.6. Aerospace Sector Evolution

Again, in this section the companies and institutions questionnaires results will be presented together since no significantly differences were found.

Figure 12 - Factors importance for the aerospace sector evolution in Portugal.

According to the queried organizations the most important factors to consider about the aerospace evolution in Portugal (Figure 12) are both qualified personnel and partnerships. It is important to notice that internal market have little importance for the organizations.

The experts’ opinion about the aerospace sector evolution in
Portugal is not consensual. Figure 13 summarizes the main scenarios for the sector's evolution base on the opinion of 30 experts.

![Figure 13 - Main aspects pointed out by experts (30) for the Portuguese aerospace sector evolution in next 10 years.]

As it can be observed from Figure 13, some experts claim that the aerospace sector will be affected by the economics and financial crises and therefore, due to the fierce and global competition in this sector associated with the lack of organization, future planning, qualified workforce, which may cause the loss of market share for the most fragile companies. Therefore, experts believe that the sector evolution in Portugal will be slow, secured by some isolated key-companies. On the other hand, the most optimists seem to think that partnerships, R&D activities and components manufacturing may lead to the growth of the aerospace sector.

Relatively to aeronautics experts claim that the aeronautical cluster and the two Embraer plants will boost this industry since it will promote sales growth, high-qualified employment creation. Moreover, small and medium companies might have a great opportunity to integrate the aeronautical supply-chain, acquiring knowledge, which could be extremely valuable to start participating in other international projects.

In what concerns the space domain, experts believe that since it relies on institutional funds, namely the governmental connection to ESA, it will be less exposed by the financial crises. Nevertheless, now without the ESA-PT taskforce, Portugal competes directly with other member states, in more fierce competition.

Despite the difficulty in predicting accurately the future of the aerospace sector in Portugal due to lack of organization and future planning, associated with the fierce and global competition, organizations need to be aware of key strategic issues for the development of the sector. Hence, this requires planning ahead a long-term national strategy for the sector evolution, with well-defined objectives so that national firms and institutions can be adequately promoted and encouraged. It is also important to involve technical schools and universities in order to form qualified personnel.

According to the respondents' perception, it is almost certain that most of them will continue to grow despite the economic and financial crises. Therefore, they intend to provide high quality products to specific niches of the aerospace sector, becoming a reference in the international market of this industry. On the other hand, some claim that in order to achieve that, first they have to overcome the economic and financial crises that Portugal and the world are undergoing.

### 4.2. Aerospace key-players in Portugal: a statistical analysis

In this research work, two groups were identified through the exhaustive mapping of the organizations with activity in Portugal in 2010, the main key-players in the aerospace sector in Portugal and all the other companies that are trying to enter this competitive industry.

This section provides and discusses statistical results obtained from the comparison between the companies that were considered key players in the aerospace sector and the remaining companies. The analysis will focus on the existence of significant differences between these two groups, with respect to organizations' general characteristics. In the sample, the organizations which have a key role in the Portuguese aerospace sector (32) are slightly less than the ones that intend to actively contribute to the aerospace industry (33). Therefore, this section aims at testing the existence of statistical significant differences between the Portuguese aerospace key-players and the remaining organizations, in terms of: its main characteristics; its socioeconomic information; Innovation in the aerospace sector; and, aerospace sector evolution.

In order to investigate these associations the Chi-Square independence test will be used to verify if there is a significant association between the two groups of organizations in the aerospace sector in Portugal and some of the collected variables. Although the Chi-Square independence test was performed for every variable, only the relevant results will be presented, that is for p-value less or equal to 0,1.

#### 4.2.1. Organizations' main characteristics

The organizations' main characteristics were analysed in order to understand if there are significant associations between the variables: establishment year, legal form and organization group (if an organization belongs to a group of companies/institution or not).

In these variables, for a significance level of 90% there were statistical significant differences for firms’ legal form and for organization group. For the other variable tested there is no statistical significance.

In the legal form analysis according to the firms' importance in the Portuguese aerospace sector, see Figure 14, it can be seen that 61% of the aerospace key-players are Sociedades Anónimas, since most of the companies in group 1 are larger companies, while only 19% of other firms present this legal form.

Moreover, the calculation of the Chi-Square independent test with the continuity correction has shown a p-value of 0,007, which indicates a relationship between the legal form and the firms' importance for the Portuguese aerospace sector. To measure the degree of association of the variables, it has
been used the Cramer’s V coefficient, whose value is 0.426, indicating that the association between this two variables is moderate.

Likewise, it has been analysed if the fact of an organization belong to other entity are associated with its importance in the Portuguese aerospace sector. As it can be observed from Figure 15, while 69% of the organizations which have a significant contribution for the Portuguese aerospace sector belong to other entity, only 41% of the remaining organizations belong to other entity.

The Chi-Square independence test has shown a p-value equals to 0.027, meaning that the fact of an organization being a part of other entity is related to its importance for the aerospace sector in Portugal, being the degree of association 0.284 (using the phi coefficient).

