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The anchor tenant and the Regional Innovation Systems

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1. Introduction

High technology clusters research has been on the spotlight for more than a decade and considerable knowledge has been accumulated on the structure and behaviour of such regions. Yet, several factors have hindered researchers' efforts to depict the finest recipes for reproducing the best results of some clusters in other regions. On one hand, the theoretical debate on industrial clusters tried mainly to seize and explain firms and industry agglomeration advantages based on the geographical proximity with other organisational or institutional actors. The lack of consensus on the nature and effects of spillovers generated inside a cluster has, for a long time, monopolized the attention of scholars. Hence, little attention has been invested on the understanding of the stages and mechanisms which underline a cluster development (yet, see Niosi and Banik, 2005; Braunenjelm and Feldman, 2006). On the other hand, empirical research often consisted of snapshots of the most successful clusters. Several scholars have pointed out the lack of a dynamic perspective in the studies on clusters. In order to overcome the limitations associated to the largely adopted static view, many authors claim that it is necessary to reorient the research and focus on the study of the creation and evolution of technological clusters (Barthlet and al, 2004; Braunenjelm and Feldman, 2006). Furthermore, by focusing predominantly on the cases of successful clusters, there is little understanding on the issues regarding those clusters that failed or were unsuccessful (Doloreux and Bitard, 2005).

We designed this research by trying to avoid some of these common pitfalls. The paper revisits the anchor tenant concept, which is considered as one of the central elements involved in cluster formation and growth. The ad hoc definitions, the somewhat informal or static analysis and the variety of contexts in which the concept of anchor tenant has been applied in

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the clusters literature have lead to a certain degree of vagueness and confusion about the following questions: 1) What is an anchor tenant? 2) Who may be an Anchor tenant? 3) What is the role of an anchor tenant in the formation and growth of the cluster? 4) What happens to the cluster when its anchor tenant leaves/fails to generate the expected cluster externalities? How does the number of Anchor tenants in a cluster affect its viability?

The purpose of this paper is to shed some light on these questions. The research is based on a longitudinal study of the aircraft industry and embraces an evolutionary perspective on clusters formation and growth processes. The first section focuses on the definition and the role of anchor tenant and on the theoretical debate about its role as a generator of technological spillovers. The following section describes the methodological issues and assesses the results of our empirical research on the anchor tenant in aerospace clusters. The third section makes concluding remarks and states the main implication of the study in terms of public policies which purpose is the formation of new clusters or the upgrading of the existing ones.

2. Theory

Many studies confirm the thesis that geographical concentration of technological firms affects positively their innovativeness and economic performance. Agglomeration externalities, which explain such location advantages, are defined as benefits that firms derive from the geographical proximity to other economic actors. Even if the nature of the agglomeration externalities has been studied extensively, the mechanisms that generate these externalities have received less attention (Basant, 2002). The anchor tenant hypothesis focuses on the role that some specific and important economic actors such as large firms, universities, public laboratories and others, play by anchoring other actors and thereby, affecting the dynamics of clusters.

2.1. The origin of the Anchor tenant concept

Industrial cluster analysts have borrowed the concept of anchor tenant from the real estate body of literature. According to Agrawal and Cockburn (2003: 1229): “The classic anchor tenant is the large department store in a retail shopping centre that creates demand externalities for other shops. Large department stores with a recognized name generate mall traffic that indirectly increases the sales of lesser-known stores.” Brueckner (1993: 5) notes that “high traffic levels are a result of the spatial concentration of stores achieved by the center, which reduces the time cost of a multiple-stop shopping trip.”

Land developers seem to agree that the presence of at least one anchor tenant is essential for the viability of a shopping mall. This presence has become a pre-requirement for the beginning of the project. The most common incentive in the developers’ efforts to lure an anchor tenant to a shopping center is lease price discrimination. The anchor tenant is offered substantial rent rebates while the other tenants pay higher prices (Benjamin and al, 1992; Pashigian and Gould, 1998). The shopping mall rental contracts are written to (i) efficiently price the net externality of each store and (ii) align the incentives to induce optimal effort by the developer and each mall store according to the externality of each store's effort (Gould et al. 2005: 411).

Even if there is a consensus among real estate developers about the role of the anchor tenant, it is striking to find out the scarcity of theoretical and empirical investigation about the anchor tenant concept, and the nature of the overall externalities generated among the different tenants. The Anchor tenant is supposed to have the largest externality-generating ability in the shopping mall, but the other tenants have a complementary role. They help multiple-stop shoppers find items they have on their shopping lists. In order to internalize the externalities among all the shopping-center tenants, the project developers must resolve a two stage problem by first, optimizing the combination of the various types of stores, whether they are anchor and tenants, and second, optimizing the combination of their size. This is a hard problem, because as several studies have indicated, the possibility of defining the nature of the externalities in shopping centers and to quantify their strength and importance is very limited (Brueckner, 1993). As Konishi and Sandford (2003) point out, researchers have focused on the analysis of positive externalities from the collocation, while there is very little understanding of the negative externalities generated from the anchor tenant. These authors have shown that, in certain conditions, the anchor tenant presence may reduce the benefits of smaller stores from the collocation. They argue that relatively high product substitutability rates of the large and small stores will benefit the brand name store or the anchor tenant itself. Yet, empirical evidence on this issue is still scant. Furthermore, there is a flagrant lack of studies vis-à-vis the dynamics of the relationship between the anchor tenant and the shopping center. How does the relationship among the anchor tenant and the shopping center evolve?

