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Understanding High-Tech Clusters of the World with Special Reference to Aerospace Industry

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ABSTRACT

Clusters have been constantly a topic of central interest in the area of business and economics. Their origin can be traced from the time man mastered the art of trade and commerce. Throughout history, we can see many people discuss about clusters in their works. It is remarkable to note that, aerospace clusters occupy a place of prominent significance among many high-tech clusters in the world; because of the exceptional characteristics: regional prominence and stakeholder network. In this theoretical paper, we draw attention towards global aerospace industry, major aerospace clusters in the world, including Bangalore aerospace cluster. Being a theoretical paper, this study is heavily oriented on academic research and secondary data from numerous sources. We conclude by exploring the potential of Indian aerospace industry through cluster approach in Bangalore region, the hub of aerospace in India.

Keywords : Cluster, Aerospace, Value Chain, Economy, OEM, Network.

I. INTRODUCTION

Enterprises have their genesis in cooperation and collaborations since the time the world learned the nuances of trade and commerce. It's always the joint missions with the partners that have paved way for mutual learning and new knowledge creation. Ipso facto, antecedents of interconnected firms and institutions concentrated in a particular geographical location have attracted much attention from economists and social scientists around the world on the phenomenon of regional agglomerations, (also called as industrial clusters) the conditions for their existence and dominating role in local economy. In his book, Principles of economics, Alfred Marshall wrote about the prevalence of 'industrial districts' in specific regions of the United Kingdom, like Lancashire Cotton, Staffordshire pottery, and Sheffield cutlery.

In order to explain what our paper is about, we shall first describe the commonly accepted meaning of industrial clusters. According to Michael Porter's magnum opus, Clusters, and Competition, where he defines clusters as a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities.(Porter, n.d.) According to Sexanian, the region's vitality is enhanced due to inter-firm collaboration breeding complementary innovation and cross-fertilization among interdependent producers yet a network of autonomy. (Saxenian, 1991). This is an insightful truth, as clusters seldom conform to standards of industrial classification systems, which do not acknowledge crucial and prevailing cross-industry interconnections which strongly affect competitiveness.(Porter, n.d.)

Albeit in the modern era of global completion, the traditional role of a cluster has been condensed, it is hard to reconcile with competitive reality. Though, experts and scholars make use of financial and economic indicators like profitability, sales, and productivity or strategic indicators like market share, innovative capability, and internationalization to assess the response and dependence to external markets, (Puig & González-loureiro, 2017) the prevalence of clusters in a geographical context is one of the focal points to gauge the degree of productivity and operational efficiency of local firms in an increasingly complex, knowledge-based, dynamic economy.

The aerospace industry is one of the most paramount industries in the world. It also plays a central role in multifarious illustrations of a nation's economy. Aircraft manufacturing contains complex shapes, large part sizes and uses of exotic materials, which complicate the production process. Approximately 3 million set of parts used in bigger crafts require high reliability and accuracy and featherweight components and materials. And since internationalization is the core of the aerospace industry, as a strategy, much of the manufacturing, MRO, and other inputs are sourced in global markets – an array of interconnected industries and other entities important to competition. (Porter & Porter, 2000) .

Over the last century, aerospace clusters have emerged as one of the high-tech industrial clusters around the world. Comprising the highest degree of advanced parts and materials among manufacturing industries; aerospace industry needs sophisticated and precise processing and advanced assembly technology. (Odake, 2010). Being a global industry, aerospace manufacturing consists of multiple firms who provide new technologies, processes, and estimates for future demand.

II. LITERATURE REVIEW

Theoretical Framework

A significant amount of authors use several typologies like industrial districts, clusters, industrial complex, innovative milieu, networks and local partnerships to discuss the common notion of clusters. In limine, the literature content is studied under three broad themes: clusters, hi-tech clusters, and aerospace clusters for it lucidly reviews the ambit of cluster from its origin to cynosure of aerospace industry in the world.