4.2.2. Innovation in the aerospace sector

This section presents and discusses the main differences in terms of innovation in the aerospace sector between the central organizations in the Portuguese sector that have answered the questionnaire and the rest of the respondents. From the variables analysed, the ones that are statistically different for these organizations are the introduction of new goods, services or methods significantly improved, and the cooperation between companies. Firms also present substantial differences approaches in terms of R&D and marketing activities, as well as see competitors with different importance in terms of innovation.

As detailed in Figure 16, the organizations which are considered as key players in the Portuguese sector have introduced more new or significantly improved goods, services and methods (83%) than the other organizations (50%).

The Chi-Square analysis with the continuity correction is 0.045, being the correlation factor, measured using the Phi coefficient, equals to 0.346, which means that this is a moderate association.

Additionally, in Figure 17 and Figure 18, it can be observed that the key-players in the aerospace sector are more likely to invest in R&D and marketing activities that the remaining respondents.

The statistical Chi-Square tests for the variables R&D and marketing activities, have been used using the correction continuity and the result are 0.054 and 0.084 respectively and the degree of association using the Phi coefficient are 0.385 and 0.339 being the association between this variables and the firms’ importance to the Portuguese aerospace sector moderated.

As it can be seen in Figure 19, aerospace key-players seem to give less importance to the competitors than the other companies.

Thus, the Chi-Square independence test, with the continuity correction, result is 0.083 and the degree of association between the variables is 0.377, meaning that they are reasonably associated.
Finally, in terms of cooperation the organizations that have a strategically important role in this sector are more likely to cooperate with other companies or institutions (95%) than the other respondent organizations (72%). The result of the Chi-Square independence test, using the continuity correction is 0.093 and the degree of association between the variables is 0.370.

### 4.2.3. Aerospace Sector Evolution

This section discusses the main differences in respondents' opinion about the evolution of the aerospace sector in Portugal, according to the importance of the following factors: public governmental funds, European funds, intern market, incubation and technology transfer programmes, international internships programmes, search for new markets, partnerships, qualified workforce, regulation and legislation and finally, the economic crises. Similarly, it has been analysed if the respondents' opinion differs significantly relatively to the aerospace sector importance for the country development and if the society recognizes its importance.

The respondents' opinion about the evolution of the aerospace sector in Portugal only seems to differ in terms of European funds importance. While the respondents from the organizations that have a key importance in the Portuguese aerospace sector think that European funds have are important to sector evolution, the other respondents are not so sure about its importance, see Figure 21.

The result from the application of the Chi-Square independent test with the continuity correction has shown a p-value equals to 0.098 and a degree of association moderate degree association between the respondents' opinion about the importance of the European funds to the evolution of the Portuguese aerospace sector ($\Phi$ is 0.370).

As previously mentioned, the deterioration of economic conditions associated the growing pressure in government budgets, have strongly affected the worldwide aerospace industry, as well as in Portugal. Therefore, it might be important to establish a strategic framework of policies to promote the national aerospace industry, able to stimulate the creation and consolidation of SMEs. In this context, this study contributes with a first step in that direction since it deals with crucial questions for the aerospace sector growth in Portugal.

Prior work has documented the importance of the aerospace sector for the world's economy, as well as to the countries' socio-economic development. Hollanders (2008), for example, reports that the aerospace sector is widely recognized as a leading sector for high technology and innovation, which spreads out knowledge to many other areas, sectors and domains. However, these studies have either been short-term studies or have not focused on the Portuguese aerospace industry. This study provides a worldwide analysis of the aerospace sector in the last ten years, with the aim to pinpoint key aspects and some contextual facts that have influenced the evolution of aerospace sector across time. In this sense, two major aspects have had a substantial impact in the aerospace sector, namely:

- The September 11 attacks since it increase people's fear of flying, which led to a reduced use of airlines fleets, causing a decline in maintenance requirements from airlines;
- The deterioration of economic conditions due to the financial crisis in the end of 2008, which alongside with the rise of volatility in fuel prices led to a difficult economic situation.

Since the Portuguese two major companies with activity in the aerospace sector operate in the aeronautical sector, mainly in maintenance field, the decline in maintenance after the September 11 attacks have had a significant impact also in Portugal. Similarly, the financial crises in the end of 2008 led to a decrease of Portuguese aerospace sector turnover.

As an exploratory study about the aerospace industry in Portugal, the first and foremost aim of this research is to characterize this sector in Portugal. Therefore, a first important issue to consider is how the aerospace sector in Portugal is composed, in other words which are the organizations that contribute or aim to contribute for this industry. In this sense, an organization directory was designed and assembled encompassing the main Portuguese companies and institutions that contribute to the aerospace sector. Therefore, this directory constitutes the first contribution of this article for future academic research or other investigations regarding this subject.

### 5.1. The Portuguese aerospace sector key drivers

As an exploratory study about the aerospace industry in Portugal, the first and foremost aim of this research is to characterize this sector in Portugal. Therefore, a first important issue to consider is how the aerospace sector in Portugal is composed, in other words which are the organizations that contribute or aim to contribute for this industry. In this sense, an organization directory was designed and assembled encompassing the main Portuguese companies and institutions that contribute to the aerospace sector. Therefore, this directory constitutes the first contribution of this article for future academic research or other investigations regarding this subject.

