Clustering and Value Chain: Example of Aerospace and Defense Industry

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Abstract

Globalization affects all sectors including primarily technology-intensive sectors. The rule of globalization for technology-intensive sectors such as aerospace and defense is to outsource low-value-added activities in any location and to keep high-value-added activities in-house. In order to understand this trend value chains should be thoroughly evaluated and make clarification of the structure. However, despite globalization clustering concept emphasize the importance of location and economic actors in the value chain to rise competitiveness level of a nation or a region. This article reviews examination of the value chain structure of aerospace and defense industry and clustering model. The structure of aerospace industry is thoroughly presented. Global defense spending has also been compared. Then, production pyramid and value chain of aerospace has been told in order to clarify global value chain. There has still been an opportunity of upgrading in the aerospace value chain with a concrete model that is, clustering model. Three examples of clustering have been showcased to analyze complex system of competitiveness of aerospace industry using Porter's diamond model.

Keywords: Aerospace, defence, value chain, clustering, diamond model.

Kümelenme ve Değer Zinciri: Savunma ve Havacılık Sanayii Örneği

Öz

Küreselleşme başta teknoloji yoğun sektörler olmak üzere bütün sektörleri etkilemektedir. Küreselleşmenin örneğin havacılık ve savunma sektörü için bu kuralı, düşük katma değerli faaliyetlerin düşük ücretli ülkelere gönderilmesi ve yüksek katma değerli faaliyetlerin ülke içinde kalmasıdır. Söz konusu trendi anlamak için değer zincirleri ayrıntılı bir şekilde incelenmeli ve yapıları açıkça analiz edilmelidir. Bununla birlikte, küreselleşmeye ragmen kümelenme kavramı bölgelerin ve değer zincirindeki ekonomik aktörlerin üzerinde durmaktadır. Bu makale, havacılık ve savunma sanayinin hem değer zincirini hem de kümelenme modelini değerlendirmektedir. Havacılık sanayinin yapısı ayrıntılı bir şekilde incelenmiştir. Ayrıca, küresel savunma harcamaları da karşılaştırılmıştır. Havacılık ürün piramidi ve değer zinciri sektörün küresel yapısını anlamak için anlatılmıştır. Kümelenme aracıyla değer zincirinde bir üst basamağa çıkış fırsatları mevcuttur. Konu hakkında üç küme örneği karmaşık sistemi anlamak amacıyla Porter'ın elmas modeli kullanılarak anlatılmıştır.

Anahtar Kelimeler: Havacılık, savunma, değer zinciri, kümelenme, elmas modeli.

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Introduction

Technical progress in all fields fasters globalization which has significantly influenced all sectors both labor and capital intensive sectors. Particularly, information and communication technology enables firms to spread their economic activities in any location in the world in order to decrease operational costs. That needs to be performed because growing competition in domestic and international market drives companies to be more efficient and productive to retain their competitiveness level.

The globalization of sectors or value chains brings about at least one concrete outcomes: outsourcing low value-added activities to low-labor-cost countries. Whereas global value chain allows the production to be outsourced, other parts of the chain such as design, research and development, marketing etc. remain at home, in developed countries. Global value chains view industries through the lens of organizational networks made up of not just firms but relationships that are governed by powerful lead firms that play an integral role in the upgrading of the firms and countries that participate in the chain.

High and medium-high technology industries are generally more globalized than less technology intensive industries. Defense and aerospace industry are technology intensive sector and according to OECD classification they are high technology industries which have more R&D expenditure than most of other industries.

The purpose of this study is to examine the value chain structure of aerospace and defense industry and clustering model for upgrading in the value chain. The structure of aerospace industry is thoroughly presented. Global defense spending has also been compared. Then, production pyramid and value chain of aerospace has been told in order to clarify global value chain. There has still been an opportunity of upgrading in the aerospace value chain with a concrete model that is, clustering model. Collaboration in the value chain will be a chance for small companies to reach economies of scale and scope.

This study indicates the importance of value chain structure and aerospace and defense cluster to improve technology and innovation in the country. It makes contribution to national literature in the context of embracing both value chain and clustering model for the aerospace and defense industry. It also encourages experts to take advantage of implications and lessons learned from case studies.

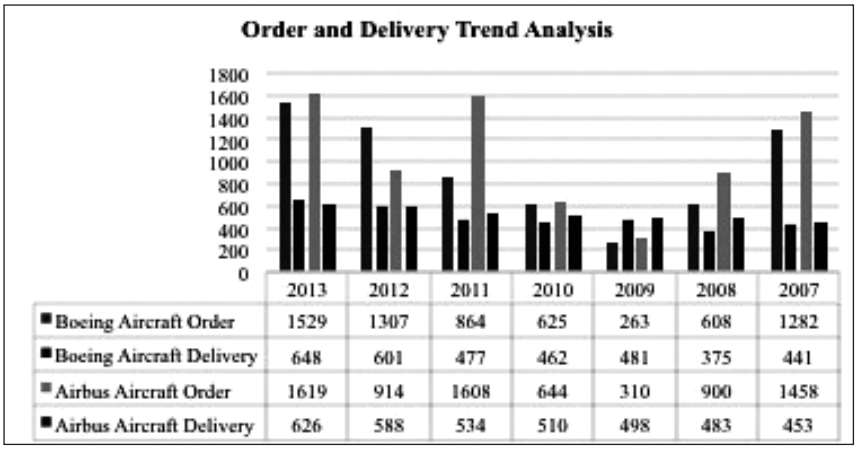
The Structure of Aerospace Industry and Importance for Security and Defense

Aerospace industry can be divided to 5 main segments (large commercial air-

craft, regional aircraft, business jets, helicopter and military related) in order to make simplification of the analysis. However, these segments are gradually blending into one another with changing industry dynamics (Capgemini, 2011).

Large Commercial Aircraft

Commercial aircrafts heavily depend on air traffic. If there is a slowdown in the economy, most passengers will avoid mobilizing by airplanes. This results in low passenger yields and decrease in orders for big new aircraft due to economic slash. Asia became the largest market in terms of air traffic in 2011, and according to Rolls Royce market forecast, it will be double the size of Europe or North America by 2031.



	2013	2012	2011	2010	2009	2008	2007
Boeing Aircraft Order	1529	1307	864	625	263	608	1282
Boeing Aircraft Delivery	648	601	477	462	481	375	441
Airbus Aircraft Order	1619	914	1608	644	310	900	1458
Airbus Aircraft Delivery	626	588	534	510	498	483	453

Table 1. Order and Delivery Trend Analysis of Boeing and Airbus, 2007-2013

There are two major global player in the commercial aircraft market. According to the Table 1, for both companies there is gradually increase in their aircraft deliveries from 2010 to 2013. Airbus has 310 orders in 2009, down from 900 in 2008; for Boeing it was 263, down from 608 because of global financial crisis. However, according to Airbus Global Market Forecast global airline traffic is expected to grow 4.7% on average every year from 2009 to 2028. This means that orders and deliveries can be expected to grow by 2028 (Leahy, 2014).

