Anchor tenants and regional innovation systems: the aircraft industry

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Abstract: The concept of anchor tenant was advanced to explain the emergence of regional systems of innovation. The anchor tenant is an organisation, often a large innovative firm or a research university or public laboratory that produces knowledge externalities in the region where it is located. The anchor produces such effects by spinning off new companies and attracting other ones. This paper argues that the dynamics of the anchor may help to explain the subsequent evolution of the region. It also maintains that anchor tenants are attracted to or created in regions that possess some favourable conditions and that such conditions are industry specific.

Keywords: anchor tenant; regional systems of innovation; aircraft industry; cluster dynamics.

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1 Introduction

Research on high technology clusters has been under 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 their geographical proximity to other organisational or institutional actors. The lack of consensus on the nature and effects of spillovers generated within a cluster has, for a long time, monopolised the attention of scholars. Hence, little attention has been invested on the understanding of the stages and mechanisms that underline a cluster development (see Braunerhjelm and Feldman, 2006; Niosi and Banik, 2005). 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 (Bathelt et al., 2004; Braunerhjelm 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).

This research has tried to avoid some of those 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 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 the 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 light on these questions. The research is based on a longitudinal study of the aircraft industry and adopts an evolutionary perspective on clusters formation and growth processes. The next 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 anchor tenants in aerospace clusters. The final section makes concluding remarks and presents the main implications of the study in terms of public policies aimed at 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 non-traded 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, p.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 recognised name generate mall traffic that indirectly increases the sales of lesser-known stores." Brueckner (1993, p.5) noted that "high traffic levels are a result of the spatial concentration of stores achieved by the centre, 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 centre is lease price discrimination. The anchor tenant is offered substantial rent rebates while the other tenants pay higher prices (Benjamin et al., 1992; Pashigian and Gould, 1998). The shopping mall rental contracts are written in order to

1. efficiently price the net externality of each store
2. 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), p.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 potential 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 internalise the externalities among all the shopping-centre tenants, the project developers must resolve a two stage problem by first, optimising the combination of the various types of stores, whether they are anchor and tenants, and second, optimising 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 centres and to quantify their strength and importance is very limited (Brueckner, 1993). As Konishi and Sandford (2003) point out, researchers have emphasised positive externalities from the co-location, while there is very little understanding of the negative externalities generated by the anchor tenant. These authors have shown that, under certain conditions, the anchor tenant presence may reduce the benefits of smaller stores from the co-location. 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 centre. Little is known about the evolution of the relationships among the anchor tenant and the shopping centre (Gatzlaff et al., 1994).

2.2 Anchor tenant definition

The anchor tenant concept has been applied to cluster analysis in both a formal and informal way. In the majority of the studies, it is implicitly assumed that there are certain location specific factors which contribute to the formation and the growth of industrial clusters (Feldman and Lowe, 2008; Dahl et al., 2005). Recent research on the genesis of high technology cluster shows that the presence of a large firm, university or public laboratory *has attracted*, to the same location, other important organisations related to that industry (Braunerhjelm 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, explicitly, the anchor tenant and therefore offer valuable input for a rigorous definition. Agrawal and Cockburn (2003, p.1229) define an anchor tenant as a *large*, *locally present* firm that is:

1 heavily engaged in R&D in general

2 has at least minor absorptive capacity in a particular technological area.

Feldman (2003) argues that a regional economy may benefit from the presence of large, technologically sophisticated organisations that anchor local economies. According to her, a large established entity is central to *the creation of an important volume of ideas and knowledge externalities* that may benefit other firms, especially the start-up ones. According to Feldman, such entities may be large research universities.

