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Globalization and the Patterns of Industry location: the case of the aerospace industry

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Abstract:

This paper is about the influence of a growing global supply chain on the geography of innovation. Although numerous studies conclude that geographical agglomeration and globalization of R&D are two ongoing and interacting processes, boundaries between local and global frameworks remain yet unexplored. (Doloreux, David and Saeed Parto, 2004).;(Fagerberg et al., 2005). Since the 1980s, considerable theoretical and empirical work has been done in order to understand the role of national and regional systems in promoting successful innovation practices. A decade later, scholars' attention has also been concerned by a 'counterpart' phenomenon of regionalization. Studies on globalization have revealed multitude of factors that influence the performance of innovative activities. Both corpus of literature emphasizes the importance of factors related to their own local or global perspective, considering the other as a limit-state. We believe that the use of single-lens theoretical perspectives may have originated the lack of attention regarding the complex interdependencies between the two phenomena.

In this paper we attempt the discernment of mechanisms (both local and global) that generates changes in geographical patterns of industrial location and innovation. We explore the possibility that, among others, globalization of the supply chain is a crucial one. Trying to avoid a one-side perception we will concentrate in the co-evolution of both local and global supply-chain innovators and in the ways, that home or international location reacts to this co-evolution. The case of aerospace, which is as well locally rooted as an internationally ramified industry, provide the possibility to analyze consistently both aspects. In the past, longitudinal studies have aimed at the innovation patterns in this industry, mostly, from a firm or a country's viewpoint: instead, this paper focuses on the regional dynamics.

Keywords: globalization; geographic agglomeration; aerospace

1. Introduction: The metaphor of blind men and the elephant

Since Nelson and Winter offered a new evolutionary interpretation of the economics, considerable amount of research has been following their path. This definitively more realistic perception of the phenomena has augmented the preciousness of scholar's our 'boite à outils' for further explorations.

There are clear signs of maturity of this mainstream theoretical corpus. There is a new tendency that goes through the concentration of the debate not in old resentments, but in future developments and in approaches aiming the surpassing of the own limits (Foster et al., 2001). This paper joins the efforts going in this direction.

At present, very profound and detailed perspectives of innovation are available. And, from their own perspective, scholars have been introducing convincing arguments. Yet, they look as individual parts of a puzzle. Even if most of them have obtained the peer's consensus, it still remains the impression of having seen the elephant's description from a group of blind men: resembling to many other things but an elephant. Fagerberg and al. (2005) stress on the fact that an holistic view of the phenomena has become a prerequisite.

Although numerous studies conclude that geographical agglomeration and globalization of R&D are two ongoing and interacting processes, boundaries between local and global frameworks are yet unexplored (Doloreux et al., 2004; Narula and Zanfei, 2005). This paper proposes a useful framework for the study of the co-evolution of industries, regions and innovations systems in the world economy.

The following section outlines theories explaining either localization or globalization of innovation. The third section analyse the case of aerospace industry with regards to the phases and the mechanisms that generate changes in the location patterns. Aerospace is as well a locally rooted as an internationally ramified high technology industry. In the current phase of its development, the supply chain is considered as one of the most important factors influencing the dynamics that are going on in this industry. Then we attempt to integrate the diverse theoretical standpoints in one model. The last section conveys some concluding remarks.

2. Exploring the frontier between local and global economies. Theoretical perspectives.

2.1 Theorization about the geographical agglomeration of the industry and innovation

Since the beginning of the Industrial Revolution era, in 1750, the capitalistic economies have been involved in a sustainable growth process. Even, ever since, the technological change has been the engine of the economic growth, economic theories have struggled to recognize the reality. As a matter of fact, the mechanistic metaphor has gone a long way, imposing its perception of static equilibrium. It is only after the Second World War (some two hundred years later) that scholars started to consider the technological change and increasing returns as endogen premises of growth. On the other hand, scholars have been concerned much more earlier about the impact of geographical location for the growth of firms. Yet, these concerns have been condensed in terms of transport cost or input resources, always transiting by the market. And again, is only after the Second Word War that Marshall's 'something in the air' element and all the other so-called 'market imperfections' will be scrutinized, and the findings will be more than surprising. Indeed, the increasing returns and the knowledge spillovers are now believed essential for the sustainable growth (Hansen, 2002). The agglomeration effect is also seen as central to the production and diffusion of production and innovation.

All these have currently become a common knowledge. However, the theoretical interpretations and, consequently, the policy implications have often followed divergent paths. In one side stand the convinced economists, who try to integrate to the theory of equilibrium new conceptions like technical change, increasing returns, or imperfect competition. Still, the principal limit consist in the gap between their models and the reality.

In the other side stand the evolutionary perspectives and system thinking theories that elude the equilibrium perspective from the economic studies. The former, has drown the analogy with Darwinian selection theory in attempting the explanation of the structural economic changes. The later, highlights the role of the systemic interactions in promoting innovation and growth. The major contribution of both approaches is their determination to deal with the world complexity without simplifying it in something totally abstract. Nevertheless, the risk associated to this effort is the adoption of a somewhat inductive, interdisciplinary empiricism which may obstruct the way towards a conventional scientific goal. The 'new' evolutionary economists look after simple analytical principles that can be used to understand temporal and spatial patterns in complex realities. (Foster et al., 2001) .

From both sides, numerous theories have been drawn and empirical studies have been conducted in order to explore the geographical patterns of production and innovation. These studies fall in one of the following theoretical frameworks:

- The New Economic Geography, that grew up in the 1990s. Krugman, has characterized the emergence of the research in this domain as a fourth wave of increasing returns revolution in economics (that started with the works of Stiglitz on the monopolistic competition). The larger ambition of the authors is that by modeling the sources of increasing returns to spatial concentration, to be able to learn something about how and when these returns may change, and then explore how the economy's behaviour will change with them.(Fujita et al., 1999). In this context, the models developed relate to the balance between "centripetal" forces, that tend to promote spatial concentration of economic activity, and "centrifugal" forces that oppose such concentration. They remain prisoners of an 'equilibrium-seek' conception and of the (mathematical) tools advancement (that will help in modeling it).
- The Learning Economies and Knowledge Spillovers Theories that offer an enriching perspective about the technical externalities (that are just knowledge externalities of one form or another)[1] and learning processes. Scholars attention has been focused in different angles related to the question of Why, How, Were and When the innovation happened. Their most outstanding contribution in the understanding of the innovation is the exploration and explanations about the role of tacit knowledge in the

[1] To be distinguished from 'pecuniary externalities' or 'thick market effects' that arise in monopolistically competitive markets.

regional interactions. Many scholars have been putting forward, with considerable success, concrete ways of investigating the mechanisms of creation and transfer of the knowledge components contained in a 'black box' considered for a long time as untouchable.