Clusters:

Though La Hanse, a French merchant was one among the first to mention of the cluster in the port of Visby (near Sweden, Northern Europe) in the 13th century, it was only in the 18th century, the word, 'cluster' made its way into the dictionaries. A large body of etymology works say that it originated from the Old English clyster, which probably related to a clot which itself is derived from the Germanic 'klotz' (to clump).

In the year 1890, the conception of clusters shot to prominence when Alfred Marshall discussed the economics of local partnerships in his work, 'Principles of Economics.' He observed the high levels of localized knowledge with robust ties between local firms such as Sheffield and Bedfordshire in the UK. He termed localized industries as 'Industrial Districts' and defined them as, "concentration of specialized industries in particular localities."

Francois Perroux's work, Growth Pole Theory in 1955 terms those regional agglomerations as 'industrializing industries' which attract both upstream (input) and downstream (output) manufacturing firms. One exceptionality of this study is it doesn't consider the influence of related and supporting industries. Therefore, Perroux's work is one-dimensional in nature. (Mønsted, Mette.2006)

In 1979, Czamanski and Ablas used the term, 'industrial complex' for sectors that were related through formal production linkages, irrespective of their geographical proximity. (Czamanski, Stan & Augusto de Q. Ablas, Luiz. 1979).

As globalization took over the world economy in the 1990s, industries witnessed a paradigm shift in their focus from the regional economy to the global economy. Michael Porter, a professor at Harvard University, observed that though businesses could outsource capital, goods, information, and technology around the world, still the competitive advantage of location could not be out ruled. In his work, 'Clusters and the New Economics of Competition' (Porter, 1990), he argued that if locations mattered less in a globalized economy, then why, is it true that the likelihoods of finding a world-class mutual-fund company in Boston are much greater than in most any other place? Or a fashion shoe company in Italy or auto companies in Germany for that matter? Hence he called these clusters as not unique, but highly typical which is a paradox. Further, Porter also mentioned that the enduring competitive advantages in a global economy lie increasingly in local things – knowledge, relationships, motivation – that distant rivals cannot match (Porter, 1998).

Presently, in the era of "individual" organization which can be largely defunct and where technological developments have enabled widely dispersed proximity, 'e-clusters' are the new value creation conceptions which enable widely dispersed organizations to cooperate (in terms of supplier-client relationships, competitor-client link, and competitor-competitor relationship) using the internet. In other words, the presence of clusters suggests that much of the competitive advantage lies outside a given company or even its industry, residing instead in the locations of its business units. Hence, they provide a constructive and efficient forum for dialogue among cross industries, related companies and their supplier, government, and other salient institutions.

Hi-tech Clusters:

One can note that the term 'high-technology' is used too chaotically in almost all industries worldwide. Essentially, any product birthed from advancement in technologies and sophistication denote high-technology. An agreeable meaning of high-technology is given by Keeble and Wilkinson (High-technology Clusters, Networking and Collective Learning in Europe, dav,) where they say high-technology refers to those firms and industries whose outputs embody new, innovative and advanced technologies through the development of applied scientific and technological expertise, making them as one of the prominent competitive advantages of the firm. So, precisely, it can be said that high-technology refers to R&D intensive firms.

In his book, Clustering Dynamics and the Location of Hi-Tech Firms, Maggioni opines that a hi-tech cluster can be either an innovative cluster or a science park developed by policymakers. The choice may be centered on the potential evolution of the areas and the different policy instruments implemented for success conformity. (Maggioni, 1999).

On similar lines, authors Wang and Yang, believe that a high-tech cluster is a level of high-tech industry development which is strengthened through the ability of independent, original and integrated innovation, scale economies and with its own intellectual property rights. Besides, high-tech cluster also has a strong patronage of government support in terms of legal and policy-making and competitive market coordination.(Wang & Yang, 2012).