2.2 Anchor tenant definition

The anchor tenant concept has been applied to cluster analysis in both a formal and informal way. In this context, which constitutes the majority of the cases, it is implicitly supposed that the anchor tenant is an important constituent contributing to the formation and the growth of industrial clusters (Agrawal and Cockburn, 2003, Feldman 2003). The recent research on the genesis of high technology cluster show that the presence of a large firm, a university or a public laboratory *has attracted*, in the same location, other important organisational or institutional actors related to that industry (Braunenjelm and Feldman, 2006). However, it has not been the primary purpose of these studies to develop an in-depth analysis on the characteristics and the role of the anchor tenant in industry and cluster evolution.

There are only a few studies that examine, in an explicit way, the anchor tenant and therefore offer valuable input for a rigorous definition. Agrawal and Cockburn (2003: 1229) define an anchor tenant as a *large*, *locally present* firm that is: (1) *heavily engaged in R&D* in general and (2) has at least minor *absorptive capacity in a particular technological area*.

Feldman (2003: 323) stresses also on the argument that a regional economy may benefit from the presence of large, technologically sophisticated entities that anchor local economies. According to the author, as part of an innovative infrastructure, a large established entity is central to *the creation of an important volume of ideas and knowledge externalities* which may benefit other firms, especially the start-up ones. According to Feldman, such entities may be large research universities.

Link et al. (2003: 1219) identify high-technology anchor tenants as large R&D-intensive firms, as defined by their patenting activity, that have a strong focus on a particular technological field. They conjecture that high-technology anchor tenants *enhance regional innovation systems by stimulating technological externalities through their own actions and by attracting firms* (what the authors refer to as 'co-location') that also generate technological spillovers within the local region.

Niosi and Zhegu (2005) have identified large aerospace firms as main anchor tenants in aircraft regional systems of innovation in Canada. These firms have most often started the cluster, and in a similar dynamics with shopping malls, other smaller firms agglomerated afterwards in the area. This paper develops the argument for the vast majority of aerospace clusters in the world.

We define the anchor tenant as a central innovating organization in a high technology cluster which contributes to the enhancement of the advantages of co-location by generating an important volume of knowledge and technology spillovers through its own actions, and by attracting in the same location, other organizations.

A set of questions arises regarding the relationship between the anchor tenant and the industrial cluster. On the one hand, there is the lack of theoretical and empirical evidence about the nature of the knowledge spillovers generated by the anchor tenant. On the other, there are no studies that take into consideration the evolution of the relationship between the anchor tenant and the cluster. What happens when an anchor tenant leaves or goes bankrupt? Several scenarios are possible:

- The anchor tenant leaves/fails and employment in cluster declines;
- The anchor tenant leaves/fails and the number of smaller tenants declines;
- The anchor tenant leaves /fails and other anchors fill the space
- The more the anchors there are in the cluster, the smaller the chances that the loss of one anchor has an impact on employment or small tenants

3. **Empirical Research**:

This paper identifies the role of the anchor tenants in the creation and development of North American aircraft clusters. We have studied the evolution of these clusters throughout the industry lifetime.

3.1 Sources of data and methodological issues

In order to test the research hypothesis we have triangulated several sets of data about aircraft industry clusters and their regional technological and institutional infrastructure.

Longitudinal series of data on aircraft industry employment, production and industrial dynamics such as, companies' market shares, their market entry or exit, the number of acquisitions, mergers, and technology transfers or alliances, have been possible through the combination of data provided by governmental sources, (US Bureau of Census, Statistic Canada, Strategis), industrial associations (US Aerospace Industries Association, Aerospace Industry Association of Canada, CAMAQ), several aircraft industry specialised encyclopaedias or other publications (Jane's All the World Aircraft, Mondey and Taylor (2000) The new illustrated encyclopaedia of Aircraft), companies' information and business reports directories (Mergent, Hoover's, Scott's).

The US Patent and Trademark Office (USPTO) database has also been a main source of data for our research. Two factors have influenced this choice. One, the United States has dominated the innovative activity in the aerospace sector, and has generated the largest number of patents in this sector. Two, the American market constitutes the most conspicuous technological market in the world, which forces the international innovators to protect their inventions in this market. Therefore, the USPTO database shows that the most patented aircraft inventions are in this part of the world. We have extracted 40013 patents belonging to class 244 from this database. This class, according to the current classification of USPTO, regroups the patents corresponding to the technological domain 'Aeronautics and Astronautics'. In the majority of the cases, each patent lists several technological domains where the invention may be applied. Among the extracted patents we found some which have claimed simultaneously, up to 40 different technological domains. To avoid noises created by the presence of distant or secondary inventions with respect to the aircraft sector, we kept in our database only the patents which claim class 244 as the principal (first) technological domain for their invention. Some 26533 patents have satisfied this condition. From each patent we have collected information about the assignee(s) name and location, inventor(s) name and location, and the year in which the patent was officially issued by the USPTO. This information has allowed the mapping of aircraft industries' patented invention in time and space.

3.2 Anchor tenants, labour pools and the emergence of the aerospace clusters

From its origin, the aircraft industry has revealed a persistent tendency to be concentrated geographically. The first focal areas appeared in the US northeast regions or in the so-called "the manufacturing belt", which at the beginning of the twentieth century counted for around three quarters of the country's industrial production (Perloff et al, 1965). The geographical location of the emerging aircraft industry has been highly independent from the markets of both its inputs and outputs. So, for instance, when the airplanes were made in a wooden structure, the forests of spruce trees were situated in the northwest regions, while the industry clustered on the northeast. Later on, when the metallic structure replaced the wooden one, the industry went away from the northeast regions which dominated the production of metal. Also, there are only a few isolated cases of companies which show that the proximity to their customer as a criteria for the choice of their operational sites. Such is the case of Glenn L. Martin Company, which was heavily dependent on government military contracts, and therefore it transferred, in 1928, its installations from Cleveland, Ohio to Baltimore, Maryland.