- The System of Innovation perspectives explain the innovativeness of nations, regions or sectors in function of multidimensional interaction between their components. These are *organizations* (or formal structures that are consciously created and have an explicit purpose) and *institutions* (the set of common habits, norms, routines, established practices, rules or laws that regulate the relations between individuals, groups and organizations.(Edquist, 1997). One would mention as essential contributions theories about the learning aptitude, the level of cooperation, the technological dynamics in the three levels of analysis (national, regional or sectoral). This is an interdisciplinary perspective based on the evolutionary economics, institutional economics, the economics of innovation, the regional sciences, the networking theory, etc. This constitutes at the same time the main advantage and the main disadvantage of this theoretical corpus. The System Innovation theories are impregnated with a higher degree of reality. But Systems of Innovations do not yet constitute a formal theory. The multidisciplinary roots elicit a kind of conceptual diffuseness (ex. institution as a term may assume many meanings) and imposes the search for boundaries.

2.2 *Theorization about the internationalization of the industry*

As Allen Scott (2001) puts forward, one of the main paradoxes of the contemporary economy is the parallel ongoing of two, apparently opposing, processes: the instauration of a new global economic order, goes hand in hand with the reinforcement of the role of regional economies. In Scott's opinion, the world is becoming a global mosaic of local economies. More interested by the discernment of the factors influencing a fulgurating success of some regions, it's only in the 1990s that, scholars' attention has also been also returned toward a 'counterpart' phenomenon of the regionalization. An important amount of empirical research has emphasised a strong tendency toward the globalization of the innovation. Studies on the causes and drivers of such a tendency have followed. Niosi (1999) evokes three phases of development of the literature about the globalization of R&D. During the first phase, before the 1980s, internationalization was associated with the transfer of technology from the mother company to the foreign branches and the life cycle theory had been drawn as a modeling platform. During the 1980s and the early 1990s many studies found that the globalization process had been frequently generating some polycentric structures and have been implying radically new methods of management of the innovation. Since the mid 1990s, scholars have been much more concerned with the central role of learning in the shape of these growing globalization tendency.

Narula (1999) suggests that in a myriad of factors that have been driving the internationalization of innovative activities the most recurrent is the need to respond to different demand and market conditions across locations, and the need for the firms to respond effectively to these by adapting their existing product and process technologies through foreign-located R&D. Archibugi (1995) proposes a taxonomy of globalization that consider the acquisition of knowledge as a principal motivator. In this context firms will adopt a technology-oriented posture (Florida,1997). Zedtwitz et al. (2002) have also analysed the decisions of firms about their R&D location. Based on that, the authors propose four archetypes of R&D internationalization: the national treasures, the market driven, the technology driven or the global firms. The multinational firms have been considered as the most important mechanism that has been carrying out and coordinating the majority of supranational functions related to the globalization of R&D. (Asheim et al., 2002).

However, studies on globalization have focalized the benefits and costs of the globalization process mostly from a firm perspective. But less is done in terms of regional or national effects. The recent debates about the 'Hollowing out' effect or the 'Technological accumulation hypothesis' suggest that the interaction between local and global systems are becoming more problematic and calls for a more sophisticated analytical tools. (Narula et al., 2005).

In a larger view, the majority of studies consecrated to the localization and internationalization tendencies have been adopting a single-lenses perspective, considering the local and global dynamics mostly as juxtaposed. Although their zoom in on every one system have been providing a better understanding of each of them, it has also generated a lack of attention regarding the boundaries between both of them. There is little consensus about the limits, as well as little evidence about the permeability (or porosity) of the frontiers between the systems. Scholars have started to point out the need for the adoption of a synchronized theoretical and empirical perspective about the interaction and co-evolution of regional and global dynamics. (Doloreux et al., 2004 ; Fagerberg et al., 2005 ; Narula, 2004).

Although the interaction between the two systems have been neglected for a long time, some attempts of reunifying the two separate strands of literature have been already done. Kerstin (2004) suggests that the effects generated by the interaction between inside/outside the cluster are function of the degree of adaptability of cluster's components. Bathelt et al. (2004) examine the processes of creation and diffusion of knowledge in and out the clusters based in the co-existence of local buzz and global pipelines. Isaksen (2001) links the vulnerability of local areas to the strategic decision making of transnational corporations. Yet, a general picture of systems interactions is missing and little is known about their influences in each other evolution. What are the patterns and the mechanisms that drive the co-evolution of industries, regions and innovations systems? We'll try to draw together the theoretical perspectives that may be helpful to answer this question.

The product life cycle theory has offered explanatory models of the entry, exit growth and innovation of firms. Abernathy and Utterback (1978) captured some regularity in innovation patterns related to divers stages of product life cycle and put forward the importance of 'early entrance advantage' and 'dominant design' as principal factors influencing these regularities. Later on, their influence has been considered as overestimated and both demand and supply side factors have been reconsidered. (Mowery, 1982; Porter, 1983). Klepper (1996) revisited the product life cycle theory and his enriching approach has renewed the interest of scholars on it and gave way to a lot of further applications. Audretch and Feldman (1996) have linked the tendency for innovative activity to spatially cluster to the stages of the industry life cycle. They found that in the earlier stages of an industry life cycle, innovative activity tend to be more dispersed. Then, during the mature and declining stages of the life cycle the location of production and innovation tend to geographically concentrate

The anchor tenant hypothesis that has recently been developed, stipulates that the presence in a cluster of one (or some) large firm generates a prolific traffic of ideas influencing though the creation and/or the growth of other firms in that same location. (Feldman, 2003; Agrawal et al., 2002). In the case of biotechnology firms, Feldman recognizes that during the creation stage universities will play the role of the anchor in attracting new firms. Afterwards, during the maturity stage, are the big pharmaceutical firms that will be invested with the anchor role. Carmel (2001). also found that more than 60% of high technology firms that had been founded in Israel, in further stages of their development have established part of their activities in the United States. The important pool of highly specialized expertise had been the attractor in the first stage of industrial life cycle. But, the lack of market critical mass and of a powerful marketing network have been orienting the mature firms toward other locations. The tables 1 reveals the delocalisation of production of US civil aircraft during a period of 30 years. (Pritchard et al., 2005). The industry is considered as very strategic from the point of view of the National Defence and also for its contribution to the economic growth. Once a totally domestic based production, now companies are outsourcing a large part of it. So, even in the case of this sensitive industry, the domestic resources are no more adequate to its time-specific exigencies.

(Table 1 about here)

Important questions remains yet unexplored. What are the patterns and the mechanisms that drive the co-evolution of industries, regions and innovations systems? How comes that a region that have nurtured an industrial success story, at a certain point, is unable to follow its needs? How does the tension between local and global attractor forces affect the relationship industry - region over time?

This paper trays to draw a framework based on the integration of diverse theoretical perspectives. We adopt here an history-friendly and empirically inductive approach. We will be first outline the major moments of the evolution of the airspace industry and then we will propose a model of the co-evolution processes involving industries, regional systems and public policies. The following section deals with the question of how have the location matter during the life cycle of the American aircraft industry.

3. The aircraft industry in the USA: How local and global dynamics interact?

Usually the case of aircraft industry has been serving as an illustration of an industry characterized by major geographical inertia due to heavy sunk costs in large plants that cannot be easily moved from one location to other. In spite of this, the century long history of the aerospace has been demonstrating a very versatile relationship between the industry and it's location.