Regional Aircraft

Two major regional manufacturer in this category are Bombardier (Canada) and Embraer (Brazil). Typically, regional jets are considered to be commercial ones with fewer than 100 seats. However, it has recently produced aircrafts with 20 to 149, 20 to 99, 100 to 149 seats so product diversification takes place in this market.

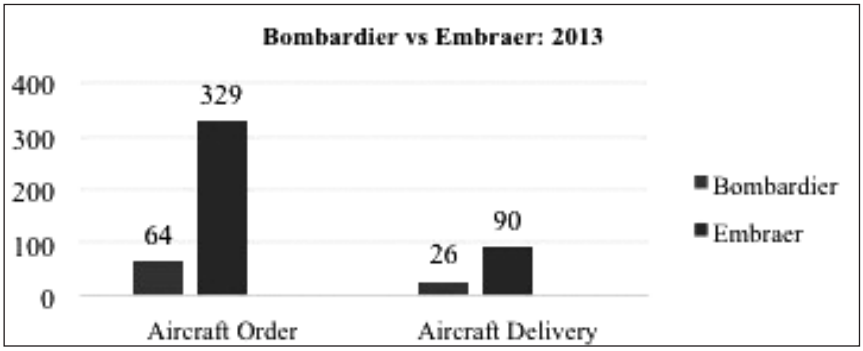


Table 2: Aircraft Order and Delivery for Bombardier and Embraer 2013

In 2013, Table 2 shows that Embraer seems to be streaming ahead of Bombardier's jet programs. It should be noted that Embraer has emerged as the world's largest manufacturer of commercial jets up to 130 seats. And also, North America and Europe are the two primary markets for regional jets, representing 41% and 28% of the current fleet in the 20 to 149 seat aircraft category, respectively.

Business Jet

North America and Europe are two largest market for business jets in the world. The global business jet market was worth USD 20.9 billion in 2013 and is projected to reach USD 33.8 billion by the end of 2020. Both North America and Europe are showing recovery in business jets market demand. While both the regions have a comparable size of economy, the private jet flight activity in North America is 3.5 times larger. In the Asian region, the players are focused on China and India. It is expected that in the next decade the business aviation industry in India will grow three times and emerge as the third largest aviation market by 2020. According to Table 3, key global players in the business jets industry including Gulfstream Aerospace Corp., Bombardier Inc., Cessna Aircraft, Embraer S.A. and Dassault Aviation (Capgemini, 2011).

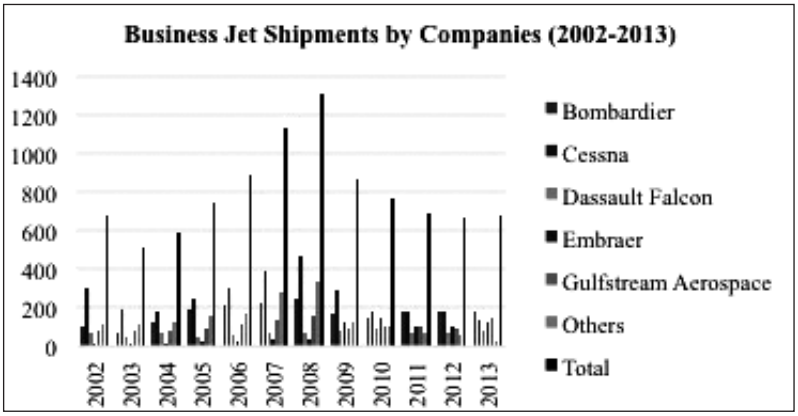


Table 3: Business Jet Shipments by Companies Between 2002 and 2013

Helicopter

The key companies in the global helicopter market are Bell Helicopters, Airbus Helicopters, Russian Helicopters and Agusta Westland (Finmeccanica). Bell Helicopters is the market leader thanks to their major presence in the vast majority of countries worldwide, coupled with their strong penetration of the defense and civil helicopter market. While North America and Europe take the largest share of the market, developing economies such as Latin America, China, the Middle East and India are rapidly growing markets. The global civil helicopter market alone was worth $3.69 billion in 2013. The military market was worth $4.82 billion. While the U.S. federal government is the largest spender on military equipment including helicopters, their purchases are expected to decline (KPMG, 2015).

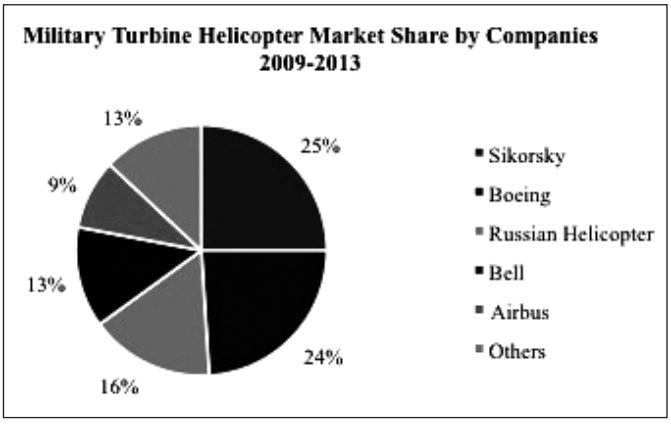


Table 4: Military Turbine Helicopter Market Share of Companies Between 2009 and 2013

Table 4 illustrates that Sikorsky has the largest market share in military turbine helicopter market. Boeing has the second largest market share in the world.

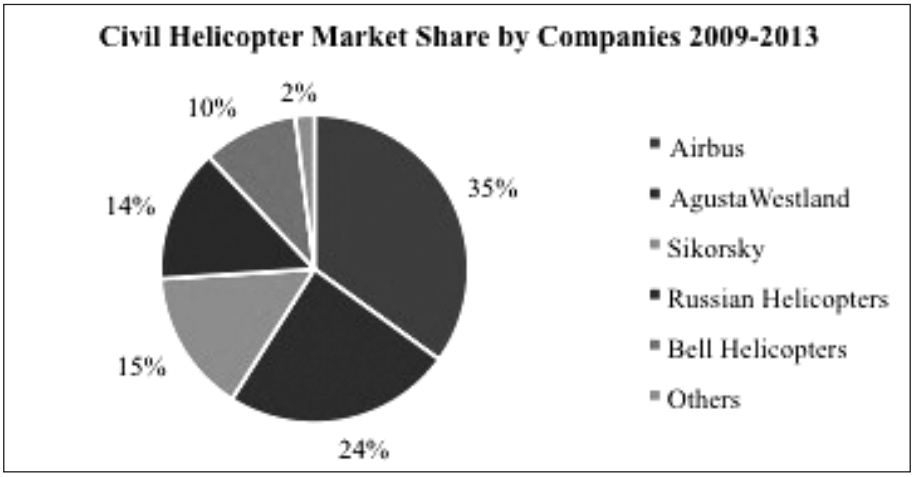


Table 5: Civil Helicopter Market Share of Companies Between 2009 and 2013 (GAMA, 2013)

According to Table 5, Airbus Helicopters is the number one robust leader of the civil and parapublic turbine helicopter market over the past five years.