The first question is what anchored the emergent aircraft industry in the “manufacturing belt”? According to Cunningham (1951), during the first decades of the twentieth century, 90 per cent of the job positions of the aircraft industry required employees endowed with a highly or more than the average qualification by standards at that time. Considering that the employees were supposed to accomplish multiple, non-standardised tasks, and resolve numerous unpredictable technical difficulties, the training of the workforce for the new industry would have been very long and expensive. In this context, the presence in the manufacturing belt of some formative industries attracted the infant aircraft industry to these regions. According to Todd and Simpson (1986), the presence in the northeast part of the US of several industries such as shipbuilding, railroad construction, automobile manufacturing and other mechanical engineering industries contributed to form on the one hand, a pool of potential entrepreneurs, and on the other hand, a considerable pool of qualified manpower capable of understanding the complexity and satisfying the requirements of the emerging industry. Furthermore, during the first decades of the aircraft industry’s existence, it frequently happened that companies from these formative sectors, acted as “incubators” by dedicating part of their activity to aircraft production. Afterwards, based on their performance, some of these incubators converted themselves entirely to aircraft production, while others returned to their previous activity, and closed or split their aircraft production department, which continued to develop in an independent way. In the majority of the cases, these spin-off companies pursued their development in proximity of their mother’s company site. So, Vickers was formerly operating in the shipbuilding and defence industries. Curtiss Aeroplane and Motor Company originated from the motorcycle industry while the Wright brothers built the first flying-machine prototype in their bicycle factory.

However, the initial advantage of the “manufacturing belt” did not last long. At the beginning of the 1940s, almost half of aircraft firms had moved away from their original location (Cunningham, 1951). Three types of industrial migration underline the rapid change of the aircraft industry location. The first, and the most important one was the so-called “westward migration”. Since the beginning of the 1920s, numerous companies started moving from the “manufacturing belt” towards the “Sun Belt”, the region situated on the south coast of the Pacific. In 1920, Donald Douglas Sr. founded his own aircraft company based in Santa Monica, California. Douglas Aircraft became the principal anchor that attracted several other companies to the region. In 1935, Reuben Fleet of Consolidated Aircraft transferred its company from Buffalo to San Diego. In 1939, John Northrop chose Los Angeles for the its manufacturing plant. According to the US Census of Manufacturers, in 1925, among 44 large American companies only 4 were in California; in 1937, Los Angeles and San Diego were hosting 24 large aircraft companies.

A second and minor industrial migration involved an intra-regional movement of firms going from big centers toward peripheral locations. This was the case of Grumman Aircraft, Brewster Aeronautical and Republic Aviation, who moved to the suburbs of New York. Piper

Aircraft had also changed its site without leaving Pennsylvania. Curtiss Aeroplane and Motor Company moved its installation from Buffalo to Clifton, both in New Jersey.

Historical factors forced a third wave of industrial relocation. During the Second World War conflict, the US government, as a security measure, strongly encouraged the transfer of the aircraft production in regions situated at least 200 miles inside the borders. Consequently, on the eve of the victory, the aircraft industry was geographically scattered between several regions. From 1940 till 1944, the aircraft production share of the central regions of the United States went from 4 to 44, 7 per cent (Cunningham, 1951).

The first set of factors that motivated the rapid relocation of the aircraft clusters is related to the specific requirements imposed by the growing industry. Both technical complexity and the size of the new airplanes kept on rising and forced aircraft producers to enlarge their factories. When aircraft manufacturers considered the competing sites for their relocation, they looked for places offering vast territories and adequate topographical characteristics, as well as weather conditions facilitating flight tests. The southwest American coast had all these conditions.

A second set of economic and institutional factors seem to have driven aircraft firms toward the pacific coast. This region offered an abundant working force at lower costs compared to the “manufacturing belt”. In addition, a less unionized labour environment made the southwest region more attractive than the original location of the aircraft clusters. Furthermore, during the first decades of the industry’s existence, the geographical location of sources of capital often determined the choice location of the aircraft firms. On the one hand, the emerging industry was still too unstable, uncertain and ignored from the investors. On the other hand, the aircraft firms were, yet, relatively small in size and their reputation was restricted to a small geographical area. In these circumstances, the geographical proximity with the potential investors increased firms’ visibility. So, the interest that oil industrialists from Kansas had shown for the new aircraft sector attracted Clyde Cessna to this region. He benefited from their support, and opened, in 1916, his workshop in Wichita. Walter Beech followed his example a few years later. Also, after several years of bank refusals for loans, Donald Douglas was able to open his own aircraft company after he obtained the financing of a California business angel who was fond of aviation.

A third set of historical factors exerted a major influence in the aircraft industry development and its choice of location. The new industry emergence period coincided with the two World Wars, whose strategic military needs made it possible for the aircraft industry to require that the government have a strong involvement in the financing and supervision of the aircraft industry. The industry remained highly strategic and therefore under government influence, even after part of the firms’ activity was reoriented toward the civil sector.