The most evident consideration that comes out from an overview of the geography of location of the aircraft industry is the disregard to traditional location theories. All factors related to the cost of primary materials had have never been considered. That is because the aircraft assembler companies' work is based in semi-product, not in the primary inputs from what depend and that have been driving the localization decisions in other industries. Moreover, the very large number and nature of the parts and materials that compose an aircraft, imply the very large extension of their geographical origin. The transportation costs have also had a trivial role, because they are only a small fraction in the overall cost of the project. What are the factors that have determined the location of the industry?

3.1 The Take-off period

In the beginning, one of the most important factors that had been strongly influencing its location decision is related to the fact that aircraft production is an labour intensive industry requiring a sizeable quantity of high skills employees. The balance between quality and quantity of labor, both important for the final cost of the product, has been explaining a big deal in the patterns of location. In the pioneering years of the industry, large agglomerations, offering a large pool of engineering and knowledgeable labour have been the principal attractor of aircraft plants. As Todd and Simpson (1986). describe, the industry formation period had represent a 'seed-bed' development. This means that some formative industries, as the shipbuilding or the railroad construction, have nurtured the entrepreneurship initiative and have created a pool of labour endowed with the level of expertise that satisfied the requirements of the new very innovative and complex industry. That would explain why the Northeast coast region of the United States was the first concentration of the aircraft firms. The aircraft history have registered abundant cases of firms previously specialized in other industries (most of them in defence sector) that had first logged an aircraft department and some time later, they had transformed their business and have dedicated it entirely to the aircraft production. This was the case of Vickers (an arm producer company) and Crayford (machine-gun shops) in US, or James White and William Beardmore (both of them were shipyards owners) in UK, just to name a few.

(**Figure 1 about here)**

Even if a certain level of inertia in the aircraft site-location appears to be present (mostly related to the specificity of labor supply and the large size of plants), in 1940, one-half of the industry's capacity was in location other than the original location of the companies concerned. (Cunningham, 1951). By that time, two tendencies have been depicted. One was the interregional movement from the northeast manufacturing belt, toward the Sun Belt and the Pacific coast (called 'westward' movement). The second tendency concerns a local move of plants from inside large agglomerations toward their suburbs. With regard to location issues, the airframe plants have been proved of being the most 'footloose' part of the industry contrary to the aircraft engine plants that showed more stability in their location.

(Figure 2 about here)

Three principal motivation explain the delocalisation of the aircraft industry during this fast growth period (before the Second World War). With the expansion of the industry and the growing in complexity and size of the aircrafts that had been produced, the enlargement of the operational utilities became indispensable. In choosing the new location, the decision makers sought for more suitable condition in terms of bigger space and also for some better weather conditions that will had have facilitated the flying tests (and, of course, also minimizing heating coast of enormous plants). From this point of view, because of its cold winters, northeast region was not considered the fittest solution for many companies (even, if others continued to develop their activity in Seattle, Buffalo or Bridgeport). Douglas was one of the first to transfer his activity in California, and so becoming an powerful anchor for the aircraft industry in this region. Chance Vought (LTV) left Connecticut for Dallas, and so one. The same need of expansion, after the take-off period of the industry, has been experienced also in Europe, but the transferring distance were much modest than in the US. With a few exceptions, the most part of firms delocalised in the neighbourhoods of London or Manchester. The industry tended to concentrate and during the delocalisation the plant had generally been completely transferred to the new location (Notice the difference with the our days practice consisting in new branch opening, without closing the prior ones). The industry was oriented toward the military market.

Meanwhile, the haunting spectre of the a World War, caused an never-seen-before movement of strategic relocations instigated by the government resolution to decentralize the aircraft industry far from sites considered as enemy's attainable targets. The outcome of the 'Shadow factory scheme' in UK or 'Modification Centres Program' in the US, was the burgeoning of many branches and war-borne companies in location completely new to the aircraft industry as in the case of Elizabeth City in North Carolina (the branch was managed by Consolidated), Dagget in California (under the Douglas' wing), Phoenix in Arizona (the branch was run by Goodyear Aircraft) et cetera. The ever fast growing demand during the World War was offset short after the war and the industry location patterns returned to its normality of the prewar period. In fact, the 'Modification centres', these branches implanted only following a national security criteria, were eliminated. The overflowing creation of war-borne companies was also an ephemera phenomenon. They fail to survive to the drastic cut-back of government orders as well as numerous prewar companies did. Some of them proceeded to a conversion of production in previous activities.

(Fig. 3 and 4 about here)

3.2 The growth period

Governments have always been preponderantly influencing the trajectory of the aircraft industry. The manufacturing of civilian aircraft is a long-term, high risk and multi-billion venture. In the context of high uncertainty, the great achievements of the industry would have been unconceivable without the government support. The military and civil aircraft sectors, share in common a large part of the same technology base, supply chain base and many skills and processes. This dual-use character of the industry has been leading the activation of considerable knowledge spillovers flowing from the government financed defence sector to the civil sector.(Pinelli et al., 1997b). The later has been preserving the necessary industrial infrastructure that assure the viability of national defence objectives. Because of these interlinked interests, the government's interventions have been hindering the market-driven functioning of the civil aircraft sector. Of course these interventions have in some ways affected the location decision of the industry. One may think that the proximity to the governmental sites, since they have been an essential sources of financing, may have been a good location. However, this has happened only in some very isolated cases. For instance, this criteria has prevailed in the case of Lockheed Martin after the company have totally converted his production in defence sector. Even the principal government R&D centres have had a modest role in anchoring the industry. In explaining the management of R&D knowledge spillovers from NASA, to the industry, Pinelli et al. (1997a)seem to not give much importance to the geographical location of the implicated firms. Moreover, government has demonstrated a certain lag in following the new tendencies of industrial location. During the World War Two, the geographical distribution of the contracts for the war aircraft has revealed a clear predisposition for the oldest location: East North Central and Middle Atlantic regions had raffled more than 54% of the contracts when the Pacific regions (Washington and California) received only 19% of them. So, the government's ability to choose where the industry will be located is limited. Many initiatives aiming the redeployment of the industry for security reasons or for regional development policies have not succeeded and the industry has returned to its own patterns of location. Nevertheless, once these patterns were established, the government intervention has been a determinant factor in their reinforcement.

During the postwar period the US had been imposing an irrefutable leadership in the world's aircraft industry. But this important ascending period has been unequally lived by different locations. Some of them have been growing faster and some of them have abandoned the very competitive battlefield. Almost always, the raise and the fall of the aircraft industry hosting regions have closely followed the raise and the fall of their anchor-firms. The fates of these one have been strongly depending on the concentration process that the industry has been going through.

(**Table 2 about here)**

A study about the competitive status of the U.S. civil aviation conclude that the financial records of commercial transport manufactures since the WWII is not reassuring. Only 5 of 22 manufacturers of large transports survive in the free world, and the viability of some of them is questionable. (Seitz et al., 1985). The geographical concentration have followed the industrial concentration. The winner hosting-states like California, Washington, Texas, Florida or Ohio have been corroborating their position in the industry, while other states position has declined. Connecticut, Massachusetts or the central regions are some of them.