Military Related

Overall global defense spending is declining, resulting mainly from reduced armed conflict in Iraq and Afghanistan and affordability concerns in many traditional militarily active governments. The global military spending has gradually declined after 2011 and is expected to stay flat in near future due to the fact that there has been a decline in the US military spending after 2011.

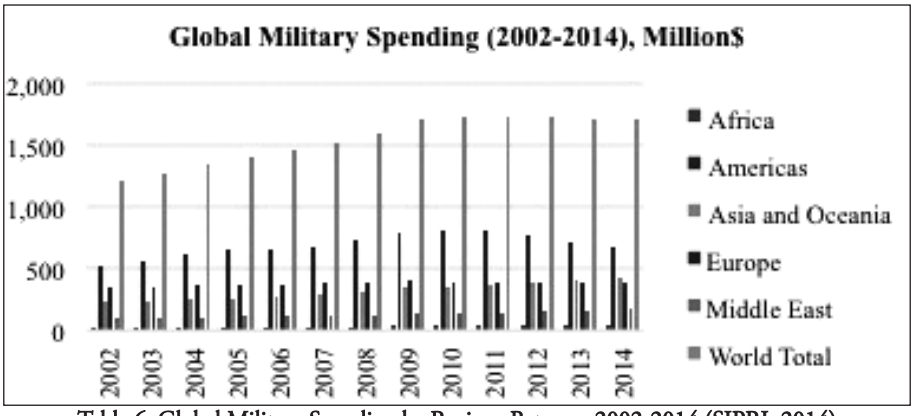


Table 6: Global Military Spending by Regions Between 2002-2014 (SIPRI, 2014)

From 2002 to 2011 total global military expenditure increased slightly. Following the year 2011, it started to decline slowly. The region of America remained leader with respect to global military spending. There was slight decrease in defense expenditure in America after 2010. Furthermore, there was continuous rise between 2002 and 2014 in military spending in Middle East.

Table 7: The Largest Defense Buyers in 2014 and Its GDP Percentage (SIPRI, 2014)

Country	2014 Spending	Percent of GDP
USA	639.704	3,8%
China, P. R.	191.228	2,02%
Russia/USSR	87.831	4,2%
Saudi Arabia	67.020	9,0%
France	62.417	2,3%
UK	56.861	2,2%
Japan	48.728	1,0%
Germany	47.667	1,3%
India	47.403	2,5%
Korea, South	33.940	2,6%
Italy	33.892	1,6%
Brazil	32.958	1,5%
Australia	24.825	1,7%
UAE	23.561	5,5%
Canada	18.464	1,0%
Turkey	18.431	2,2%
Israel	16.967	5,8%
Colombia	13.001	3,4%
Spain	12.607	0,9%
Oman	11.688	14,8%

According to Table 7, although the US is the biggest defense buyer, Oman, Saudi Arabia, Israel and UAE are the countries spending proportionately higher amounts. Defense spending is increasing in several areas of the globe, especially in UAE, Saudi Arabia, India, South Korea and Oman.

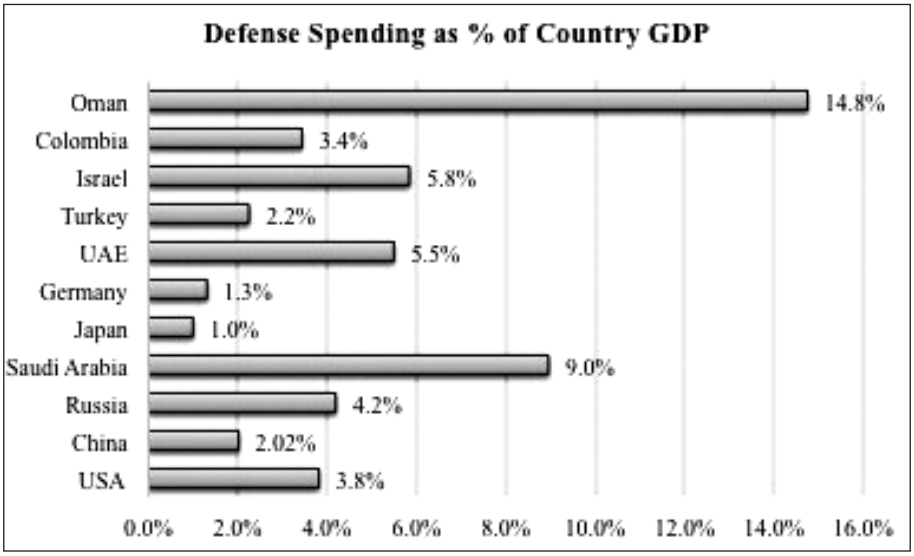


Table 8: Defense Spending as Percentage of Country GDP (SIPRI, 2014)

The table 8 illustrates countries' expenditure on defense as percentage of their GDP. According to the table, Oman is the largest defense expenditure country in terms of percentage of its GDP. With 9 per cent, Saudi Arabia ranked second. As can be seen from the table, countries which have political instability in their region have proportionately higher defense expenditure.

In terms of sales revenue in the aerospace and defense industry, Boeing was the largest and most profitable firm in 2014, followed by Airbus and Lockheed Martin; however, Airbus experienced the largest growth and Lockheed suffered the biggest decrease in revenue due to its dependence on the U. S. military.

The Importance of Aerospace and Defense Industry for a Country

Today, aerospace and defense is a highly concentrated industry, dominated by a small number of large firms that are supported by a large number of smaller contractors. It is also characterized as a capital intensive and high-value added industry. Profitability depends a great deal on technical expertise, innovation and the ability to accurately price long-term contracts for programs that may take years to design, develop and build.

Furthermore, aerospace and defense industry reflects hierarchical structure that means that high value added products can be produced by advanced countries. This can also be called league 1 nations or countries where nations take place at top of the leagues .

Aerospace and defense industry is an essential contributor to any national or supra-national system of security and defense. Its products, which include aircraft, space technologies, electronics, engineering systems and sub-systems, are crucial for domestic security as well as providing the capabilities for realizing policy aims in neighboring and in more distant parts of the world. A competitive aerospace sector is vital for any nation or region wishing to maintain full sovereignty over its territory, to exercise political influence beyond its borders and to have available to it the necessary range of political choices and options.

Those who work for companies involved in the aerospace and defense industry play a critical role in ensuring the safety and security of the world's population. They are responsible for researching, designing, manufacturing and operating military aircrafts and tools used to fight terrorism and protect the world both politically and economically.

In a world where borders are becoming increasingly blurred, this is no easy task, which explains why governments are increasingly interested and investing in this industry. Governments are constantly striving to ensure that they have the most sophisticated aircrafts available, and they're pushing companies to innovate at a faster pace than ever before.