The first forty years, the location and relocation of the aircraft industry seems random at first sight. Yet, it is possible to identify certain patterns and distinguish the role of some actors, which seem to have been crucial to the cluster creation and industry development, and which may be interpreted as anchor tenants. In the very beginning of the industry’s existence, firms from the formative industries anchored the new industry by incubating its future leaders. Also, by supplying a pool of potential entrepreneurs and qualified employees, these firms attracted other ones to the same location. As other studies have pointed out (Duranton and Puga, 2001; Heblich and al, 2008) the emerging industry beneficiated more from Jacobs externalities found mostly in diversified urban agglomerations and consisting in inter-industry spillovers. Furthermore, the private or public sources of capital attracted and anchored aircraft firms in specific locations. Also, a small group of keen entrepreneurs, in spite of the small size of their new firms, succeeded to attract other companies and encourage the creation of a regional, physical and institutional infrastructure. In 1917, Boeing Airplane Co. had only a 28-person payroll (including also pilots, carpenters, boat builders and seamstresses) (Boeing, 2008). Nevertheless, William Boeing was able to pay for the construction of a wind tunnel at the University of Washington so that it offered courses in aeronautics, and could attract some of the few US aeronautical engineers to Seattle. Donald Douglas, James McDonnell, James Kindelberger and Howard Hughes followed similar trajectories as Boeing by planting also the seeds of its subsequent great successes.

3.3 Industry, anchor tenants and aircraft clusters dynamics

After the Second World War, the aircraft industry became a cornerstone of the American economy. By the late 1960s, the industry represented 1.5 per cent of the GDP and 7.1 per cent of the country's manufacturing exports. With a level of R-D close to 15 per cent of sales, the aircraft industry became by far, the most technologically intensive US industry. Yet, it was the victim of a highly cyclical demand, especially related to the volatility of the military demand. The industry underwent drastic downsizing and persistent consolidation processes on numerous occasions. Furthermore, since the mid-1970s, aircraft manufacturing was obliged to cope with the decentralization of the airline industry, the volatility of the civil market, the unpredictability of governmental financing and lately, the fierce competition from the European Airbus consortium.

The concomitant effect of all these factors imposed the long and intensive process of major industrial reorganization. The industry consolidation persisted till the end of the 1990s, when Boeing became the only American major civil aircraft assembler while sharing with Lockheed Martin, Raytheon, Northrop Grumman and General Dynamics the military and space market.

Since the mid-1970s, due to the decentralization of the airline industry, aircraft manufacturing was involved in a long and intensive process of reorganization. The concentration of the prime contractors' activities on their core competences followed by the vertical disintegration of the supply chain, created a highly hierarchical industrial structure. This is often represented by a three level pyramid, with the aircraft constructors on top, followed by the subsystem assembling companies, and lastly, at the base, the other supply chain companies.

The industrial consolidation was also reflected in a concentrated geographical distribution of the industry. In the 1960s, 92 per cent of the after war aircraft industry was clustered around the remaining large firms in the six US states: California (40 per cent), Texas (14 per cent), Washington (12 per cent), New York (11 per cent), Maryland (8 per cent) and Kansas (8 per cent) (Patillo, 1998). The present geographical distribution of aircraft clusters represents the same tendency of high concentration around the remaining firms. According to the US Bureau of Census , 85 per cent of the industry is located in six metropolitan regions: Seattle-Tacoma-Bellevue (Washington); Los Angeles-Long Beach-Santa Ana (California); Dallas-Fort Worth-Arlington (Texas); Hartford (Connecticut); Boston-Cambridge-Quincy (Massachusetts); Cincinnati (Ohio).

It is easer to identify the role and effect of the anchor tenant firms on the cluster development for the growth and maturity period of the aircraft industry. The consolidation of the industry and the reorganization of its supply chain have affected the aircraft clusters by associating their dynamics with those of the large anchor firms. It is interesting to investigate what happened with the clusters when, following the persistent processes of fusions and the acquisitions, major aircraft companies disappeared or changed their place in the industrial hierarchy. With respect to this, it is possible to detect three types of situations. The first anchor tenant-cluster co-evolution pattern corresponds to the cases in which, when the anchor firm ceased its activity, the aerospace cluster also put an end to its aeronautical activities. In 1987, when Fairchild Industries decided to completely quit the aircraft sector, this put an end to a fifty-nine year old aircraft cluster anchored by this firm in the area of Farmingdale, New Jersey. In 1986, in a context of a major reorganization, Lockheed Martin transferred its head office from Burbank to Calabasas, both in California. Two years later the company closed its installations of Burbank and by doing this put also an end to sixty years old aircraft production activities of this cluster (Pattillo, 1998).

The second pattern regroups the cases when the anchor tenant merges or is bought by another firm, but the aircraft cluster remained active. In a few cases, the cluster preserved its place in the industrial hierarchy, as it happened after the fusion of McDonnell and Douglas which did not affect the work of their respective operating sites. Thus, the Long Beach cluster in California kept developing the DC-8 and DC-9 models even if the new company's headquarters were transferred in St-Louis, Missouri.

However, in the majority of cases, by losing its anchor tenant, an aircraft cluster activity was relegated to the subcontracting level. Usually after a merger or acquisition, research and development activities were centralized at the new company center. This happened for instance, when Bombardier acquired the Lear Jet and Short Brothers and centralized all their R&D activity in Montreal.

Finally, another pattern emerges in the cases where the anchor tenant changed its activity from the aircraft industry to another sector. This new company usually required a similar set of expertise as the former. The cluster continued on the same path as its anchor tenant. This happened, for example, with the aircraft cluster of El Segundo, in 1988, when Rockwell North American Division, its anchor tenant, quit the aircraft sector and reoriented its activity to the electronic industry.

3.4 The anchor tenant and the innovation activity of the aircraft clusters

Our research hypotheses suggest that the presence of an anchor tenant firm in a region significantly affects the innovating activity of that region. This section shows evidence favouring this position.

Who are the aircraft innovator clusters? We have collected and distributed, geographically, the aeronautical patents issued between 1905 and 2003. Only five clusters represent around 60 per cent of the patenting activity: California (22 per cent); New York (13 per cent); Washington (8 per cent); Ohio (8 per cent) and New Jersey (5 per cent). Analysis shows that at the level of the metropolitan areas, there is also a high local concentration of the innovation activity as shown in table 1.

