



BUCHAREST UNIVERSITY OF ECONOMIC STUDIES
DEPARTMENT OF INTERNATIONAL BUSINESS AND ECONOMICS

CCREI WORKING PAPERS SERIES

No 7/2017 September

**The Aerospace Cluster in Washington State
Microeconomics of Competitiveness
Study Case**

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ISSN 2285-2700
ISSN-L 2285-2700

EDITURA
ASE

CCREI WORKING PAPERS SERIES

No. 7/2017 September

Case studies in international business

Department of International Economics and Business
Bucharest University of Economic Studies
Piața Romană 6, 010374, București, România

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septembrie 2017

Online at <http://www.cercetare.rei.ase.ro/despre>

CCREI WORKING PAPERS SERIES No. 7, posted September 2017

Abstract

The paper analyzes the development of the Washington cluster in the aeronautics industry and the factors that contributed to this continuous and substantial growth. In the first section of the text it is described the profile of the country as well as the region and the city, in order to understand the exogenous factors that made possible the enrichment of the aerospace cluster in that particular area. Moving further with the analysis, the paper identifies the main competition from rival clusters, emphasizing the strengths of each rival cluster in comparison with the aeronautics cluster from Washington. A cluster map is provided later in the study, for explaining the intertwined relation between many supporting industries that help sustain the aerospace cluster. Additionally, the text explores the performance of the cluster and the overall competitiveness in the business environment. In the end, the paper seeks to answer the question: What are the key issues that the cluster is facing?

Keywords: cluster, aerospace industry, Washington, competitiveness.

Content

Part 1. Country Analysis	5
1.1. Country profile and economic development	5
1.2. Competitiveness analysis.....	6
1.2.1 Endowments.....	6
1.2.2. Competitiveness.....	6
1.3. Country Cluster Profile	9
Part 2. Washington Cluster Description	11
2.1. Profile of the cluster	11
2.2. Competing clusters	12
2.3. Cluster Map	13
2.4. History of the cluster.....	15
2.5. Cluster performance.....	16
2.6. Cluster competitiveness	17
2.7. Key issues facing the cluster	19
2.8. Conclusions	20
References	21

Part 1. Country Analysis

1.1. Country profile and economic development

The United States of America (U.S.A.) is the third largest country in the world by size, with a total land area of 9,147,420 square kilometers, having more than twice the size of the European Union. With a population of over 321 million people in 2015, the U.S.A. ranks number three on the list of countries measured by population.

As a constitutional federal republic, the U.S.A. embodies 50 states, out of which 48 states, as well as the federal territory of Washington D.C. are situated on the continent of North America, leaving the two remaining states, Alaska and Hawaii, as disjoined territories. Other dominions of the United States of America are the American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, Puerto Rico, and Virgin Islands of the United States.

The capital city is Washington D.C. and it is home to all three branches of the federal government of the U.S.A, including the executive, the legislative, and the judicial bodies (Cia.gov, 2016).

The United States of America has been the biggest economic power since the start of the 20th century, being the most technologically advanced and diverse economy in the world. With the exception of the global financial crisis that hit the country the hardest in 2009, US' growth has been increasing, with small business cycle fluctuations around the trend line. This growth is the result of constant productivity growth, determined by various investments in the research and development (R&D) area and managerial practices (Data.worldbank.org, 2016).

The firms based in the US are leading major sectors due to their technological progress, especially in the fields of aerospace, medical science, and military equipment. (<http://foundersguide.com/top-states-among-the-10-major-industries-in-us/>)

According to the data released by the Bureau of Economic Analysis, GDP increased 2.9% at an annual rate in the third quarter of 2016. This increase in real GDP is the result of effective contributions from consumer spending, government spending, and exports. Consumer spending saw a smaller increase in the third quarter compared to the second quarter of 2016 due to a fall in citizen spending on non-durable goods, such as pharmaceuticals, tobacco, and household suppliers. Government spending increased mainly because there was higher spending on national defense sector, where heavy investments are usually made. Last but not least, exports registered positive results due to an increase in exports of foods, feeds and beverages (Bea.gov, 2016).

1.2. Competitiveness analysis

1.2.1. Endowments

The extraction of natural resources has been a major industry in the US since the 19th century, including fossil fuel, renewable energy, and non-energy mineral resources. As far as fossil fuels are concerned, they represent the US' main source for obtaining electricity, powering motor vehicles and for heating homes.