(Figure 5 about here)

In the beginning of 1970s, the supremacy of the American aircraft industry was challenged by two principal events. The first was related to the successful outcome that coroneted the decades-long efforts of European countries for building up a strong aircraft industry. Well-supported by the participating Governments, Airbus has been increasingly investing in new technologies and have achieved major innovations. From the beginning the company had targeted a worldwide market penetration. In fact, it took only 10 years to Aérospatial to almost equalize the number of wide-bodied commercial aircraft produced by its American competitors: in 1980 they produced respectively 155 and 160 of those aircrafts. The gradually but surely rising success of Airbus has injected more uncertainty into an already uncertain business outlook for US manufacturers. Furthermore, the aggressive competition delivered by Airbus has been accounting as a major factor that has further reduced the investment attractiveness of the US commercial aircraft industry, whose performance, even before, has been modest at best. (Seitz et al., 1985).

The second hurtful event for the American aircraft manufacturing related to the deregulation, in 1978, of fairs and routes for the domestic airlines companies. Combined with a deep economic recession, the restructuring of the airline market had dramatic effects on the financial performance of many operators.

(Figure 6 about here)

Unsurprisingly, this have caused the consistent reduction of the demand for new aircraft, the deferment of deliveries, and some times even the inability to take delivery of firm-order aircraft. Certainly, this has reinforced the tendency to the erosion of the investment capacity of the American aircraft manufacturing. In terms of location, the hub-and-spoke feeder system that was the immediate response of the airlines to the new situation, emphasised, even more, the role of the most leading regions.

3.3 Maturity and /or decline period

Subsequently, the joint effect of the cyclic nature of the industry, the domestic market restructuring and the growth of foreign competition, have seriously affected the capabilities of US aircraft companies to lunch new aircraft. It has been estimated that the recovery of the initial investment (4 to 6 billion dollars. This figure attains 12 billion dollars in the case of A380) requires 10-15 years. And yet, this is the case only for the successful programs. That made the consequences of an error unbearable even for giant companies.

The irony of the situation was that the Government, that had been directly or indirectly shaping the path taken by the aircraft industry, had been facing the limits of his power. His action has been neutralized by the determination of another actor of the same stature. Furthermore, the game was engaged in an international context. Consequently, new rules have quickly have been put in place and the involved governments have been trying to respond, with diverse degree of success, to the changing situation with more adequate public policies.

How all of this have influenced the geography of production and innovation of the aircraft industry ? From the point of view of the manufacturers it was clear that the only possible response to the ever-changing environment was the internationalization of the industry. (Mowery, 1988). US aircraft industry had have a long history of cooperation with foreign countries. In the military sector just after the world War the US government has been widely adopting co-production agreement with its allies. These agreements were meant to contribute to the reconstruction of European and Japanese economies. Moreover they have been considered as a powerful instrument for the expansion of markets for American military products. But this form of collaboration excluded any participation of foreign companies in the design and development stages. After the 1970s the pressures of foreign government led the US government toward the acceptance of joint collaboration including the R&D. So the offset agreements took the place of co-production agreements and became the current currency in the military sector collaborations. On behalf of the U.S. Department of Commerce after the 1980 they have represent from 40 to 98% of military exports.

The forces that drove the American aircraft civil sector toward the international collaboration were more complex than just foreign governments' pressures. As we have already seen, the kind of 'no-choice' situation was rooted in a combination of both domestic difficulties and a growing foreign competition. In the 1980s remained only three integrators in the world: Boeing, McDonald Douglas and Airbus. The latter has been based, since the beginning, in an international partnership among the principal actors of European aircraft industry. Boeing also decided to embark into risk-sharing contracts and to allow the transformation of its European and Japanese partners from traditional suppliers and subcontractors into co-developers. Indeed, approximately 25% of the value of Boeing's 777 is from Asia (5 Boeing's Japanese partners alone had 20% risk sharing stake). (Watskin, 1999). The tendency in the last years, has consisted in a growing participation of foreign companies in the design and development process of aircraft composants. McDonald Douglas was much more reluctant to the international collaboration development. After a series of unsuccessful cooperation attempts with European partners, McDonald Douglas avoided risk-sharing ventures in new aircraft developments. The direct consequence of the lack of foreign partners was the lack of new aircraft. The choice of being an independent producer constituted a major impediment for the viability of the company in the competition race. (Mowery, 1999). McDonald Douglas merged with Boeing in 1997.

A lot of controversy has been emerging parallel to the increasing globalization of the industry. The strong opposition to this tendency has been mostly concerned with the risk of decline in the country's competitiveness. The considerable amount of technological transfer has been proved to have reinforced other countries' capabilities. The Boeing's internationalization attitude has been considered as provoking the surrounding of the American aircraft industry for foreign financial support (Pritchard, et MacPherson, 2005).

The other burning issue, negatively associated to the globalization, concerns the massive downsizing of the employment due to the increasing role of foreign suppliers. The employment figures and aircraft shipments have been continually declining as shown in fig.

Tabela me employment per t'u bere)

In spite of these opposing opinions, many other analysts persist in saying that it is not possible to clearly separate the effects of offsets from the multitude of other forces affecting the downsize of the American aircraft industry. At the same time, the cases of Boeing or General Electric that have maintained their rhythm of lunching ambition new programs while gaining access to important foreign markets and resources is thought to serve better the competitiveness of the U.S. aircraft industry than McDonald Douglas that failed to do so.

If the impact of the globalization is hard to define as being positive or negative in terms of economy, there is, however, a real victim of the new path in what the industry has been engaged for more than two decades and this is the myriad of small supplier or subcontractor firms (the Tier III) spread throughout the U.S. regions. This part of the supplier chain has been gradually vanished: there were around 11000 of those companies in the 1980s. Only 4000 of them have survived in 1998. The restructuring of the relationship between the integrator and the supply chain has been going through two different stages.

(Figure 7 about here)

The lean manufacturing strategies has been imposing a radical change in the role of small and medium firms. From a large base of suppliers the integrator has concentrated its relationship to a small number of sub assembler companies. The next section represents the way in what different region have responded to the structural changes that have been going on in the industry.

4. The Regions and the industrial evolution

What have been the key factors that made a hosting region of aircraft industry more successful than another? Through what mechanisms have the co-evolution of industry and regional systems operated ?

Despite the fact that in this paper it was impossible to include all the components of the evolution process involving the American aircraft industry, our short overview depicts some essentials elements. We have schematized them in the following figure:

(Figure 8 about here)

4.1 Three Archetypes of regions

It seems clear to us that the life cycle of the aircraft industry has strongly influenced its geographical location patterns. Three profiles of regions have responded to each stage of the cycle:

- The 'seed-bed' type of development confirmed during the emerging stage, suggests that the industry was looking foremost for an ***incubator region***, endowed with certain characteristics that were indispensable to the infant industry such as the entrepreneurship spirit, the pre-existence of formative industries, a pool of knowledgeable labor.
- In the expansion stage the industry was oriented and concentrated toward the ***national champion hosting regions.*** This is not necessarily the most important agglomeration in the country. When McDonald Douglas decided to transfer his activity in California, nobody knew that the region would become the Sillicon Valley that we know. In 1951 Cunningam notes, not without surprise, that 'a considerable concentration in one small region, namely, Southern California, has been characteristic the last several years, with 39% of all wage earners in the industry'. (Cunningham, 1951). The Sun Belt attraction of multiple industrial anchors created the best success story of geographical agglomerations. At the same time Texas and Seattle have been able to established a powerful and supportive regional system for the aircraft industry and have became essential to the industry dynamics itself.
- In the maturity stage, when the concentration process attains its climax, some ***international-mega regions*** host the 'crème de la crème' of the industry. They may have been national champion hosting regions as California, or may had have not as much to do the industry before, but during the anchoring process evolution the industry looks for other regional characteristics. The transfer of Boeing headquarters from Seattle to Chicago, was in some way an expression of such a change. The growth of international region also influences the new location patterns. The most important difference between the national champion hosting regions and international mega regions is that the former fate is strongly related to the fate of

their champion. Conversely, the international mega-centres do not ‘disappear’ when a giant fails its development. Some would have thought that the capitulation of McDonald Douglas would have provoked the declining of the aircraft cluster in California. Nonetheless, the region still remains the heart of the American aircraft industry in terms either of employment or innovation. The aircraft industry employment in Washington consist in a third of the total employment of the region, when in California it correspond to only 3%. The difference between both regions appears also in term of innovation figures.