It is not only important for national security, but also for sustainability for a nation. The industry requires high-skilled work force, particularly computer, space and electronic engineers. It provides great employment for high-skilled labor force making ensure that sustainable economic development exists in the long run. For example, in 2013, the industry employed 84.000 people in the UK and contributed 9.4 billion pound to the economy. In 2012, California (USA) accounted for $62 billion in aerospace industry revenues, 9 percent of the global market and 21 percent of the U.S. market. The industry directly or indirectly accounts for 510,000 jobs in California-203,000 directly, including commercial, military, and civilian employment, and 307,000 in indirectly related industries such as finance, real estate, construction, and transportation.

The Value Chain Analysis of Aerospace

Today, with rapid pace of globalization most of value chain is internationally fragmented. That means fragmentation of production process geographically. It results in the growth of global production networks. Some countries and firms, in this process, gain strategic advantage of global value chain due to the fact that they provide high value-added steps to the chain. Developed nations keep high value-added operations in-house in order to retain their competitive advantage. They outsource lower value-added operations to the low cost countries to benefit from decreasing price of workforce. Other countries have a role to play in the low

value-added parts of the chain. However, the development of global value chains offers new opportunities to small enterprises by enabling them to expand their business opportunities across borders, although reaching international markets is often a difficult step for SMEs.

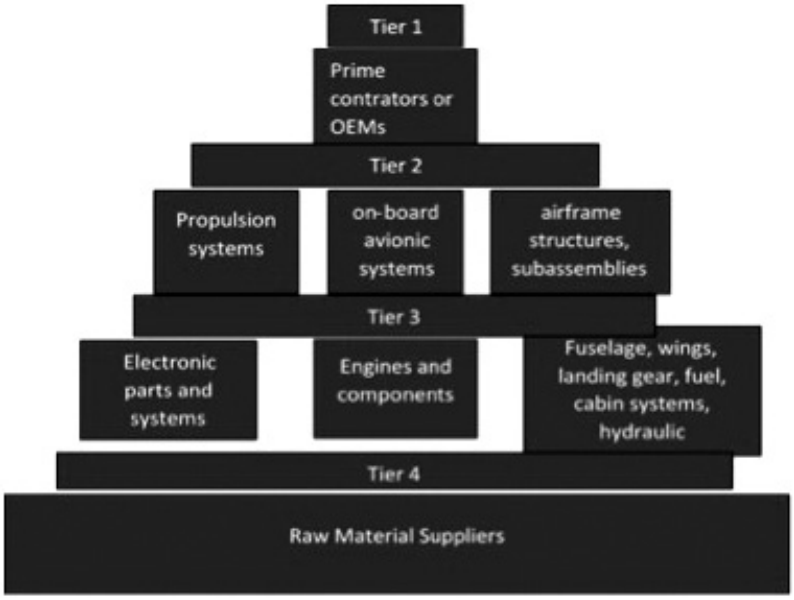


Figure 1: Production Pyramid of Aerospace Industry (Niosi & Zhegu, 2005)

The increased opportunities for SMEs come along with important challenges in terms of management, finance and the ability to upgrade and protect in-house technology. Suppliers are often given more responsibilities in the value chain to undertake more and more complex tasks than in the past.

The aerospace industry is divided into several tires based on the value added as, at top comes Original Equipment Manufacturers (OEMs), in other words, prime contractors. We call it Tier 1. Then we have three more tiers, Tier 2, Tier 3 and Tier 4 consisting suppliers operating at different levels.

Prime contractors consist of manufacturers of aircrafts (civil and military) such as Airbus, Boeing, HAL, Bombardier, Embraer, etc. Tier 2 suppliers consist of manufacturers of airframe structures, avionics systems, propulsion systems. Tier 3 suppliers comprise manufacturers of landing gear, engines and components, electronic parts, wings, cabin and hydraulic systems. Tier 4 is comprised of raw material suppliers. Special light-weight, high-strength raw materials are used such as aluminum alloy, titanium, stainless steel, and composite materials that meet engineering design requirements. There are also companies which manufacture component and parts required for Tier 2 and Tier 3 suppliers.

Production process starts with specification of requirements of Tier 1 (prime contractors). Airframe manufacturers design total aircraft, and give their suppliers detailed specifications and drawings for the manufacture of sub structures and sub systems. Tier 2 suppliers have become large scale system integrators by improving the complexity of the modules that they are manufacturing.

The value chain starts with orders of big airline companies or individuals with marketing and sales efforts. Applied research and development is continuous in this sector to remain competitive. It is provided by OEMs in collaboration with research institutions. In the production step, many parts are manufactured with the specification of requirement. Then, next step is the formation of parts and subsystems into the larger systems. Each system is modular to ensure compatibility. Final integration is one of the highest value-added activities in the production process. It contains testing modules and requires complex supply chain management systems to ensure that all modules are interfaced properly. Once components such as wings, engines, stabilizers, and landing gears are integrated into the configuration, the final product is delivered to the customer. Before the delivery, of course, all of the controls and systems are then inspected and tested, using integrated test benches. After the delivery, there is after-market services including maintenance, repair, overhaul and trainings for airline firms as well.

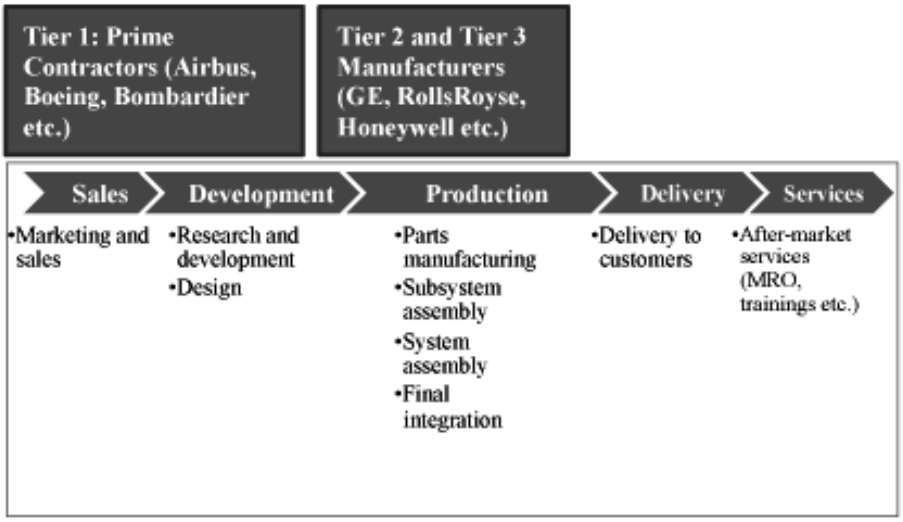


Figure 2: Aerospace Value Chain (Porter & Takeuchi, 2013)

Upgrading in the Aerospace Value Chain and Clustering Model

Aerospace and defense industry is a high value-added sector, strongly affected by scale and timing. The industry success depends on rapid technological progress; government support for corporate R&D is essential. Their activity depends on

components and parts which can be widely dispersed in terms of both industry and location. Barriers to entry are very high due to know-how and fixed capital required to design and produce aircraft .