The geography of aircraft industry innovation has gone through many changes. During the emergence period of the industry the northeast represented 75 per cent of the patenting activity. The New York area alone counted for 45 per cent of the total number of patents issued between 1905 and 1944. However, since the end of the Second World War, California regions took the lead in industry innovation activity.

In the table 2 the aircraft clusters are organized on the basis of their innovative performances. The first group includes the clusters whose innovating activity matured. The second group includes the regions whose innovation activity over the industry lifecycle declined. The third category includes the clusters whose innovating activity kept growing during the industry growth phase, and declined during the industry maturity period. New York, Ohio, Pennsylvania and Michigan lost their dominance in favour of California, Washington and Texas, while New Jersey, Connecticut and Maryland went through an innovation activity growth period, which declined during the maturity phase of the industry's lifecycle.

What explains the growth or decline of aircraft clusters? The reason suggested is that the presence in a region of an anchor tenant firm attracts other innovators working in the same or in related industries to this region. Who were the anchor tenant firms in the case of innovative aircraft clusters? Tables 3.1 to 3.6 illustrate the phenomenon of innovation anchoring in the aircraft clusters. Two types of anchor organizations emerged: large companies and the government laboratories. Thus, Douglas Aircraft, Curtiss Wright, Boeing or Goodyear and B.F. Goodrich became the anchor tenant, respectively, of the California, New York, Seattle and Ohio clusters. Elsewhere, it is the public laboratories that gave birth to some clusters, such as that of Connecticut or Texas. The last line of each table represents the number of inventors that each cluster hosted in a particular decade. It is evident from these numbers that the dynamics of the innovators' presence in a cluster coincide with the dynamics of the anchor tenant firm.

The data contained in these tables show that the number of innovator firms has increased in the decade following the arrival of the anchor tenant. Thus, the presence since the 1928 of Douglas Aircraft Company attracted some 30 innovators to the California cluster during the decade that followed. After the entrance of Curtiss Wright Co., the number of innovator firms rose from 17 to 42. A similar situation occurred in the case of the Ohio cluster, where the presence of Goodyear Tire and Rubber Co. and of B.F. Goodrich Co. kept many other innovator firms anchored in that region.

Furthermore, with the growth or the decline of the anchor firm innovation activity, the overall innovation activity of the aircraft clusters often headed in the same direction. In the case of all the aircraft clusters studied, the slowing down or the closing down of the innovation activity of the anchor tenant, has provoked the slowing down and the decline of the innovation activity of the cluster. Thus, the decline of Curtiss Wright signalled the beginning of the decline of New York aircraft cluster. Both the number of patents and innovators fell during the decades that followed. The same phenomenon is visible in the Connecticut cluster, where the reduction of the innovation activity of the public laboratories was followed by the decline of the number of innovating companies hosted in that region. The decade following Curtiss Wright closure, the number of innovator firms in the region fell from 20 to 4.

The propensity to patent an aircraft cluster is positively connected to the number of its anchor firms. So, even if the Seattle cluster has been hosting the largest aircraft constructors in the world, the region falls behind California in terms of number of aircraft patents. If the presence of Boeing contributed to propel Seattle to second position, the decline of McDonnell Douglas did not involve the decline of the Californian system of innovation. The presence in the California clusters of other large innovator firms contributed to keeping the innovators anchored in that region. Thus a multi-anchor cluster has the opportunity to perform better than the one depending on a single anchor firm.

4. A typology of the anchor tenant-cluster relationships

The findings of this research are compatible with those of some recent studies which focused on the industrial clusters lifecycle. As Heblish et al (2008) point out, industrial regions evolution follow some regularities which, in many ways are linked to the Klepper's industry lifecycle theory. Here we suggest that the anchor tenant role must also be considered in a dynamic industry lifecycle context. The analysis of the long-term role and effects of the anchor tenant for cluster creation and development brings to light several elements regarding the workings of this mechanism and the way in which it affects cluster dynamics. The conclusions and results of the research and the proposal of a typology of anchor tenant-cluster relationships are represented in table 4.

There is no doubt that anchor tenant firms have had a crucial role in cluster dynamics during all of the aircraft industry lifecycle. However, both concepts of the anchor tenant and the cluster itself have evolved over the subsequent phases of the industry lifecycle. During the whole of the industry's existence, it is possible to discern three types of aircraft clusters: the incubators, the hosts of the national champion, and the international mega-centres. Path dependence and some historical accidents were the principal factors which attracted the aircraft industry to the northeast part of the United States, while presence of training industries in this region had the role of incubating the new industry. During the industry growth phase, the consolidation process that took place reinforced the geographical concentration of the industry, while a few clusters became the hosts of the national champion firms. This was the case of the California cluster which hosted MacDonald Douglas headquarters or Seattle, which hosted Boeing. During the maturity period, among other factors, the industry had to cope with a fervent international competition and the declining of no-the domestic public financing. Only a few firms did succeed by creating a powerful interaction by means of both local and global industry factors, thereby, generating and benefiting from all types of domestic or international spillovers. The clusters hosting these firms became the leading centers of the world industry.