(Figure 9 about here)

4.2 Mechanisms that influence industrial and regional relationship

During the early years of the industry an atomistic movement characterized the location decisions. A sort of 'trial and error' will be orienting location and relocation. The more the industry grew, the more some decisional criteria’s were proved right and other wrong. The exigencies concerning the weather conditions, for instance, were an additional requisite to those that constituted the initial ones. For sometime, some new firms continued to start their activity closed to the government sites, hopping for more access to public resources. However, gradually, such proximity was not considered to be a key advantage any longer. During this period the location decision is not the most influencing among the other decision taken by the company. And, in any case, the location choice is driven by internal industrial dynamics.

When, after the WWI, the strategic importance and the dual-use character (military and civil) of the industry had become evident, the government, some times directly and some times indirectly, seized the quasi total control of the military sector. Given that there is no clear-cut separation between the two sectors, the civil aircraft sector has also been developed under the government's ail. Therefore it is not surprising at all to find out the government’s fingerprint behind the orientation that the industrial trajectory took in a moment or in another. The relocation of the industry during the war time was the extreme intervention in terms of location. But some more elegant intervention, has constituted the regional development programs, that stimulated the implementation of aircraft plants in some region ore in some others. The same consideration applies to the European postwar experiences. One of these is the case of Italian constructor Alenia that was implemented in the mid 1960s, in the underdeveloped Mezzogiorno (South of Italy) in order to promote and to develop the industrial infrastructure of this underdeveloped part of the country. The geographical destination of the direct or indirect subventions, public procurement and R&D investments, is helpful in the measurement of the influence of this powerful mechanisms.

However, the entrance of the industry in the maturity stage, has limited the government support that has ceased to be the major factor in changing the balances. The survive of the industries depend from the combination of domestic with foreign resources. So global pipelines link clusters with the outside milieu (Bathelt, 2004). These global pipelines will though be driving the industrial and regional dynamics.

4.3 A system dynamic perspective

How does each region follow the industrial life cycle? The Figure 9 represent three system dynamics that correspond to each phase of industry and regional co-evolution. The first corresponds to a 'limit to success' model. It begins with a growing action, stimulated by the current state. This one consists in the specific characteristics of the incubator region. In a second step the current state suffers from some limiting conditions and this compromises the growth action. At this point it became very important the nature of the intervention that may contribute to reinforce the growth action or to slow it down even more. A typical reaction of the system in this case is the decline of the regional performance notwithstanding the growing of the efforts that have been furnished. In some point, a region could not furnish the needed support to a growing industry and the attempts of public policies to absolutely hang on them (by offering different kind subvention) will be an expensive and not a long term solution.

In the second stage the growth of national champions hosting has been compromised by an under-investment problem. That is represented in a 'growth and underinvestment' model. In this case the growth tendency may be kept by investing aggressively and intensively. The timing of the investments is also very important since the volume of investment raise the risk for its recovery. Many cases of late investments that have not been a market-success for the company have been fatal for the company and often also for the hosting region. The cases of Fokker, Saab or Fairchild Dornier illustrate this case.

The dynamics that prevail during the maturity phase of the aircraft industry may be represented by an ' Esacade' model. The increase of the results of Airbus relative to the Boeing's results will influence more action from Boeing. The Boeing's results increase will tend to reduce the results of Airbus relative to Boeing. This reduction will tend to influence more action by Airbus. Additional action by Airbus will increase the results of Airbus relative to Boeing, and the cycle restarts again. Only international mega-regions may be able to furnish the necessary support and resources that may follow up the industry exigencies.

We will reserve the discussion about the public policy evolution to further papers. But we may say that its implication are crucial to the co-evolution process of regions and industries. Because of its strategic importance for the national security, all government have been extremely supporting in the development of the aircraft industry. Generally speaking, the evolutionary course of public policy has followed the life cycle of the industry. However the degree of adaptation to each stage has had major consequences. The same may be set also with regard to the rapidity of governmental actions. In the early stages of the aircraft industry the public support characteristics is composed by 'infant industry support measures'. Later on the government has become the engine of the industry expansion. In latest stages this role has been constituted by more protection comportments. During the maturity stage the international cooperation position become essantial to public policies. This is the component of the public policies that has suffered much more than the other, from the lack of innovative reactions, the delays in decision taking procedures and the misunderstanding of the evolution process of industry and regional economies.

5. Concluding remarks

The aim of this paper was to propose a transversal model that eludes the risks of being locked in time (snap-shut studies), in space (local, national or regional studies) or in sectorial perspective.

The sketch of the co-evolution patterns of industry, location and public policies has been developed. It contributes to a better understanding of the dynamics that go on in the diverse stages of industrial life cycle and the relationship of the industry with its hosting region. This framework offer the possibility to determine from different perspectives (either from industrial, regional, or public policies side) the specific adequate strategy in a specific moment.

Additional work remain to be done to refine the model and for the measurement of its reliability in the context of other country (ex. Development countries and emerging countries) or in the case of other industries. However, even in this embryonic stage it seems to us that this model has the merit to propose a systematic perspective of the interaction among the organisations, without compromising the idea of their diversity, We recognize so that the evolutionary process est buissonnant, pluriel et mosaïque.

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Tables and Figures

Table 1. Outsourcing Trends for Boeing Airframe

Airframe	727	767	777	787
Wing	US	US	US	Japan
Center Wing Box	US	Japan	Japan	Japan
Front Fuselage	US	Japan	Japan	Japan/US
Aft Fuselage	US	Japan	Japan	Italy
Empennage	US	US	Foreign	Italy/US
Nose	US	US	US	US

Source: Pritchard, David and MacPherson, Alan. 2005

Figures

Table 2 Concentration of the aircarft industry

Manufacturers of Aircraft, 1933–1941, 1947–1965.