In the aerospace value chain, OEMs or prime contractors are dominant players and shape the sector. The geographical concentration of interconnected small and medium-sized companies around OEMs and other related institutions such as universities, public agencies and research institutions comprise clusters. In the aerospace and defense industry, clusters consist of one or several OEMs surrounded by SMEs manufacturing parts and components for Tier 1, 2 and 3 companies.

Clustering Model

Cluster concept has been recognized by both developed and developing countries which are willing to increase their competitiveness and productivity level. There are many cluster definitions in the literature, but we adopt and implement Porter's definition. In this regard, clusters are geographic concentrations of interconnected companies and institutions in a specific area that compete but also cooperate. They can be connected by functional relationship (e.g. suppliers and purchasers, producers and distributors etc.) or by competition for similar markets (Porter, 1998; Sölvell, Lindqvist, & Ketels, 2003). Porter defined cluster as geographical concentrations of firms in a location and introduced diamond framework to analyze the role of location on competitiveness at national, regional as well as cluster level. In the framework analysis, there are four attributes including factor conditions, demand conditions, context for strategy and rivalry and related and supporting industries. (Porter, 1990). These attributes interact with each other and the more interaction between them the more successful and productive companies exist in any location or clusters.

Factor conditions

Factor conditions include soft (skilled workforce, human capital etc.) and hard (industrial zones, techno parks etc.) infrastructure, and raw materials. These factors of production impact competitiveness of an industry. Companies do business in an environment where they can easily reach raw materials, advanced infrastructure and highly skilled workforce. However, today, these factors should not be evaluated by themselves. Particularly, in knowledge-intensive industries, reaching raw materials is less important than creating and having institutions that are specialized in a specific field such as aviation research centre.

Demand conditions

The level of domestic and international demand size affect companies' investment decision. High domestic demand gives companies opportunity to get customer needs earlier and develop product segments for the market. Furthermore, it forces firms to innovate with sophisticated demand and at the end of the day product segments which are developed by innovation pressure can be upgraded into more advanced levels. Export level is also important for developing new products. If a country's companies are able to export their products to countries which have sophisticated demand, they are forced to innovate faster to meet international market desire.

Context for strategy and rivalry

Strategy, organization and management practices differ country-to-country and can influence competitive structure of a region or cluster. The existence of strong rivals can also influence innovative capacity and development of companies exposing strong competition. Due to the existence of strong rivalry in the cluster, companies look for different markets to perform effective and profitable operations.

Relating and supporting industries

The final attribute of competitive advantage is the presence of relating and supporting industries. Clusters are not isolated from interaction between other industry clusters. For example, aerospace cluster is highly related to electronics and communication clusters in order to integrate parts into final products. The absence of the industries or clusters decrease competitiveness of the aerospace cluster. By the same token, logistics as a supporting industry can deliver cost-effective service to the aerospace and this home-based service makes contribution to the cluster.

Each of four attributes represent a part of a system for a national or regional economy. Factor conditions are not independent from other determinants. For instance, sophisticated demand cannot be benefited enough by companies if human capital in the cluster is not developed well to produce products (Porter, 1990).

Clustering model for aerospace industry represents inter-firm collaboration and cooperation between public agencies and industry. Not only public agencies but also universities that provide strong research base for the industry are important for benefiting from doing business together. Strong collaboration in the aerospace cluster results in reducing R&D cost because of knowledge spillovers.

Furthermore, this model provides good opportunity for firms to be more competitive in the international business market.

Thanks to the longer manufacturing cycle time for airspace, small batch size and the need to cut manufacturing costs, OEMs, especially in Europe have spread their supply chain across several countries. Because of this, some countries that have clusters specialize on the parts of production process. OEMs are outsourcing sub-assemblies such as structures, land gears and avionics and engines to reduce costs and are focusing on their core competencies of design, assembling and marketing aircraft. In the global value chain, developing nations are satisfied with outsourced activities by developed countries' firms. In other worlds, high value-added activities are performed in house by developed countries, but low value-added operations are done by developing countries. In order to upgrade in the value chain, firms in the developing countries have to reach economies of scale through organizing clustering activities. With this commitment they can reach joint research activities with universities because they have technical knowledge for developing a new product or improving the existing products.

Aerospace and Defense Clusters – Three Examples

Aerospace cluster in Toulose (France)

Toulose has a big aerospace cluster, which comprises 80% of French total aerospace export and approximately 9% of total country export. Economic value is about 39 billion Euro, which is 15 times larger than Bordeaux wine cluster in France . This cluster has also 1.500 companies and 100.000 workers, a number of OEMs including Airbus, Dassault, ATR, Astrium, Thales Alenia Space, Turbomeca, and Snecma. In this regard, Toulose region has critical mass of companies that is going to manage design and fabrication process.

The aerospace cluster is constructed around Airbus and other important OEMs which is as in case of other strong clusters in the world. In Figure 3, the cluster map states situation of Toulose aerospace cluster. On the left side, there are some contractors and suppliers which subassemblies (fuselage, landing gear; communication etc.) are combined into system assembly (structures; avionics) before being sent to Airbus or other OEMs.

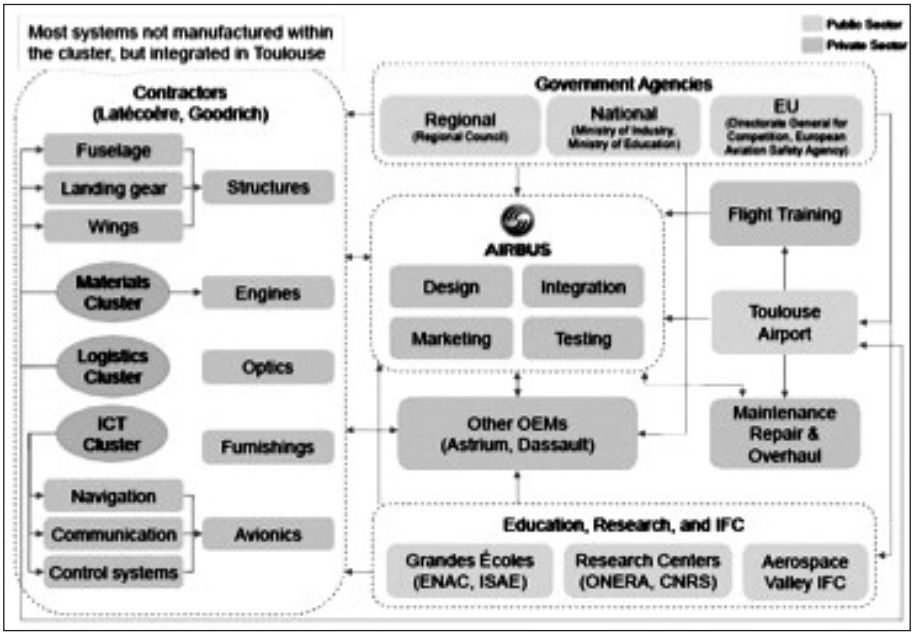


Figure 3: Toulose Aerospace Cluster Map (Porter & Takeuchi, 2013)

Most of system and subassembly systems are not manufactured in Toulose, but they are all integrated finally in the cluster. In this regard, at the centre of the cluster, Airbus and other OEMs (Astrium, Dassault) are responsible for marketing, designing, integrating and testing of final products.