The presence in a cluster of an anchor tenant firm attracted in the same region other companies from the same or related industrial sectors. Moreover, the growth or the decline of an anchor tenant firm has affected the performances of the cluster. Yet the role of the anchor tenants and the nature of the knowledge spillovers that they generate in the cluster have evolved over time. During the first phase of the industry lifecycle, inter-industry spillovers were more important for the emerging aircraft cluster. They consisted of both a pool of potential entrepreneurs and a qualified working force capable of coping with the technical complexity and unpredictability of the new industry. The formation of aircraft clusters is strongly related to the role of a few entrepreneurs. Other recent studies have concluded that their presence has been essential to the creation of the cluster (Feldman and Berkovitz, 2005; Dahl and al, 2005). During the growth and the maturity phase, aircraft clusters dynamics were progressively identified as those of large firms occupying the upstream levels of the industry's value chain hierarchy. In some cases, large public research centers anchored the industry in certain locations. ***This means that, even in the aerospace industry, private firms are not the only type of anchor tenant***. Agrawal and Cockburn (2003) and particularly Feldman (2003) insisted on the role of the research universities for the formation of biotechnology clusters while Feldman and Lowe (2008) evoke institutional factors that have anchored biotechnology cluster in Cambridge area. The local intra-industrial knowledge spillovers dominate during the growth phase, while the international spillovers rise steadily during the maturity stage. This combination of local and international spillovers is becoming a general tendency of industrial clusters (Bathelt et al, 2004). An in-depth analysis and empirical evidence of such knowledge spillovers is necessary to explore better the positive effects of such spillover but also to consider their less studied negative side (Alcacer, 2007; Alcacer and Chung, 2006)

Exploring the specificities that characterize the relationship between the anchor tenant firms and the industrial clusters during each phase of the industry lifecycle, may provide useful guidelines for public policies, whose aim is to facilitate the development of the existing clusters or to craft new ones. The analysis of the co-evolution between industry, anchor tenant and cluster seems indispensable to the formulation of effective targeted public policies. Further research and analysis is required in relation to comparing these issues within the context of other high technology industries. This will offer a more complete portrait, and provide more precise and general conclusions regarding the workings of the anchoring mechanism and the nature of spillovers generated in those clusters.

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Figure 1: Geographical distribution of US aircraft patents (Class 244), 1905-2004

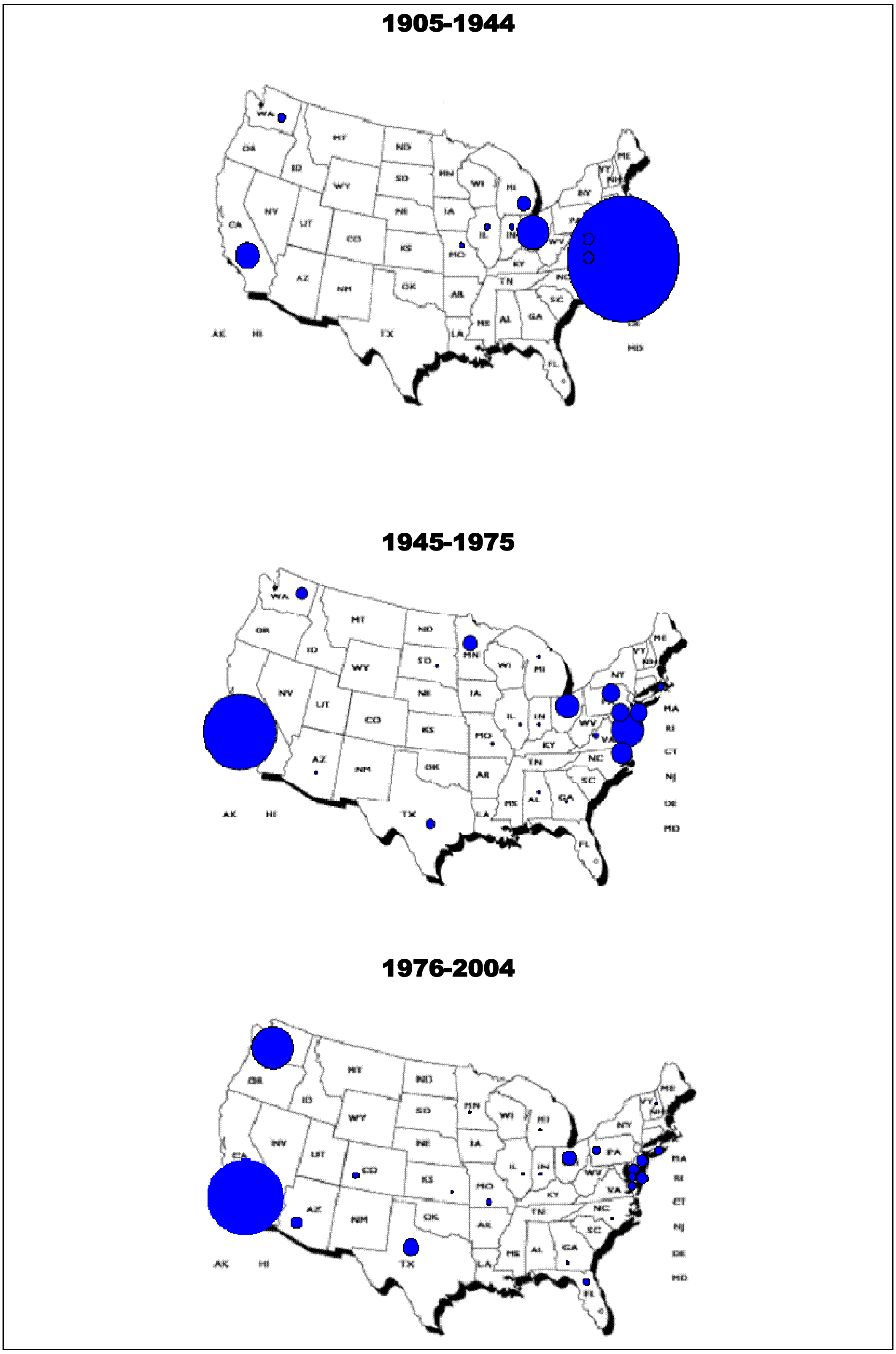

Table 1 US Aircraft Patent distributed according to Census Metropolitan Areas, 1905-2004