In her contextual study of the Cambridge hi-tech cluster, Athreye considers that universities play an important role in the influence of knowledge transfer to practices in a hi-tech cluster. Examples of such form of frequents will be through collaborative projects, academic and commercializing technical inventions.(Athreye, 2002)

Though on a comprehensive note, one may infer that universities play a major role in shaping hi-tech clusters, in reality, there are multitudinous factors influencing the development of a hi-tech cluster in a region. Chen argues that the dynamic mechanism of a hi-tech cluster can attribute to the factors like technological innovation, the growth of related industries on par with anchor industry/industries, a complete supply chain from technology to market, knowledge spillovers, entrepreneurial culture and immigrant culture (Ex: Silicon Valley) (Chen, 2012)
Thus, in this perspective, a high-tech cluster may be considered as a technologically advanced agglomeration of firms, who contribute to innovative outputs and spin-offs that are largely influenced by scientific expertise, collaborations, and coordination between the firms.

Aerospace Clusters:

Long before, an accurate description of a hi-tech cluster was established, Pavitt classified industries into three types, based on science, supplier-dominated, and scale-intensive. He placed aerospace industry under science-based category, where industry works in cooperation with universities and research center to strengthen their in-house research. Thus, Pavitt's taxonomy provided a much-needed base to position aerospace sector as a peculiar one, centered on science and technology.

Later, Butchart incorporated aerospace equipment manufacturing and repairing in his popular work, High-technology sectors relating to Standard Industrial Classification. Here, Aerospace equipment manufacturing and repairing is listed as UK SIC Code 3640.
More recently, according to specialty consulting firm, AeroDynamic Advisory and Teal Group, aerospace industry includes all in-country activities pertaining to the development, production, maintenance and support of aircraft and spacecraft (Business Insider, 2018)

In this point of view, Aerospace industry is truly a multidisciplinary high technology industry because it manufactures range from aircraft, space vehicles, and aircraft engines to propulsion units and related parts. In fact, no other industry is as international as commercial aerospace (Grover, 2008) As a domain, aerospace industry has certain unique characteristics, such as geographical proximity, long project life cycle, longer learning curve (since it's a slow clock speed industry), backward linkages (inputs from other diverse hi-tech industries), complex supply chain, high level of regulations, strategic localization in developing markets, cross-industry interconnections, strong relationship to national security and risk intelligence and knowledge spillovers et cetera.

A cluster's geographical proximity is best described in terms of a system of linked industries and institutions along with other entities that stimulate competition. They can be manufacturers of complementary products, universities, research organizations, channel partners, trade associations and even international firms (if they have a significant local presence).(Paone, Universita, & Luigi, 2016). For this reason, extensive academic literature review insists on calling aerospace cluster as a coopetitive arena when there is an optimal existence of competition and cooperation, though both occur on different wavelengths. Describing this is beyond the scope of this paper.

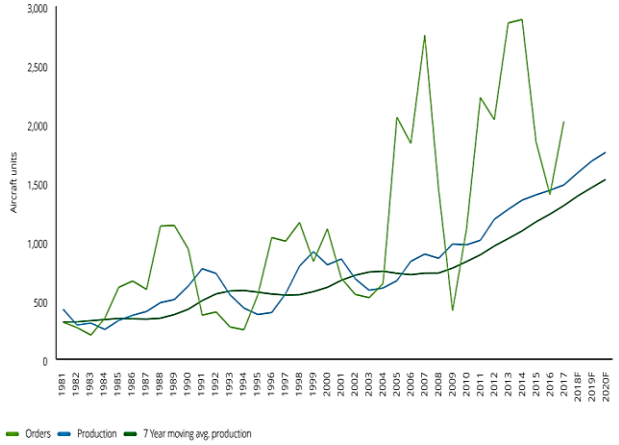
Global Aerospace Industry - Key Insights:

In spite of existential differences in defining, 'aerospace' by each nation, aerospace is one of the world's most important and influencing industries. As per AeroDynamic Advisory and Teal Group, the global aerospace industry was worth $838 billion in 2017. (Business Insider, 2018) .