On top of the map, government agencies play crucial roles in the development of cluster exist. At regional level, Regional Council promotes small and medium sized companies to facilitate their access-to-finance conditions. Moreover, it provides funding mechanism to the cluster through the Aerospace Valley institution for collaboration (IFC), was created by the French government in 2005 as part of its new national cluster policy (Aerospace Valley, 2016). At national level, Ministry of Industry and Education set industrial and educational policy, respectively. At EU level, there are concrete safety and environmental regulations that needs to be harmonized by companies.

At the bottom of the map, education and research institutions impact the competitiveness of the cluster. In the case of Toulose, there are specialized education institutions including French Civil Aviation University (ENAC) and Higher Institute of Aeronautics and Space (ISAE), which provides technical experts to the industry and make advance research on aerospace. French Aerospace Lab (ONERA) and Toulouse branch of the National Centre for Scientific Research (CNRS) impact positively for cluster performance. Furthermore, IFC promotes the cluster to increase competitiveness level.

After explaining the map of Toulose aerospace cluster, Porter's diamond model can be used to state the situation of the cluster (Porter M. E., On Competition, 1998).

Factor conditions

Infrastructure, transportation, specialized workforce can be criteria for factor conditions in Toulose. Garonne river enables barges transportation from the Atlantic Ocean to beyond Bordeaux. Infrastructures are favorable. In particular, the large Toulouse airport is used for material testing and logistics. Educational institutions provide strong expertise and skilled workforce to the cluster. Further, there is strong science base. 500 PhDs are also annually awarded in basic and applied science, while the cluster offers nearly 600 training courses in aerospace. Toulouse is home to Airbus' main training center for pilots, flight attendants, maintenance staff, and engineers (Porter & Takeuchi, 2013).

Demand conditions

Strong and sophisticated demand determines the competitiveness structure of a cluster. By nature, demand for aerospace related products is complex and sophisticated. It needs technological progress to develop a new part of aircraft. It is good for Toulose economy to host test centre in order to make testing of new parts. Furthermore, military demand for aircraft and satellites is positive for cluster in terms of pressuring innovation and technological advances.

Context for strategy and rivalry

In the cluster, suppliers and contractors are attracted by large world-class OEMs (Airbus). They also boosts investment to expand and upgrade the cluster capabilities. However, large OEMs are also a liability. Their size creates large barriers to entry for potential competitors, and limits rivalry. Actually, creation of barriers to entry explains the duopoly between Boeing and Airbus in commercial aircraft. Another issue is the geographically dispersed supply chain across Western Europe. The dispersed supply chain has multiple implications. One the positive side, Airbus became skilled at designing and managing modular interfaces that yielded effective platform strategies, reduced time-to-market, and led to component expertise. However, this modularity also creates communication issues. For instance, Germans produced kilometers of cables which were too short due to informatics incompatibilities with French (Porter & Takeuchi, 2013).

Relating and supporting industries

Aerospace cluster has strong links to other clusters such as logistics, ICT, electronics so forth. In addition to this, Aerospace Valley promotes R&D projects in order to make progress in aerospace industry. Educational institutions present good framework for supporting aerospace cluster. Moreover, European Aerospace Cluster Partnership (EACP) initiative helps to promote exchange knowledge between partners and improve collaboration between clusters that relate to the aerospace cluster.

Montreal Aerospace Cluster

Montreal is one of the most important aerospace capitals in the world. It generated 11 billion US Dollar in sales in 2011 and more than 40.000 jobs. Canadian aerospace sales come from Montreal accounted for 55% of total sales. Moreover, it presents a great research base for the industry. That is, 70% of Canadian research and development comes from this cluster. There is strong industrial concentration which has 4 prime contractors (Bell Hellicopter, Bombardier etc.), 15 Tier 2 suppliers, 215 Tier 3-4 suppliers in the region. In addition, there are collaborative organizations which serves to increase competitiveness and economic growth of the region (Aero Montreal, 2016).

Montreal Aerospace Cluster is built around OEMs (Bell Helicopter, Bombardier, CAE and Pratt and Whitney Canada) which are at the top of the industrial structure. They make up 90% of sales and account for 80% of jobs. They take the most value-added premium from the industry. Prime contractors require complete subsystems which are delivered by integrators. This include avionics, cabin parts, complete elements such as engine, fuselage, electronic parts, communication equipment etc. At the bottom of the structure, subcontractors provide a range of products and services that cover the whole spectrum of aircraft production, assembly and maintenance: machining, software, surface treatment, composite material, shot peening, rapid prototyping, hydraulics, avionics, electro-optics, etc (Aero Montreal, 2016; Communaute Metropolitaine de Montreal, 2004). Finally, supporting institutions such as marketing and financial advisers and research companies etc. are contributors to the aerospace cluster to maintain growth.

Factor conditions

98% of aerospace activities takes place in the greater Montreal. Aerospace industry in Montreal facilitate the formation of new businesses. Companies can easily access highly skilled workforce, finance and export markets. Technoparc in Saint Laurent is the largest industrial research park in Canada takes place in Montreal to stimulate leading edge technology in the aerospace industry. An excep-

tional vocational and university training infrastructure, whose annual graduating population of around 3,600 (2,800 engineers and scientists, 450 technicians and over 400 operators or assembly workers) has the necessary expertise to immediately enhance an already remarkable pool of qualified aerospace resources (Aero Montreal, 2016).

Demand conditions

By its nature, the aerospace industry rely heavily on research and development so as to make innovative products for the market. That is why, it has highly sophisticated demand from the market. Sales volume of Montreal Aerospace Cluster is 11 billion US Dollar of which 80% are exports. Local demand is relatively weak; but international demand, in particular from the USA, is strong. Overall, air traffic experienced remarkable growth over the last forty years, and will further grow fuelled by strong demand in emerging economies (Airbus, 2016).

Context for strategy and rivalry

Large firms called OEMs dominate the cluster and in this regard there is strong barriers to entry conditions in the sector. This brings about limit for rivalry. OEMs take 90% of total sales in the cluster while about 250 SMEs, which are subcontractors, represent 10% of sales. These SMEs also meet strong rivalry in the international market since emerging economies' companies (Chinese and Indian particularly) start to meet criteria to be suppliers of OEMs. They have lower labor cost and their government support the development of national industry with offset implementation (Communaute Metropolitaine de Montreal, 2004; Niosi & Zhegu, 2005).