	Concentration (percent)							No. of Domestic Manufacturers with Aircraft Included in Additions
Year	Douglas	Boeing	Lock-heed	Consoli-dated	Martin	Foreign	All Other	
1933	1.2	63.5	10.6	4.7	0.0	0.0	20.0[a]	5
1934	29.9	4.5	16.4	0.0	0.0	0.0	49.2[b]	7
1935	59.0	0.0	32.8	0.0	0.0	0.0	8.2[c]	3
1936	69.0	0.0	31.0	0.0	0.0	0.0	0.0	2
1937	87.0	0.0	11.1	0.0	0.0	0.0	1.9[d]	3
1938	87.5	0.0	12.5	0.0	0.0	0.0	0.0	2
1939	97.6	0.0	2.4	0.0	0.0	0.0	0.0	2
1940	84.8	4.5	10.7	0.0	0.0	0.0	0.0	3
1941	97.2	0.0	2.8	0.0	0.0	0.0	0.0	2
1947	74.3	0.0	17.1	0.0	8.6	0.0	0.0	3
1948	21.7	0.0	5.2	60.0	13.0	0.0	0.0	4
1949	1.7	17.2	32.8	48.3	0.0	0.0	0.0	4
1950	9.8	0.0	60.8	11.8	17.6	0.0	0.0	4
1951	47.6	0.0	23.8	0.0	28.6	0.0	0.0	3
1952	14.9	0.0	16.2	16.2	52.7	0.0	0.0	4
1953	29.1	0.0	9.4	58.3	3.1	0.0	0.0	4
1954	66.7	0.0	9.3	24.0	0.0	0.0	0.0	3
1955	38.2	0.0	43.6	3.6	0.0	14.5	0.0	3
1956	40.0	0.0	8.0	15.2	0.0	36.8	0.0	3
1957	65.9	0.0	18.4	12.8	0.0	2.8	0.0	3
1958	59.8	0.0	14.6	0.0	0.0	25.6	0.0	3
1959	10.8	30.1	57.8	0.0	0.0	1.2	0.0	3
1960	39.2	35.1	11.3	14.4	0.0	0.0	0.0	4
1961	9.6	45.6	12.0	19.2	0.0	13.6	0.0	4
1962	12.1	51.5	0.0	31.8	0.0	4.5	0.0	3
1963	8.7	69.6	0.0	21.7	0.0	0.0	0.0	3
1964	6.7	91.6	0.0	1.7	0.0	0.0	0.0	3
1965	12.6	78.5	0.0	0.0	0.0	8.9	0.0	2

[a] Curtiss-Wright.

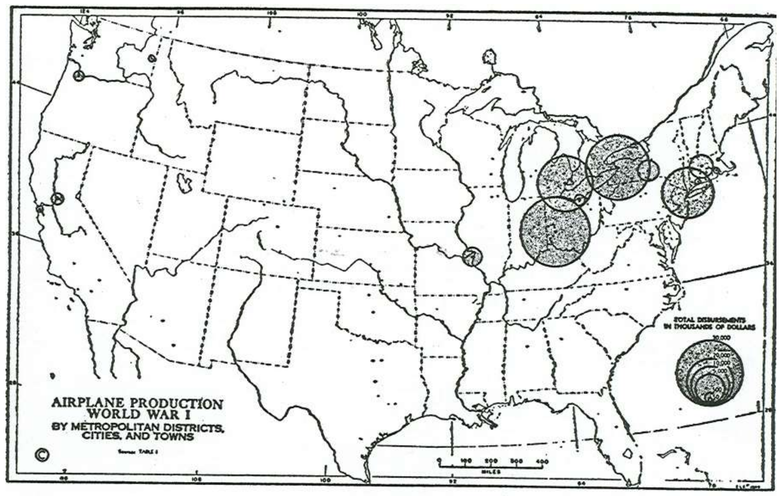
[b] Stinson, with 21.0 percent; Vultee, with 14.9 percent; Curtis-Wright, with 9.0 percent; and Ford, with 4.5 percent.

[c] Stinson.

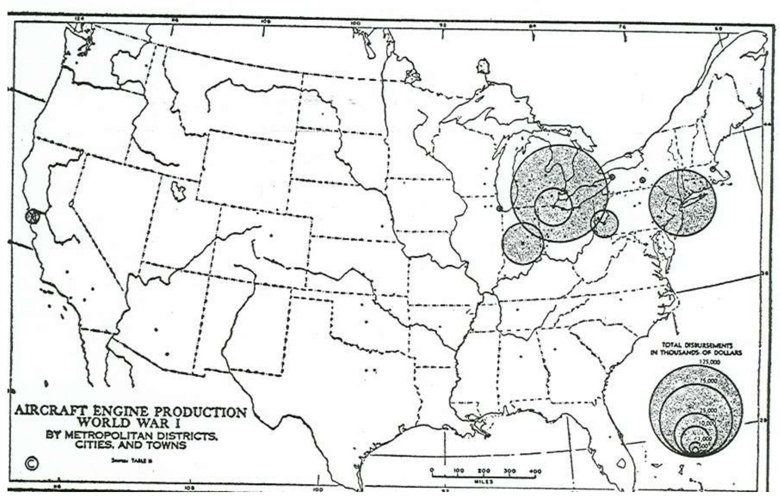
[d] Beechcraft.

Source: Todd, Daniel et Simpson, Jamie. 1986

Figure 1. Aircraft Plants during the World War I

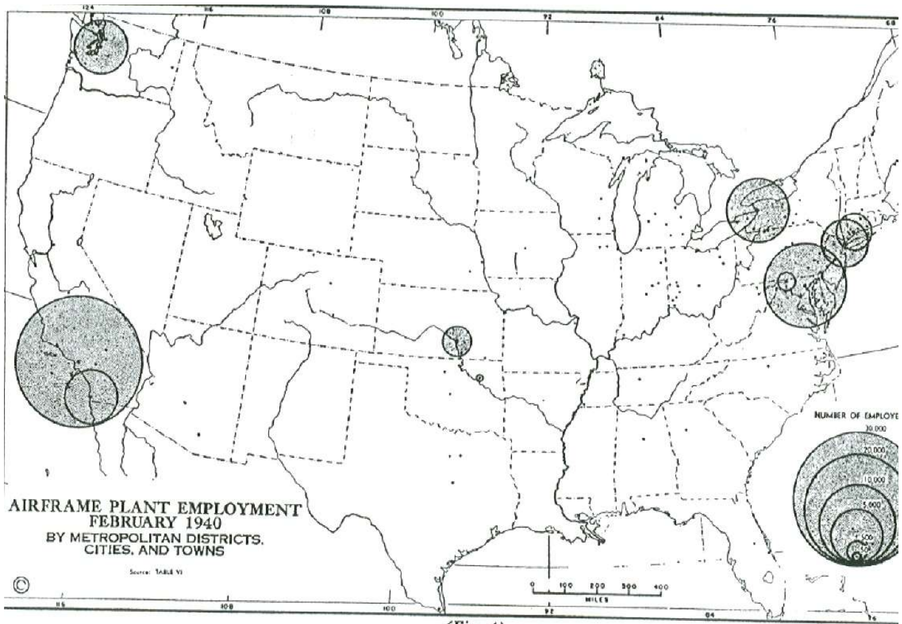


(Fig. 2)