Metropolitan Areas	Share of each metropolitan area patents in its respective state
Los Angeles-Long Beach-Santa Ana	77% of California
Seattle-Tacoma-Bellevue	97% of Washington
Baltimore-Towson	56% of Maryland
Minneapolis-St. Paul-Bloomington	96% of Minnesota
New York-Northern New Jersey-Long Island	70% of New York and New Jersey
Philadelphia-Camden-Wilmington	80% of Pennsylvania
Dallas-Fort Worth-Arlington	74% of Texas

Table 2: Aircraft clusters long-term innovation performance

	Inventor's State	Share of each State patents in the total number of aircraft patents				Long-term innovation activity tendency Based on the cluster number of patents)
		1900-2003	1905-1944	1945-1975	1976-2004	
1	CALIFORNIA	22	9	25	27	Growing
2	WASHINGTON	8	3	4	15	Growing
3	TEXAS	4	0	3	6	Growing
4	VIRGINIA	3	0	2	4	Growing
5	MASSACHUSETTS	2	1	2	3	Growing
6	ARIZONA	2	0	1	4	Growing
7	ALABAMA	2	0	1	3	Growing
8	FLORIDA	1	0	1	2	Growing
9	NEW YORK	13	43	11	4	Declining
10	OHIO	8	12	8	5	Declining
11	PENNSYLVANIE	5	4	6	3	Declining
12	MICHIGAN	2	5	1	1	Declining
13	NEW JERSEY	5	4	7	3	Growing then declining
14	CONNECTICUT	5	4	6	4	Growing then declining
15	MARYLAND	5	4	6	3	Growing then declining
16	MINNESOTA	3	0	5	1	Growing then

						declining

Table 3.1: Anchor tenant- cluster long- term relationship, California cluster

	ASSIGNEE NAME	PATENTS ISSUE YEAR								TOTAL	Share on the total number of patents
		1900-1909	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979		
1	THE GOVERNMENT OF THE UNITED STATES					3	22	88	79	192	12,3
2	LOCKHEED AIRCRAFT CORPORATION					27	70	83	9	189	12,1
3	NORTHROP CORPORATION				7	11	130	31	8	187	12,0
4	NORTH AMERICAN AVIATION					14	68	88		170	10,9
5	DOUGLAS AIRCRAFT COMPANY, INC.			**1**	10	24	25	20		80	5,1
6	RYAN AERONAUTICAL CO.					4	1	52	3	60	3,9
7	MCDONNEL DOUGLAS CORPORATION							13	43	56	3,6
8	GENERAL DYNAMICS CORPORATION						4	36	8	48	3,1
9	CONSOLIDATED VULTEE AIRCRAFT CO.				3	30	10			43	2,8
10	LEAR, INCORPORATED					3	5	15	17	40	2,6
11	HUGHES AIRCRAFT COMPANY					3	9	8	15	35	2,2
12	HILLER AIRCRAFT COMPANY, INC.						5	17		22	1,4
13	TRW INC.							11	11	22	1,4
14	NORTH AMERICAN ROCKWELL CORP.							15	4	19	1,2
15	THE BENDIX CORPORATION				2	3	3	3	3	14	0,9
	TOTAL NUMBER OF PATENTS	1	11	24	49	146	395	665	266	1 557	
	Total number of innovator firms	1	9	7	30	29	42	101	46		

Table 3.2: Anchor tenant- cluster long- term relationship, New York cluster

	Assignee name	Patents issue Year							Total number of patents	Share on the total number of patents
		1911-1920	1921-1930	1931-1940	1941-1950	1951-1960	1961-1970	1971-1980		
1	CURTISS-WRIGHT CORPORATION	**85**	63	104	57	13			322	24,3
2	SPERRY CO	4	11	42	38	96	32		223	16,8
3	BELL AEROSPACE CORPORATION			5	36	27	22		90	6,8
4	REPUBLIC AVIATION CORPORATION				23	31	1		55	4,2
5	THE GOVERNMENT OF THE UNITED STATES	1	1	2	6	11	20	4	45	3,4
6	GENERAL ELECTRIC COMPANY			3	5	17	14	1	40	3,0
7	THE BENDIX CORPORATION			2	1	14	7		24	1,8
8	BURNELLI AIRCRAFT CORPORATION		10	13					23	1,7
9	IRVING AIR CHUTE COMPANY, INC.		2	15	2	2			21	1,6
10	FAIRCHILD INDUSTRIES		4	1	3		6	6	20	1,5
11	SEVERSKY AIRCRAFT CORPORATION			15	2				17	1,3
12	FRIEDER				4	12			16	1,2
13	SIKORSKY AIRCRAFT CORPORATION			14					14	1,1
14	M. STEINTHAL & CO., INC.					1	12		13	1,0
15	BREWSTER AERONAUTICAL CORPORATION			1	9				10	0,8
	Total number of patents	118	167	315	243	285	171	25	1 324	