Relating and supporting industries

Montreal Aerospace Cluster is an industry-driven organization that brings together not only aerospace companies, but also the educational and research institutions, and the associations that contribute to the development of this strategic sector. Universities such as Concordia University, Faculty of Engineering, McGill University, Faculty of Engineering, École Polytechnique de Montréal, École de technologie supérieure) have innovative capabilities to provide and enhance technical human capital. Montreal is home to research centres including The Canadian Space Agency (CSA), The Aerospace Manufacturing Technology Centre (NRC-AMTC), The Industrial Materials Institute (NRC-IMI), The Centre technologique en aérospatiale (CTA), The Centre de développement des composites du Québec (CDCQ). Companies are also supported by associations and unions including CAMAQ (Comité sectoriel de main-d'oeuvre en aérospatiale), The

Québec Aerospace Association (AQA) (Communaute Metropolitaine de Montreal, 2004; Aero Montreal, 2016).

Hamburg Aviation Cluster

Hamburg Aviation Cluster is one of the most significant industry location for civil aviation in the world. With more than 40.000 specialized personnel, the cluster has highly skilled workforce that is necessary for upgrading in the value chain. It is dominated by two industry giants, Airbus and Lufthansa Technik, and also participated by Hamburg Airport and more than 300 SMEs with collaboration of universities, research institutions and political organizations (Hamburg Aviation, 2016; Press Release: Hamburg's aviation industry presents new strategy , 2016).

Hamburg Aviation Cluster has a long history starting from 1911, when Hamburger Luftschiffhallen GmbH was founded as an airplane shelter. In 1933, Hamburg shipbuilder Blohm and Voss founded Hamburger Flugzeugbau GmbH as its airplane production subsidiary, which later became part of DASA (Deutsche Aerospace), and ultimately Airbus in 1969. In 1994, Lufthansa located its major service facilities as well as research operations in Hamburg with the creation of Lufthansa Technik. And then many SMEs clustered around Airbus, Lufthansa and Hamburg Airport (Belotserkovskiy, Gerlemann, Jariton, Lewis, & Porter, 2009).

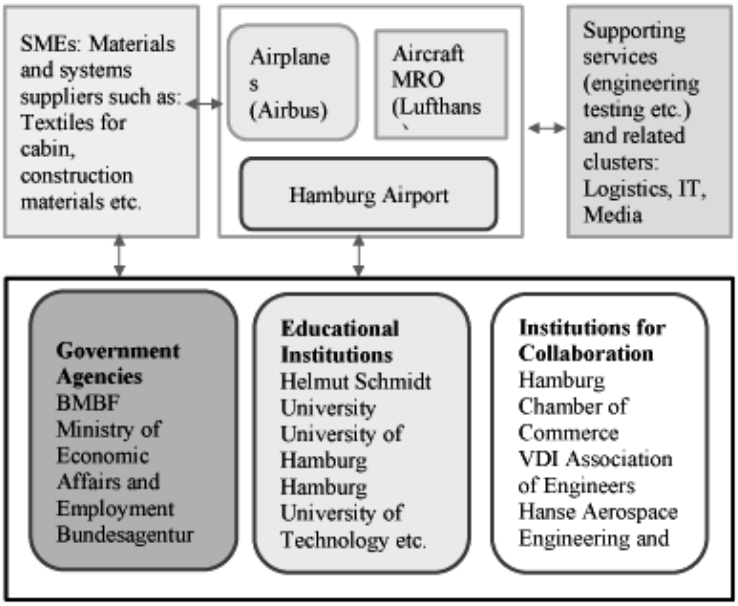


Figure 4. Hamburg Aviation Cluster Map (Belotserkovskiy, Gerlemann, Jariton, Lewis, & Porter, 2009)

Today, at the centre of the map, activities from design and production to maintenance, repair and overhaul to transportation are performed by three dominant players in the cluster. They are supported by SMEs which provide materials and systems to the industry. The existence of supporting industries such as logistics and IT impact the cluster possitively. Government agencies promote cluster development by funding clustering activities. Educational institutions help to provide highly skilled engineers by maintaining programs.

Factor conditions

Public universities (Helmut Schmidt University, Hamburg University for Applied Sciences, Hamburg University of Technology and University of Hamburg) and public/private research and training initiatives (German Aerospace Center, Center for Applied Aviation, ZAL-Aviation Research Company, Thelsys GmbH, Hanseatic Center of Aviation Training and Center for Technology Hamburg-Finkenweder) provide qualified human capital for the industry (Hamburg Aviation Members, 2016). However, in the cluster, SMEs have limited finance opportunities and entrepreneurial acitivities because of industry structure.

Demand conditions

According to Airbus Global Market Forecast Report, the sales of new aircraft over 100 seats will increase from which main demand comes Asia-Pacific Region. Therefore, international demand for aircraft can be met by differentiated products such as new cabin and entertainment systems integrated into final product. Hamburg Aviation Cluster is well positioned about the fact that the development and construction of new cabins and cabin systems is one of strategic objectives. However, it has impediments about sustainability, which means that SMEs are heavily dependent on large OEMs. They are looking for expansion in emerging economies like China, India while local SMEs are not ready to collaborate with other OEMs in Asia (Airbus, 2015; Belotserkovskiy, Gerlemann, Jariton, Lewis, & Porter, 2009).

Context for strategy and rivalry

Rivalry is quite limited due to the nature of the industry. SMEs try to adapt themselves according to specfications of two large companies (Airbus and Lufthansa). However, as a whole, the cluster try to differentiate its products because of pressure coming from Asia-Pacific region taking advantage of lower labor cost. Furthermore, government through programs such as Spitzencluster and Kompetenznetze initiative focus on supporting and promoting cluster development. By providing funding to joint R&D projects it mobilizes industry players to increase competitiveness within common goals determined by cluster organization.

Relating and supporting industries

According to Figure 4, Hamburg region has three main clusters which impact aviation industry directly. For example, efficient logistics activities enable aviation industry to ship final products and access to supplies efficiently. Also, knowledge transfer from marine industry and IT allows for quick response to changing trends in design and engineering.

Comparisons of Three Examples

The most important common ground in the case studies is that the industry is shaped by OEMs such as Airbus, Boeing, Bombardier etc. In order to have a clear view of three examples, comparison chart can be added here within the framework of Porter's diamond model.