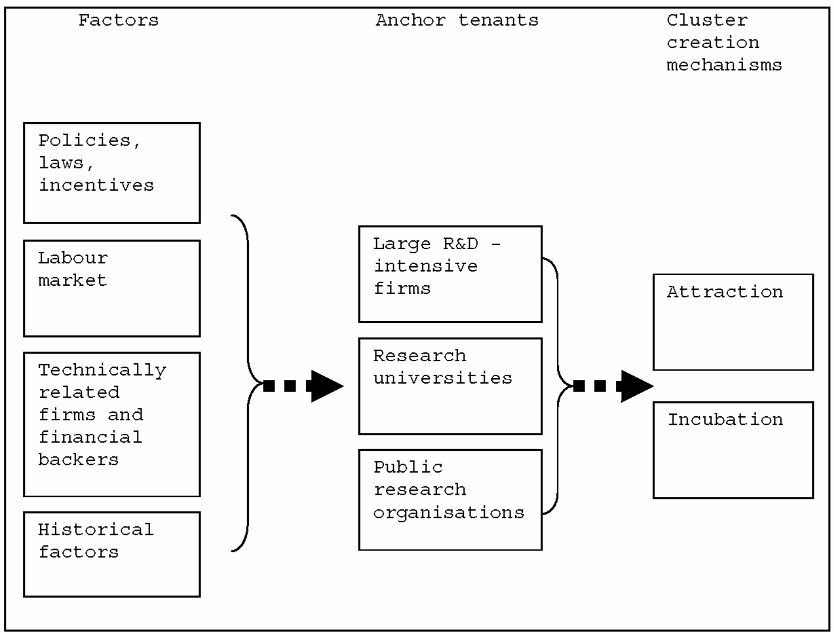
Link et al. (2003) identify high-technology anchor tenants as large R&D-intensive firms, as recognised by their patenting activity, that have a strong focus on a particular technological field. They conjecture that high-technology anchor tenants *enhance regional innovation systems by stimulating technological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

Niosi and Zhegu (2005) argued that large aerospace firms are the 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 large innovating organisation in a high technology cluster which contributes to the enhancement of the advantages of co-location by generating an important volume of knowledge spillovers through its own activities and by attracting other organisations to the same location."

We distinguish two categories of factors whose role in the creation and development of clusters are very different. As shown in the Figure 1, in one side, there is a set of favourable factors, which are of different nature like institutional (laws, institutions), market (qualified labour market, entrepreneurs or production firms market) or historical accidents (dummy factors). Their presence is a prerequisite to attract an anchor tenant in a specific location. On the other side, the anchor tenants, which are always organisations (firms, research universities or public laboratories), become the pivotal factor for the cluster creation. The anchor tenants achieve their role by attracting other firms in the same location (as in the case of large aerospace sector) or by incubating other firms and creating around them an important number of spin-offs.

Figure 1 Propitious factors, anchor tenants and cluster creation mechanisms



The favourable factors attract the anchor tenants whose presence in a location is a necessary condition for its transformation in a high technology cluster. However, this is not a linear relationship since different feedback forces are activated. Also, the presence in a location of an anchor tenant is not a sufficient condition and therefore may not lead to the creation of an industrial cluster in that location. Furthermore, the existence of several favourable factors may not suffice to attract an anchor tenant in a particular location.

In the following sections we explore several research questions on the relationship between the anchor tenant and the industrial cluster. On 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 hypotheses 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 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 investigates the role of the anchor tenants in the creation and development of the US aircraft clusters. We have studied the evolution of these clusters throughout the entire industry lifetime, i.e., the 20th century.

3.1 Sources of data and methodological issues

In order to test our research hypotheses we have gathered and combined 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 (for instance, US Bureau of Census), industrial associations (US Aerospace Industries Association,), several aircraft industry specialised encyclopaedias or other publications (Jane's All the World Aircraft, Mondey and Taylor's *The New Illustrated Encyclopaedia of Aircraft*), companies' information and business reports directories (Mergent, Hoover's).

The US Patent and Trademark Office (USPTO) database has been the main source of patent data for our research. We have extracted 40,013 patents belonging to class 244 of the domestic classification of the USPTO. This class 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 26,533 patents 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 origins, the aircraft industry has been geographically concentrated. The first focal areas appeared in the US northeast regions, in the so-called 'the manufacturing belt', which at the beginnings of the 20th century counted for around three quarters of the country's industrial production (Perloff et al., 1960). The geographical location of the emerging aircraft industry has been highly independent from the markets of both its material inputs and outputs. Thus, when 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, close to Washington DC.

The first question is what attracted the emergent aircraft industry to the 'manufacturing belt'? According to Cunningham (1951), during the first decades of the 20th century, 90% of the job positions of the aircraft industry required employees endowed with high technical qualifications by the standards at that time. Considering that the employees were supposed to accomplish multiple, non-standardised tasks and solve 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 skilled manpower capable of understanding the complexity and satisfying the requirements of the emerging industry. Furthermore, during the first decades of the aircraft industry, 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 spun-off their aircraft production department, which continued to develop independently. 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, which was the largest aircraft manufacturer in the world during World War I, originated in the motorcycle engine manufacturing 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 flows of industrial relocation took place. 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 USA. In 1920, Donald Douglas Sr. founded his own aircraft company in Santa Monica, California. Douglas Aircraft became the principal anchor that attracted several other companies to that region. In 1935, Reuben Fleet of Consolidated Aircraft transferred its company from Buffalo to San Diego. In 1939, John Northrop chose Los Angeles for its manufacturing plant. According to the US Census of Manufacturers, in 1925, among 44 large US companies only four 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 centres toward peripheral locations. This was the case of Grumman Aircraft, Brewster Aeronautical and Republic Aviation, who moved to the suburbs of New York City. Piper Aircraft also changed its site without leaving Pennsylvania.