	Total number of innovator firms	17	42	54	48	40	40	13		

Table 3.3: Anchor tenant- cluster long- term relationship, Seattle cluster

Assignee name	Patents issue Year							TOTAL
	1913-1922	1923-1932	1933-1942	1943-1952	1953-1962	1963-1972	1973-1982	
BOEING	**<u>3</u>**	14	23	19	87	63	39	248
THE GOVERNMENT OF THE UNITED STATES			1			2	3	6
NORTHROP CORPORATION					2	1		3
POSITIVE FLIGHT CONTROL, INC.						2		2
LEAR, INCORPORATED						2		2
WATKINS APPLIANCE COMPANY, INC.		1						1
U. S. AVIATION CORPORATION						1		1
THE FOX COMPANY	1							1
SUNDSTRAND CORPORATION						1		1
STINSON AIRCRAFT CORPORATION							1	1
SIRIUS CORPORATION			1					1
ROBERTSON AIRCRAFT						1		1
RESEARCH CORPORATION				1				1
R. C. STRUBLE COMPANY, INC.		1						1
JACK & HEINTZ PRECISION INDUSTRIES, INC.				1				1
HARDMAN AEROSPACE						1		1
GENERAL MOTORS CORPORATION					1			1

FAIRCHILD INDUSTRIES						1		1
CURTISS-WRIGHT CORPORATION				1				1
AIRWAYS PATENT CORPORATION		1						1
AEROCAR, INC.					1			1
AERITALIA							1	1
Total number of patents	4	18	27	22	91	77	45	284
Total number of innovator firms	2	5	4	4	4	11	5	

Table 3.4: Anchor tenant- cluster long- term relationship, Connecticut cluster

Assignee name	Patents issue Year							Total number of patents	Share on the total number of patents
	1911-1920	1921-1930	1931-1940	1941-1950	1951-1960	1961-1970	1971-1980		
THE GOVERNMENT OF THE UNITED STATES			**16**	67	63	69	24	239	59,9
KAMAN AIRCRAFT CORPORATION					4	37	2	43	10,8
PIONEER AEROSPACE				14	5	4	1	24	6,0
CHANCE VOUGHT CORPORATION			1		8			9	2,3
SIKORSKY AIRCRAFT CORPORATION			8					8	2,0
DOMAN HELICOPTERS, INC.					3	3		6	1,5
EAST HARTFORD						6		6	1,5
CAIRNS DEVELOPMENT COMPANY		2	2					4	1,0
CHANDLER EVANS INC.						1	3	4	1,0
CURTISS-WRIGHT CORPORATION			2	1				3	0,8
GENERAL SCIENTIFIC PROJECTS, INC.					3			3	0,8
Total number of patents	4	4	35	87	99	140	30	399	
Total number of innovator firms	4	2	11	8	15	20	4		

Table 3.5: Anchor tenant- cluster long- term relationship, Ohio cluster

Assignee name	Patents issue Year							Total number of patents	Share on the total number of patents
	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979		
THE GOODYEAR TIRE & RUBBER COMPANY	**6**	37	14	3	25	44	9	138	20,2
B.F. GOODRICH COMPANY	**5**	2	5	40	13	10	3	78	11,4
THE GOVERNMENT OF THE UNITED STATES				1	11	28	22	62	9,1
CLEVELAND PNEUMATIC INDUSTRIES, INC			5	11	10	32		58	8,5
GENERAL ELECTRIC COMPANY						34	5	39	5,7
CURTISS-WRIGHT CORPORATION		1		11	26			38	5,6
NORTH AMERICAN AVIATION					2	29		31	4,5
DAYTON-WRIGHT COMPANY		25						25	3,7
THE BENDIX CORPORATION			9	7			2	18	2,6
GLENN L. MARTIN COMPANY		4	10					14	2,0
THOMPSON PRODUCTS, INC.				1	6	7		14	2,0
ZEPPELIN-WERKE LINDAU, GESELLSCHAFT MIT BESCHRANKTE.		13						13	1,9
GENERAL MOTORS CORPORATION				2	7	1		10	1,5
WACO AIRCRAFT COMPANY			4	5	1			10	1,5

Total number of patents	15	96	60	115	125	220	52	683	
Total number of innovator firms	4	19	18	25	23	30	15		

Table 3.6: Anchor tenant- cluster long- term relationship, Texas cluster

Assignee name	Patents issue Year							Total number of patents	Share on the total number of patents
	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979		
THE GOVERNMENT OF THE UNITED STATES				1	**9**	33	8	51	28,0
CHANCE VOUGHT CORPORATION					**13**	13		26	14,3
BELL AEROSPACE CORPORATION					**6**	11	4	21	11,5
LTV AEROSPACE CORPORATION						6	7	13	7,1
TEXTRON INC.							11	11	6,0
CONSOLIDATED VULTEE AIRCRAFT CORPORATION				4	3			7	3,8
GENERAL DYNAMICS CORPORATION						4	3	7	3,8
GAYLA INDUSTRIES							6	6	3,3
THE DOW CHEMICAL						4	1	5	2,7
VLM CORPORATION							5	5	2,7
TEMCO ELECTRONICS & MISSILES COMPANY						4		4	2,2
IRVING AIR CHUTE COMPANY, INC.			3					3	1,6
BOEING					1	1		2	1,1

Total number of patents	3	1	3	6	32	86	51	182	
Total number of innovator firms	3	1	1	3	5	16	14		

Table 4: Typologies of anchor tenant, industrial clusters and Knowledge spillovers

Archetypes of regions	Typology of anchors	Type of knowledge spillovers	Industry life cycle
INCUBATOR (Ex. New York, Paris, Montreal, London)	**Atomistic entrepreneurs**	**Inter-industry (Jacobs externalities) University-industry**	**Emerging phase**
NATIONAL CHAMPION HOSTING REGION (Ex. Seattle, Montreal, Toulouse, Sao Paolo)	**Large firms and government**	**MAR**	**Growing phase**
INTERNATIONAL MEGA-CENTER (Ex. Toulouse)	**Global pipelines/ International anchor**	**Local and global externalities**	**Maturity phase**