### 5. Concluding Remarks

Prior work has documented the importance of the aerospace sector for the world’s economy, as well as to the countries'
personnel, partnerships, search for new markets and European and governmental funds as the most important factors to the aerospace sector evolution.

Regarding the qualified personnel it is evident from the results that the number of employees holding a higher degree has raised significantly since the firms’ establishment year until 2010. Moreover, females and employees with PhD studies or more advanced educational level are, in general, more likely to work in institutions than in companies.

In what concerns partnerships, the results show that the great majority of the organizations cooperate with other companies or institutions (83%) and that beyond cooperate inside the organizations, the inquired companies and institutions are most likely to cooperate with national universities and R&D public institutions.

In regard of the search for new markets, from the results one can note that companies and institutions differ mostly in the national market, while most companies seem to operate mostly in the national market; institutions are more likely to act as suppliers for international markets. This might mean that experts consider that search for new market could be an advantage for organizations, especially in national current situation.

Since more than half of the inquired organizations rely on financial support to develop activities in the aerospace sector, it comes with no surprise that this factor is considered one of the most important to the aerospace sector evolution. Although the funds are mainly from national and EU sources, other funds seem also to play an important role in funding the organizations, since it accounts for more than 30%. The most common financial funds originate – or are related with – Quadro de Referência Estratégico Nacional (QREN), FP7, FCT and ESA.

Regarding the Portuguese organizations with activity in the aerospace sector, major organizations (Group 1) and the remaining organizations comprehended within the sector, that have answered the survey (Group 2), present some dissimilarity. Companies fitting into Group 1 are more likely to conduct R&D and marketing activities, 95% and 71% respectively. Conversely, R&D activities conducted by Group 2 represent 65%, while marketing activities represent only 38%. Also, Group 1 seems to give more importance to European funds (100%) than Group 2 (76%).

Moreover, the findings seem to support the idea that cooperation between companies and institutions play an important role to distinguish Group 1 from Group 2. While the organizations that have a strategically importance in this sector are more likely to cooperate with other companies or institutions (95%), Group 2 presents a percentage of cooperation of 72%.

5.2. Main scenarios for the aerospace sector in Portugal

In a macro perspective, some experts claim that the aerospace sector will be affected by the economics and financial crises and therefore, due to the fierce and global competition in this sector associated with the national lack of organization, future planning, qualified workforce, which may cause the loss of market share for the most fragile companies. Therefore, experts believe that the sector evolution in Portugal will have a slow evolution, secured by some isolated key-companies.

On the other hand, the most optimists seem to picture a completely different scenario. They believe that partnerships, R&D activities and components manufacturing may lead to the growth of the aerospace sector.

It is important to notice that the factors mentioned by the most optimistic are in accordance with the main findings of this research, which present differences statistical relevant for cooperation with other companies or institutions and R&D activities performed the key aerospace organizations in Portugal and the remaining ones.

Despite the difficulty in predicting accurately the future of the aerospace sector, in Portugal it seems even more challenging due to lack of organization and future planning for this sector. However, organizations need to be aware of key strategic issues for the development of the sector. Hence, this requires to plan ahead a long-term national strategy for the sector evolution, with well-defined objectives so that national firms and institutions can be adequately promoted and encouraged, as well as to involve technical schools and universities in order to form qualified personnel. This strategy should promote and integrate the national players in the aerospace sector supply chains and encourage the participation in the projects early stages of development.

5.3. Limitations and Further Work

The exploratory and systemic nature of this study led to the analysis of different dimensions of the aerospace sector in Portugal. Consequently, main results and considerations must not be acknowledge as direct answers to specific questions, but instead, as an attempt to structure the available and most relevant information on this issue. In addition, scarcity of similar studies posed some constraints, namely relating to methodological validation and international comparisons.

Another limitation of this investigation relies on the lack of specific data for some of the companies analysed. Moreover, the statistical analyses present some evidence that should not be extrapolated for the sector due to the diversity and specification of activities developed by the companies that work in this sector. However, the taxonomy by percentage of activity dedicated to the aeronautical/space domain can be faced as a useful guideline for forthcoming analysis and theory building on aerospace sector analysis.

This work has unveiled some directions for forthcoming research, namely concerning the need for deeper investigation in each the dimensions here approached and discussed: founder’s profile; organizations’ socioeconomic information, innovation in the aerospace sector and aerospace sector evolution. It is important to highlight the fact that this study reveals statistical significant differences among these two groups of firms and, therefore, future analyses should take into account that the aerospace market is composed of different actors, with different needs and perspectives. Finally, it would be desirable to collect more data from non-respondent
companies, in order to enlarge and complete the collected sample. This will allow developing statistical models that can be used to predict the sector evolution. It also would be desirable to develop a complementary qualitative research approach, namely through interviews with directors or other people with decisional power, which will allow a better comprehension about the sector.

6. REFERENCES


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