Leading OEM	Airbus	Bombardier	Airbus/Lufthansa
Factor Conditions	☑Infrastructure ☑Logistics ☑Skilled labor ☒Limited entrepreneurship	☑Infrastructure ☑Science base ☑Specialized workforce ☒Limited entrepreneurship	☑Infrastructure ☑Specialized universities ☑Skilled labor ☒Limited entrepreneurship
Demand Conditions	☑Airbus' strong demand ☑Strong international demand ☒Weak domestic demand (2% of all Airbus orders)	☑Export-oriented structure ☑Demand coming from emerging markets ☒Weak domestic demand	☑Sophisticated local customers (Airbus,Lufthansa) ☑Specialization in cabin systems ☒SMEs' readiness for international collaboration
Context for Strategy and Rivalry	☑ The presence of integrated system suppliers ☑ The presence of Airbus ☒ Large barriers to entry for innovative business	☑ The presence of Bombardier ☒ Limited competition due to barriers ☒ Offset applications in the emerging economies	☑ Government fund to the cluster activities ☑ Focusing on cabin systems in the value chain ☒ Lack of integrated system suppliers
Relating and Supporting Industries	☑Strong links with logistics, ICT clusters ☑EACP initiative ☒Outsourcing activities	☑The presence of supporting institutions (CAMAQ, AQA etc.) ☒Weak ties with other clusters	☑Strong links with IT, media, logistics clusters ☑Quick response to changing trends in design and engineering

Table 9: Comparison Chart of Toulose, Montreal and Hamburg Clusters Conclusion

Conclusion

In this study, the value chain structure of aerospace industry has been examined. It has told us that the sector is extremely globalized and fragmented geographically. The sector is shaped by OEMs or prime contractors such as Boeing, Bombardier, Embraer, Airbus etc. They serve for both civil and military related industrial fields. SMEs around prime contractors which are serving for them try to be integrated into the value chain. However, this integration is limited with low value-added activities. Prime contractors generally focus on design, marketing, research and development and after-market services. Other companies specialize in manufacturing parts and sub-system assembly in order to be suppliers of big firms.

According to the value chain analysis, if a country wants to be dominant player in the aerospace and defense industry, it must have prime contractors which shapes the sector and creates barriers to entry. In this regard, clustering model is a good way of having a prime contractor in the country. This strategy adopted by the industry include greater collaboration between industry, public agencies and universities. Building cultural and institutional network through clustering allows productivity growth. Mobilizing all stakeholders takes advantage of not only economies of scale and scope but also allows for knowledge transfer across the value chain. This will increase production capability in direct dealings with Tier 2 and Tier 3 suppliers. Upgrading in the value chain with collaboration model and joint research activities can be essential for companies and countries which wants to take place at top of the global rankings.

Some implications may be drawn from the case studies illustrated in the comparison chart to provide a framework for future studies. They will briefly be reviewed below.

Firstly, the existence of OEM is prerequisite for having world class aerospace cluster because the industry is shaped by them. They make up 90% of sales and account for 80% of jobs. They take the most value-added premium from the industry. There should be good infrastructure for enterprises to attract investment around the OEMs. In addition, excellent logistics facility is premium to be more competitive than any other cluster in the world. Education and training programs in universities to have skilled workforce are key factors in the process of developing the cluster. However, there is concrete negative result, that is, limited entrepreneurship activities due to large barriers to entry.

Secondly, international demand mostly coming from emerging markets is driving force of the clusters in spite of the fact that domestic demand is weak. Furthermore, if the cluster has specialization on a specific part of the industry, this will increase technological level and competitiveness although there has pressure from low-cost countries.

Thirdly, the presence of OEMs and key players in the value chain such as system integrators is advantageous despite its impediments for innovative competitors to enter the market. Moreover, reaching government fund (like in the case of Hamburg) can increase competitiveness of the clear focused clusters.

Finally, it is evident from the case studies that strong ties with related and supporting clusters can promote joint R&D activities and facilitate knowledge exchange between them. However, because of global value chain outsourcing is inevitable to take advantage of low-cost manufacturing. This structure engenders decline in manufacturing in-house and can threaten innovative capabilities of the cluster in the long run. Therefore, developed countries cannot leave the industry to emerging countries since it has potential to feed other enabling technologies and military application. It also provides large number of employment.

Overall, this paper highlights the importance of value chain structure and aerospace and defense cluster to improve technology and innovation. Abovementioned implications and lessons-learned can be drawn for future studies in the realm of clustering and value chain analysis. They will be beneficial to test and expand on Porter's framework through more case studies in emerging market economies.

Appendix 1: Overview of Building an Aircraft

Raw Materials (suppliers)

Special light-weight, high-strength raw materials are used such as aluminum alloy, titanium, stainless steel, and composite materials that meet engineering design requirements

Stretch-forming the Fuselage Skin (manufacturing parts)

The aluminum alloy sheet is conformed to the curvature of the fuselage. The fuselage skin will be attached to other primary structural components, such as frames and stringers.

Shaping and Adjusting (manufacturing parts)

The skin is adjusted to its final shape and dimensions by a five-axis computerized numeric control (CNC) tooling machine. Inset, a window is being cut out and adjusted to its shape and dimensions.

Surface Treatment and Corrosion-Resistant Coating (manufacturing parts)

After the fuselage skin is manufactured, an anti-corrosion surface treatment is performed.

Structural Assembly of a Major Component (fuselage assembly)

The fuselage skins are mainly joined to frames and stringers by riveting, resulting in a fuselage segment.

Sealant

The sealant is applied in order to make cabin pressurization possible and prevent leakage.

Fuselage Mating

After the major fuselage segments are produced, they are mated by riveting and bolting, butt-joint splices, thus completing the fuselage.

Installation of Wiring, Tubing and Ducts

Ducts, wiring, cables, hydraulic systems, valves, and other equipment are installed.

Fuselage Painting

At this stage, the fuselage is painted according to the customer's livery, in a close booth, with controlled temperature and pressure.

Major Component Assembly (Final Assembly)

The major components such as wings, engines, stabilizers, and landing gears are integrated into the configuration.

Final Outfitting

Avionics, hydraulics, fuel systems, and flight control equipment are installed as well as such components as seats, galley, and lavatory.

Ground Tests

All of the controls and systems are then inspected and tested, using integrated test benches.

Production Flight

These are performed to ensure that the airplane complies with design and manufacturing requirements, and meets civil aviation standards for issuing airworthiness certification.

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Summary

Clustering and Value Chain: Example of Aerospace and Defense Industry

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Globalization affects all sectors including primarily technology-intensive sectors. Information and communication technology enables firms operated in the high technology sectors to spread their economic activities in any location in the world in order to decrease operational costs. That needs to be performed because growing competition in domestic and international market drives companies to be more efficient and productive to retain their competitiveness level. In order to understand this trend value chain is thoroughly evaluated to make clarification of the structure.

However, despite globalization clustering concept emphasize the importance of location and economic actors in the value chain to rise competitiveness level of a nation or a region. This article reviews examination of the value chain structure of aerospace and defense industry and clustering model. The structure of aerospace industry is thoroughly presented. Global defense spending has also been compared. Then, production pyramid and value chain of aerospace has been explained in order to clarify global value chain. There has still been an opportunity of upgrading in the aerospace value chain with a concrete model that is, clustering model. In the aerospace value chain, OEMs or prime contractors are dominant players and shape the sector. The geographical concentration of interconnected small and medium-sized companies around OEMs and other related institutions such as universities, public agencies and research institutions comprise clusters.

Three examples of clustering which are Toulose, Montreal and Hamburg have been showcased to analyze complex system of competitiveness of aerospace industry using Porter's diamond model.

In conclusion, if a country wants to be dominant player in the aerospace and defense industry, it must have prime contractors which shapes the sector and creates barriers to entry. In this regard, clustering model is a good way of having a prime contractor in the country. This strategy adopted by the industry include greater collaboration between industry, public agencies and universities at the same time.

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