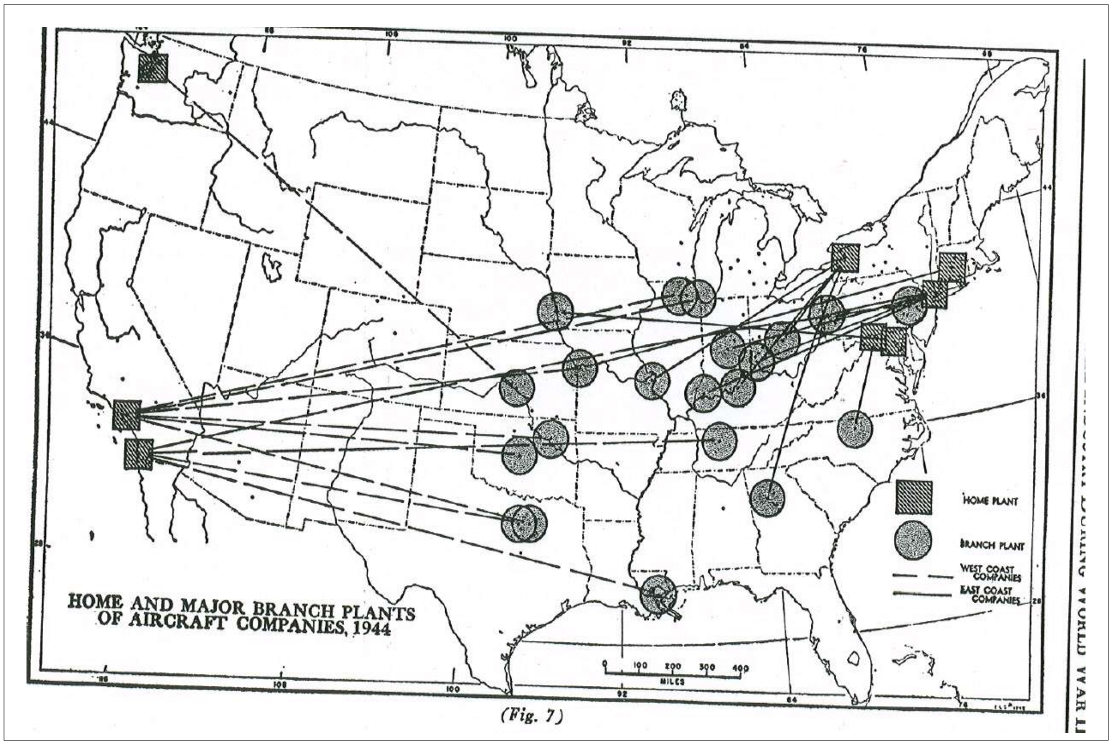
Source: Cunningham, 1951

Figure 2 Aircraft Plants in 1940



Source: Cuningham 1951

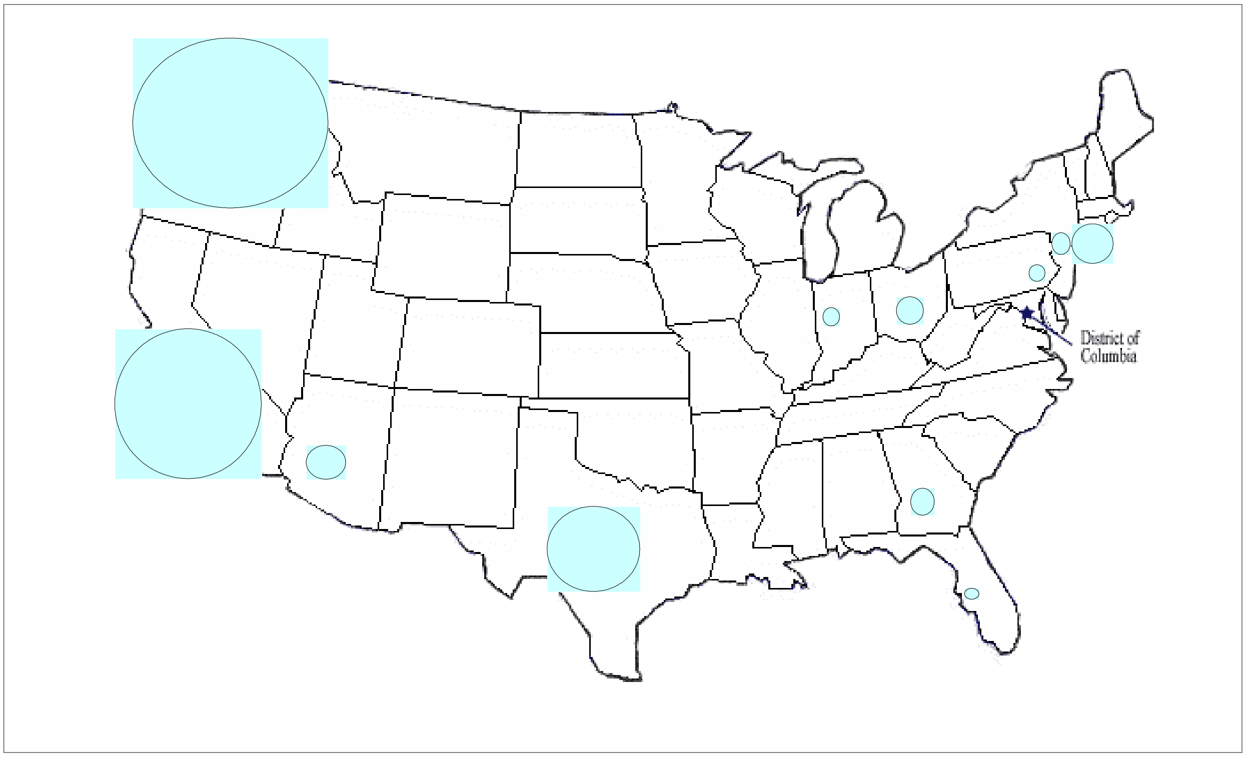
Figure 3 Aircraft Plants in 1944



Source: Cunningham, 1951

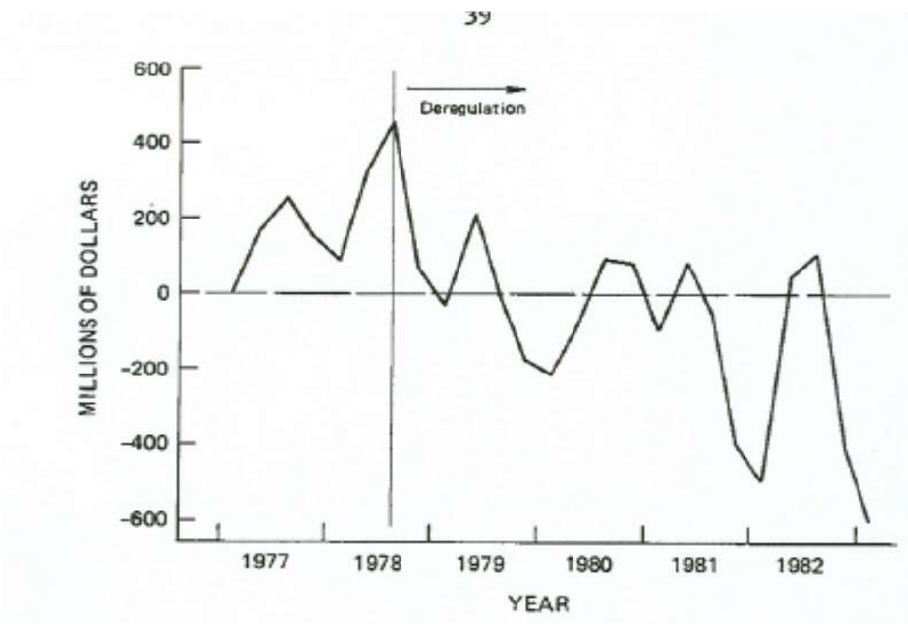
Figure 4: Total Aircraft industry in 1944