The Deloitte Global aerospace and defense industry outlook, 2018, expects the global aerospace and defense industry growth by 4.1 percent in 2018 as opposed to 2.1 percent in 2017. For the next 20 years,

there will be a worldwide demand for 36,780 aircraft. (Lineberger, S.Robin and Hussain, 2018)

History and forecast for large commercial aircraft orders and production (1981 to 2020)



Source : Deloitte Analysis, 2018

Nevertheless, the challenges are equally enormous. The global aerospace industry needs to strengthen the supply chain network and make robust use of new and advanced technologies to become highly effective and efficient. However, over-capacities in the industry, unstable oil prices, severe backlog of next-generation wide bodies, are threatening the attractiveness of the industry.

A wide amount of existing literature shows that the greatest source of competitive advantage for the growing aerospace industry is a cluster, constituted by geographical potential (regional advantage) and stakeholder relations (networks). Presence of a cluster implies much of the competitive advantage lies outside a given company or even its industry, residing instead in the locations of its business units

Aerospace Clusters in the World

Country	Region	OEM
1.USA	Seattle	Boeing
2.France	Toulouse	Airbus
3.Canada	Montreal	Bombardier
4.Brazil	San Jose	Embraer
5.China	Shanghai	COMAC

1. Seattle Aerospace Cluster, USA

Leading OEM: Boeing

Seattle Aerospace cluster is the world's first and largest aerospace cluster which is located in Washington State, USA. Started in 1916, the cluster comprises 1,350 firms working across various levels of value chain.

Boeing which is the leading OEM (which was itself founded in Seattle) manufactures 90% of all commercial aircraft in the United States. (Choose Washington analysis, 2018). The 100-year-old cluster manufactures 47 aircraft per month, stimulated by the world's demand for air travel. It also has vital tie-ups with other aircraft manufacturers, such as Airbus, Bombardier, COMAC, Embraer and Mitsubishi for global supply chain linkages in terms of latest market intelligence, robotics, trends and analytics et cetera. (Aviation benefits beyond borders report)

2. Aerospace Valley, Toulouse

Leading OEM: Airbus

Though overshadowed by the United States of America and the USSR in the 20th century, France has been the forerunner of vertical developments of aerospace in Europe from 1960 onwards. The multifaceted French industry is a witness to several significant developments like Airbus A3XX series, the A400M, Mirage F1, Mirage 2000 et cetera.

Established in 2005, Aerospace Valley of Toulouse, popularly known as "pole de competitivite" is one of the most innovative clusters and houses core industries like aircraft assembly, satellite production, aeronautics, space and embedded systems. It is strategically located between Occitania and Nouvelle Aquitaine regions and comprises more than 80% of French aerospace exports. It houses more than 859 companies, including 505 SMEs and 120,000 workers including a few world-class Original Equipment Manufacturers (OEMs). AV is also the headquarters of Airbus – the commercial aerospace giant which

encompasses capacity to manufacture four jumbo A380s in a month. (Bawa, Etxebeste, Konialian, Martin, & Ruiz-Taboada, 2013). Through its high performance, this cluster is devoted to being a galactic center of innovation for its members. Some of the main actors in the valley include Airbus, Dassault-Aviation, Stelia Aerospace, Thales Alenia Space, Safran among others. Very recently, the Aerospace Valley has pivoted its strategy on providing information and support to members for their participation in EU Research and Innovation, supporting SMEs to take part in H2020/ COSME projects and developing European inter-clustering activities like diversification and expansion.

3. Montreal Aerospace Cluster, Canada

Leading OEM: Bombardier

The Greater Montreal cluster is the world's 3rd largest aerospace cluster after Seattle and Toulouse clusters. The cluster was created in 2006 and consists of 205 companies and over 180 SMEs who work in various activities of the value chain from supply chain development to market development.