Historical factors forced a third wave of industrial relocation. During the Second World War, 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 USA increased from 4% to 44.7% (Cunningham, 1951).

The first set of factors that motivated the rapid relocation of US 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 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 US 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 work force at lower costs compared to the 'manufacturing belt'. In addition, a less unionised 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 one hand, the emerging industry was still too unstable, uncertain and ignored from the investors. On the other, the aircraft firms were, yet, relatively small in size and their reputation was restricted to a small geographical area. Under these circumstances, geographical proximity with potential investors increased their visibility. Thus, 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 plant in Wichita. A few years later, Walter Beech followed his example. 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.

A third set of historical factors exerted a major influence in the development of the aircraft industry and its location. The new industry emergence coincided with the two World Wars, whose strategic military needs made it possible for the aircraft industry to require strong government involvement in the financing 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.

During the first 40 years, the location and relocation of the aircraft industry seems, at first sight, random. Yet, it is possible to identify certain patterns and distinguish the role of some organisations, which have been crucial to the cluster creation and industry development, and were its anchor tenants. In the very beginning of the industry, firms from the 'formative' mechanical industries anchored the new activity by incubating its future leaders. Also, these firms attracted other ones to the same location, by supplying a pool of skilled employees. As other studies have pointed out (Duranton and Puga, 2001; Heblich et al., 2008) the emerging industry beneficiated more from Jacobs (inter-industry) externalities found mostly in diversified urban agglomerations. Second, the private and public sources of capital attracted 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 pilots, carpenters, boat builders and seamstresses) (see Boeing.com website). 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 and they all planted in their respective regions the seeds of future successful aircraft clusters.

3.3 Industry, anchor tenants and aircraft clusters dynamics

After the World War II, the aircraft industry became a cornerstone of the US economy. By the late 1960s, it represented 1.5% of its GDP and 7.1% of the country's manufacturing exports. With a level of R-D close to 15% 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 decentralisation 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 simultaneous effect of all these factors imposed the long and intensive process of major industrial reorganisation. The consolidation process persisted till the end of the 1990s, when Boeing became the only US major civil aircraft assembler while sharing with Lockheed Martin, Raytheon, Northrop Grumman and General Dynamics the military and space markets.

Since the mid-1970s, due to the decentralisation of the airline industry, aircraft manufacturing was involved in a long and intensive reorganisation. 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 component supplying companies.

Industrial consolidation was also reflected in a concentrated geographical distribution of the industry. In the 1960s, 92% of the after war aircraft industry was clustered around the remaining large firms in only six US states: California (40%), Texas (14%), Washington (12%), New York (11%), Maryland (8%) and Kansas (8%) (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% 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) and Cincinnati (Ohio).

It is possible 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. In this line of though we have considered the way in which the consolidation of the industry and the reorganisation of its supply chain have affected the aircraft clusters. Were these later dynamics associated with those of their large anchor firms? We investigate what happened with the aircraft clusters during the persistent processes of mergers and acquisitions when, major aircraft companies disappeared or changed their role in the industrial hierarchy. In this regard, one may distinguish 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 59 year old aircraft cluster anchored by this firm in the area of Farmingdale, New Jersey. In 1986, in a context of a major reorganisation, Lockheed Martin transferred its head office from Burbank to Calabasas, both in California. Two years later the company closed its installations of Burbank and thus put an end to 60 years of aircraft production in the cluster (Pattillo, 1998).

The second pattern regroups the cases when the anchor tenant merges or is acquired by another firm, but the aircraft cluster remains active. In a few cases, the cluster preserves 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 to St. Louis, Missouri.

However, in most 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 centralised at the new company centre. This happened for instance, when Bombardier acquired the Lear Jet and Short Brothers and centralised 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, California, 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% of the patenting activity: California (22%); New York (13%); Washington (8%); Ohio (8%) and New Jersey (5%). Also, there is also a high local concentration of the innovation activity as shown in Table 1.