Figure 5. Total US aircraft employment in 2002



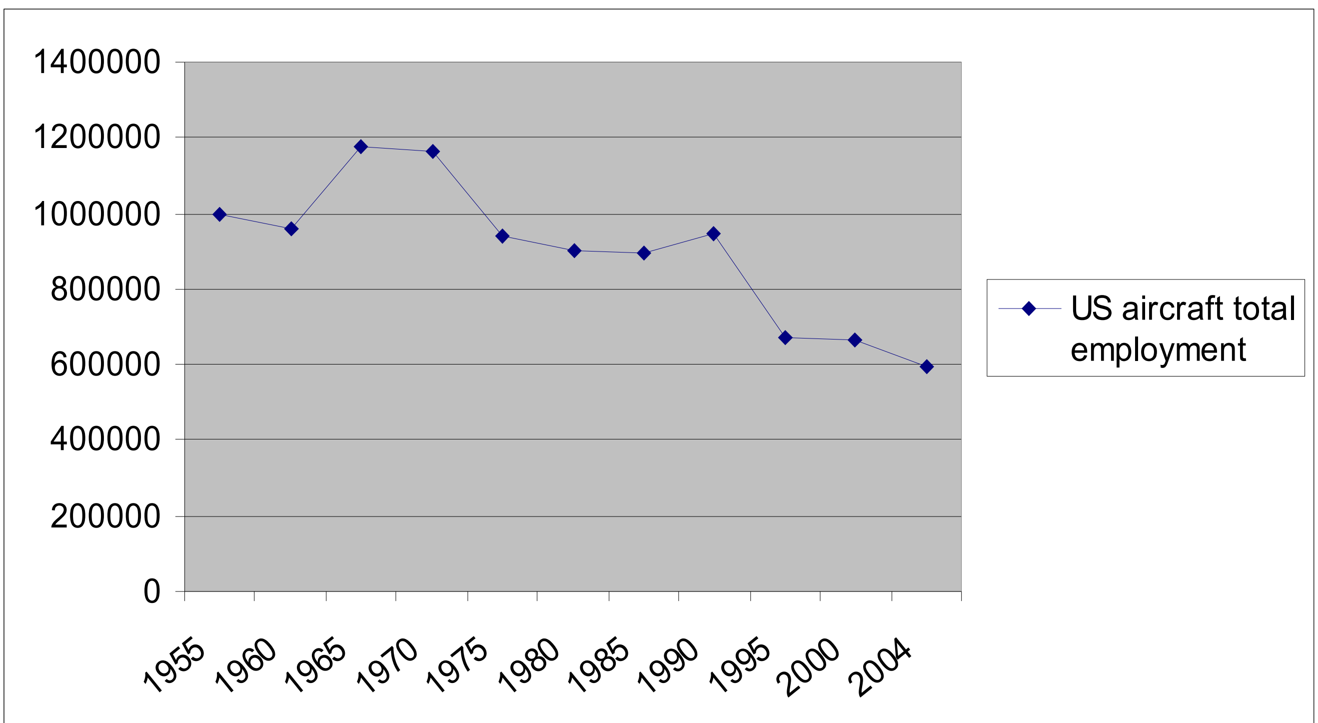
Source: US Bureau of Census, Longitudinal Research Database

Figure 6 Airline performances after the market deregulation



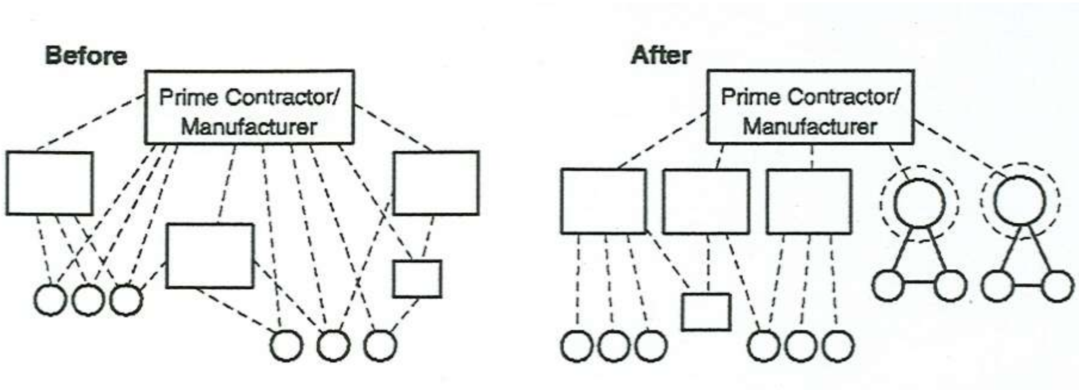
Source: Seitz, Frederick and Steele Lowell,

Figure 7: Aircraft industry employment during the period 1955-2004



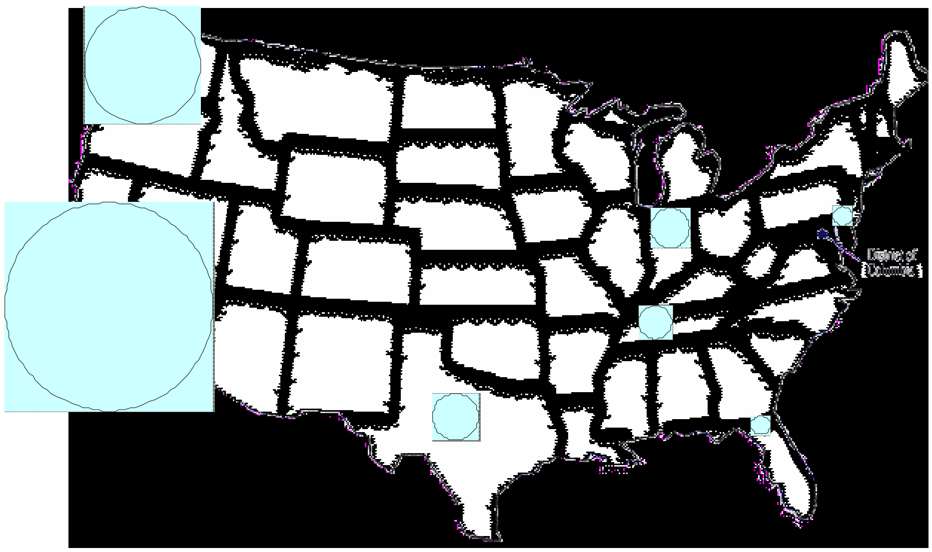
Based on data from the US Bureau of Census

Figure 8 Supply chain restructuring



Source: Watkins, A. Todd. 1999

Fig. 9 . Distribution ofpatents for the class 244for the period 1973-2003



Based on the USPTO Database

Figure 9 How industry, regional system and public policy co-evolve?