The region of Québec is an exceptional ecosystem consisting of industries like aerospace, hydro, oil and gas, base metals, forestry, manufacturing, and biotech along with a favorable geography. Montreal aerospace cluster has Bombardier as its anchor OEM. (Bombardier is the world's leading manufacturer of aircraft and trains). What makes Montreal stand out from other clusters is the adaption of triple helix model* principles. Along with world-class manufacturers, renowned OEMs, the cluster also is a concentration of academic, scientific, innovation and research associations (represents 70% of Canada's research and development spending). This gives an edge to train a skilled and highly competitive workforce which altogether ranks Quebec at the 6th place in the world's largest global aerospace equipment manufacturers.

4. Sao Jose dos Campos Aerospace Cluster, Brazil

Leading OEM: Embraer

Brazil's exploration of space is very recent. In fact, the first Brazilian satellite was launched in 1993, followed by 10 successful ventures, with Agência Espacial Brasileira or AEB agency.

The Brazilian aerospace industry is divided into three sectors, aeronautics, defense, and space. Out of these, aeronautics comprises the largest segment, owning almost 90% of the local market share. The cluster is anchored around Embraer, the leading OEM (which also happens to be the largest aerospace company in Latin America). As per Brazil-Aerospace Business Summit, 2017, Sao Jose dos Campos cluster houses 90 SMEs suppliers who are involved in the supply of components and maintenance of airplane parts and generates over US$ 7.5 billion per year (Brazil – Aerospace Business Summit, 2017) .

It is interesting to learn the paradox of export and import nuances of Brazilian cluster. The galactic size of Embraer results in revenue generation of BRL 6 billion through exports. On the other hand, there are huge importing companies in the cluster which demand parts from other countries like the United States, China, and European nations.

5. Shanghai Aerospace Cluster, China

Leading OEM: COMAC

Shanghai is the first Free Trade Zone in the Hong Kong province of mainland China. Established in 2014, Shanghai aerospace cluster is centrally managed by COMAC Enterprises, which is the short form of Commercial Aircraft Corporation of China, Ltd. COMAC mainly specializes in the manufacture of large passenger aircraft programs in China. For this, COMAC densely invests and encourages pursuits in end to end activities of value chain like research, manufacture and flight tests of commercial aircraft,

marketing, servicing, leasing and operations of commercial aircraft as well, while paying bigger attention to safety, cost-effectiveness, ergonomic and environment friendliness. (COMAC, 2018)

According to the estimates of Boeing and Airbus, COMAC will become the biggest supplier of new aircrafts thanks to its adherence to the principle of "development with Chinese characteristics" such as technological progress and self-reliance. Very recently, COMAC has opted out of Bombardier agreement to nurture regional airline startups like Genghis Khan Airlines to foster regional airlines in northern China.

The Curious Case of Bangalore Aerospace Cluster:

India was under British rule until 1947. So, the aerospace industry in India began predominantly in 1960. Indian aerospace industry primarily consists of public sector units (PSUs) promoted by the government of India over several decades. Historically, the aerospace industry all over the world initially thrived on the development and production of military orders, and India is no exception to this rule. HAL was the lone flag bearer of Indian aerospace industry in India till recently and it heavily concentrated on manufacturing military aircraft with a license from the Russians. However, since 1990s, with the support of NAL, IISc and a host of defense research organizations, the global majors such as Boeing, Airbus, EADS and Bell Helicopters have started their operations in India, albeit in a small way. A few Indian companies have joined the competition in order to gain technical footprint and significance in the aerospace industry and hopefully, around the globe in years to come. The list includes TAAL, Tata Technologies, Mahindra Aerospace, Tata Advanced Systems Limited (TASL), to name a few. (Chandra, Raghavendra & Shekar, 2016).