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

In the aircraft industry, the geography of innovation has experienced many changes (see Figure 2). At its dawn, the northeast represented 75% of its patenting activity. The New York metropolitan area alone counted for 45% of the total number of patents issued between 1905 and 1944. However, since the end of the Second World War, two California regions (Los Angeles and San Diego) took the lead in innovation, as the patent data show.

Figure 2 Geographical distribution of US aircraft patents (Class 244), 1905–2004 (see online version for colours)

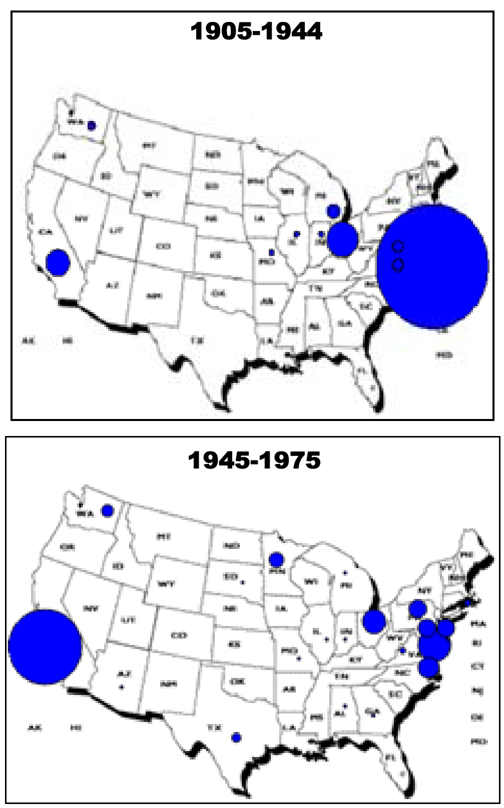
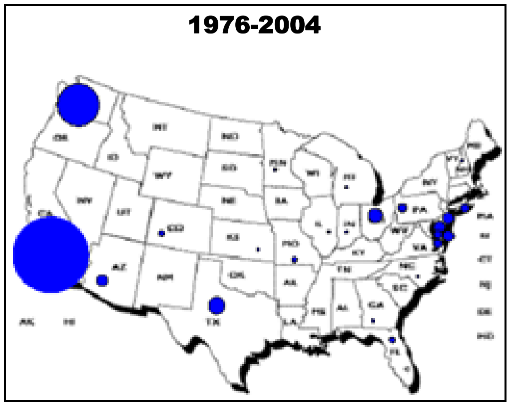


Figure 2 Geographical distribution of US aircraft patents (Class 244), 1905–2004 (continued) (see online version for colours)



In Table 2, the aircraft clusters are organised on the basis of their innovative performances. The first group includes the aircraft clusters whose innovating activity declined during both the growth and maturity periods. This is the case of New York, Ohio, Pennsylvania and Michigan. The second group includes the aircraft regions whose innovation activity kept growing during the industry growth phase and declined only during the maturity phase of the industry. This is the case of New Jersey, Connecticut and Maryland. The last group includes states like California, Washington and Texas, which experienced a continuous growing innovation activity during all the aircraft industry's lifecycle phases.

What explains the growth or decline of aircraft clusters? The reason suggested here 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 organisations emerged: large companies and government laboratories. Thus, Douglas Aircraft, Curtiss Wright, Boeing or Goodyear and BF 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 those of Connecticut and 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 innovating 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 BF Goodrich Co. kept many other innovator firms anchored in that region.

Furthermore, with the growth or the decline of innovation activity in the anchor firm, 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 initiated 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. In the decade following the closure of Curtiss Wright, the number of innovator firms in the NY region fell from 20 to 4.

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	New York	13	43	11	4	Declining
2	Ohio	8	12	8	5	Declining
3	Pennsylvania	5	4	6	3	Declining
4	Michigan	2	5	1	1	Declining
5	New Jersey	5	4	7	3	Growing then declining
6	Connecticut	5	4	6	4	Growing then declining
7	Maryland	5	4	6	3	Growing then declining
8	Minnesota	3	0	5	1	Growing then declining
9	California	22	9	25	27	Growing
10	Washington	8	3	4	15	Growing
11	Texas	4	0	3	6	Growing
12	Virginia	3	0	2	4	Growing
13	Massachusetts	2	1	2	3	Growing
14	Arizona	2	0	1	4	Growing
15	Alabama	2	0	1	3	Growing
16	Florida	1	0	1	2	Growing

The propensity to patent in 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 constructor 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 acquisition 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 keep the innovators in that region. Thus, a multi-anchor cluster performs better than the regions depending on a single anchor firm.