The existing supply-chain backed by old-economy aerospace and engineering firms, investor-friendly government, fast-track business approvals through single-window clearance mechanism has made Karnataka a very attractive destination for aerospace industry (PWC and CII, 2013). The state is investing $ 6-7 million in a dedicated aerospace business park (985 acres) at Devanahalli, near Bengaluru International Airport. (Flight International, 2013)

Manufacturing Hub: Hindustan Aeronautics Limited, with its headquarters and laboratories in Bangalore, has been a pioneer in developing new aircraft and helicopters for the Indian defense and domestic civil use. The aerospace business park will also qualify as a special economic zone, to exploit central government incentives for pure-export operations.

MRO Hub: Though MRO (Maintenance, and Overhaul) industry faces competition from Southeast Asian countries, it has been attracting new investments particularly at Bangalore.

Aerospace Hub for IT design and engineering services: Bangalore presents the highest concentration of IT and engineering services firms. Local software majors have clients in the global aviation and aerospace industry for many years with latter having their technology and engineering services support centers in Bangalore.

Aerospace Hub for R&D and simulation: Simulation and high-end research have been the forte of government-owned organizations based in Bangalore. National Aerospace Laboratories, Indian Space Research Organization, Indian Institute of Science are prominent indigenous institutions that carry out R&D and aviation simulations.

Policy Framework: 100% FDI is allowed under the automatic route for MRO, flying training institutes and technical training institutes. The aerospace policy of Karnataka has the vision to make Bangalore a magnet for global tier-1 suppliers and Karnataka as one of the leading MRO hubs in Asia. The State government has a State Level Single Window Clearance Committee and the State Level High-Level

Clearance Committee (for investments greater than Rs.50 Cr) with the object of clearing proposals in a swift manner.

III.CONCLUSION

This theoretical paper is in good agreement that clusters are a part of the economy who reflects the type and degree of regional specializations within which companies can gain higher productivity. Clusters consist many static and dynamic components which promote innovation, R&D investments, business-research collaboration and internationalization of enterprises (Christensen, Lammer & Kocker, 2012) along with economic benefits as infrastructure, labor markets, knowledge spill-overs and other comparative advantages.

Aerospace clusters act like centripetal forces which tend to concentrate industry in a specific geographical region. They result in abundant backward and forward inter-industry linkages, thus enabling entire value chain members who significantly benefit from agglomeration economies. Though the industry faces competitive and complex constraints, it needs to intensely focus interoperability and collaborative platforms to create a holistic outlook of market and create right supply chain networks which in turn enable the rapid economic, production and intellectual development of the region.

Indian aerospace industry is largely untapped with huge growth opportunities. The country has national advantages such as land, air and sea and potential core competencies like propulsion systems, aero structures, and Hull technologies. As rightly observed by the Ministry of MSME, Govt.of.India, a cluster development approach is a key strategy to enhance the productivity, competitiveness and capacity building in any industry (Micro & Small Enterprises – Cluster Development Programme, 2016) In this regard, the Govt.of.Karnataka has made a remarkable objective of making Bangalore as the leading destination for manufacturing aircraft, aircraft systems, sub-systems, assemblies, and components. In the first-ever aerospace policy framed by the state government, known as, 'The Gateway to Global Aerospace, 2013-2023', the vision is set to position Karnataka as a vibrant aerospace hub of Asia through a focused cluster approach in Bangalore, Aerospace Park, Devanahalli. (PWC and CII, 2013)

*Triple Helix Model shows that core communications are possible among three main bodies of university, industry and government. As a significant body of knowledge, it represents a paradigm shift from dyadic relationships between industry-government to triadic relationships among i.e., a close cooperation among the three nodes to foster the spirit and growth of business in knowledge based economy. It was conceptualized by two professors, Etzkowitz (Newcastle University) and Leydesdorff (University of Amsterdam) (Etzkowitz, H., & Leydesdorff, L. (1995))

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