Table 3.1 Anchor tenant and cluster long-term relationships, the 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 (AT)	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 and cluster long-term relationships, the 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 (AT)	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	1324	
	Total number of innovator firms	17	42	54	48	40	40	13		

Table 3.3 Anchor tenant and cluster long-term relationships, the Seattle cluster

Assignee name	*Patents issue year*							*Total*
	1913–1922	*1923–1932*	*1933–1942*	*1943–1952*	*1953–1962*	*1963–1972*	*1973–1982*	
Boeing	3 (AT)	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
US Aviation Corporation						1		1
The Fox Company								1
Sundstrand Corporation						1		1
Stinson Aircraft Corporation							1	1
Sirius Corporation								1
Robertson Aircraft						1		1
Research Corporation								1
RC Struble Company, Inc.								1
Jack & Heinz Precision Industries, Inc.								1
Hardman Aerospace						1		1
General Motors Corporation								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 and cluster long-term relationships, the 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 (AT)	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					4	1.0
Chandler Evans Inc.						1	3	4	1.0
Curtiss-Wright Corporation		2	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 and cluster long-term relationships, the 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 (AT)	37	14	3	25	44	9	138	20.2
BF Goodrich Company	5 (AT)	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, Gessellschaft Mit Beschrankte		13						13	1.9
General Motors Corporation				2	7	1		10	1.5
Walco 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 and cluster long-term relationships, the 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 (AT)	33	8	51	28.0
Chance Vought Corporation					13 (AT)	13		26	14.3
Bell Aerospace Corporation					6 (AT)	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		

4 Policy implications and conclusions

Anchor tenants produce positive agglomeration effects on a region by spinning off new local innovative firms and by attracting other innovative firms to the region. Anchors tend to localise themselves in regions that posses several favourable characteristics. In the origins of the aerospace industry, they included a skilled and competitive workforce in mechanical or aerospace engineering, government support and relatively low cost of land. These conditions are effective today.

However, these positive conditions may not be enough to attract aerospace anchors. Government support needs to be sophisticated and have a long-term perspective. By sophisticated, we mean that public support should be linked to the attainment of specific milestones, such as the completion of design, prototypes, commercial production, exports and profitability within reasonable timeframes. The region must be able not only to contain a skilled labour pool, but also to produce or attract new workers, technicians and engineers.

Also, an anchor does not necessarily create regional innovative systems if such propitious conditions are not present or they are denied to newcomers. If government support is allocated to the anchor but not to other potential tenants, for instance, the cluster may not grow. If the region is not able to produce or attract new skilled labour the presence of the anchor may not be enough to attract new firms.

The anchor may disappear or contract following the bankruptcy or the delocalisation of the anchor due to adverse market conditions or wrong management decisions. This happened in Amsterdam, where the closure of Fokker in 1996 drastically reduced the number of aerospace workers. But the region's involvement in a particular sector may also change the nature of the work conducted in the cluster. The Amsterdam cluster does not produce entire aircraft anymore, but it produces components for several other companies such as Airbus and Lockheed.

The original anchor may attract other anchors where favourable conditions are stable. In Montreal, Bombardier attracted Pratt & Whitney Canada (PWC), Bell Helicopter, Rolls Royce and other large innovative firms to the region. The Province of Québec has one of the most generous tax credits for R&D incentives in the OECD. It is also the host of four research universities and a federal government laboratory in aerospace. In Washington State, the original anchor tenant, Boeing, attracted Goodrich Aerostructures, Leibherr Aerospace, Rolls Royce and other large R&D-intensive companies, thus reinforcing the cluster. The state also uses an array of tax incentives for the industry. And it hosts a national centre of excellence on advanced materials in commercial aircraft, a large research university and several community colleges with programs in aeronautics.

The policy implications are that government incentives, when combined with other favourable conditions, may attract or keep anchor tenants in a region. Yet they cannot compensate for market conditions or wrong managerial decisions in firms.

Future research should include, first and foremost, the analysis of the lifecycle of the cluster itself. Through the decades, the industry has undergone two major changes: economic concentration and internationalisation. Such changes have had major impacts on clusters: many clusters have radically downsized and most of them are now heavily involved in international trade. For both commercial and cost reasons, no entire aircraft is made in any region, even if the region is capable of producing it.

Secondly, a more precise measure of externalities both regional, national and international, will be an important addition to the explanation of both the regional and the industrial dynamics.

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