Fossil fuel resources account for approximately 82% of the total US energy consumption in 2013. The US is the leading country in natural gas production. As such, in 2013, five states produced 67% of the total dry natural gas. It should be mentioned that through the natural process of degradation, plants and animals become energy resources in the form of coal and oil

On the sector of non-energy mineral resources, the main extractions are made on gold, copper, and iron. For 2013, these minerals were the most produced valuable metals in the United States of America accounting 32%, 29%, and 17% respectively, of \$32 billion worth of metal extracted (Useiti.doi.gov, 2016).

1.2.2. Competitiveness

The government of the US influences the competitiveness of the country strategically, through investing in crucial sectors of the economy, such as infrastructure, research and development, private sector, and education. It assists various regulatory institutions, whose role is to supervise numerous economic sectors. Best known and active regulatory bodies are: the Federal Aviation Administration, the Federal Energy Regulatory Commission, the Federal Railroad Administration and the Federal Highway Administration.

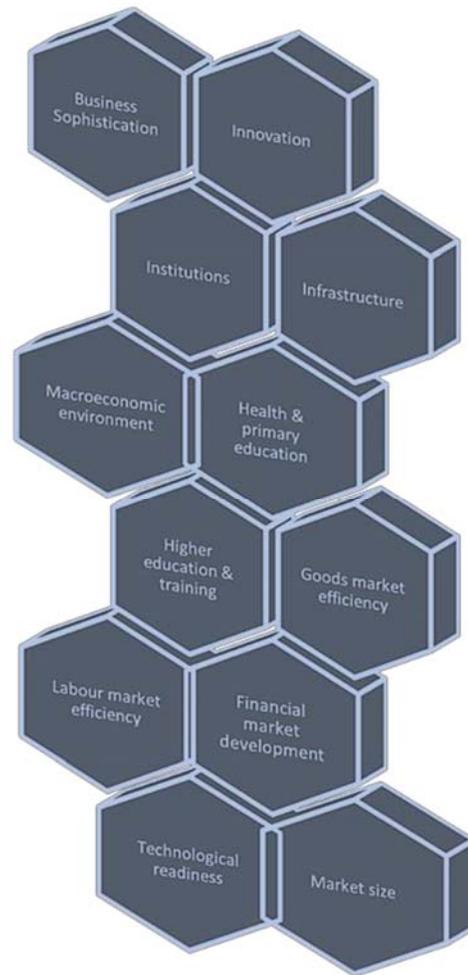


Figure 1. The 12 pillars of competitiveness
Source: Own interpretation of data

Out of these, it has to be pointed out that the Federal Aviation Administration helps sustaining the safest air transportation system in the world.

The purpose of these agencies was to assure safe market transactions, preventing the appearance of monopolies. As such, regulatory agencies constitute a vital part of the institutional framework that ensures the good functioning of the economy.

Government spending on infrastructure requires investments in airports, bridges, electricity, Internet, rail systems, roads, and seaports. As such, according to the Congressional Budget Office, in 2004, total spending on infrastructure accounted for \$406 billion.

As far as the area of research and development is concerned, the United States performs quite impressive: United States remains the world's largest R&D investor with projected \$465 Billion spending in 2014. This is a globally competitive level of research intensity equal to 2.8% of U.S. GDP (Global R&D Funding Forecast, 2014).

There are various methods through which the government can stimulate the private sector, usually by allocating loan guarantees to stimulate investments. As such, in 2008, the Congress authorized the Nuclear Regulatory Commission to offer federal loan guarantees of \$18.5 billion for helping at the construction on newer nuclear plants.

On the area of education, the US was once known for sustaining the development of human capital as a key strategy for improving economic growth. In recent international examinations, such as the program for international student assessment (PISA), Americans aged 15 years old scored 12th in reading, 18th in science, and 26th in math (Research & Development, 2011).

While the demand for other fields alternates, the need for proficient, skilled aerospace engineers is on the rise. Thus, attending an aerospace engineering program in Washington represents a popular career path among students.

The description of aerospace education cannot be fully achieved without mentioning University of Washington and its exhaustive offer. As the average class size is just 13 students, students enrolled in both Bachelor or Master degree received maximum attention and plethora of opportunities to interact with professors (Mcmasters, 2004).

The attractiveness of this sector is amplified by the so called "Hands-on experience", a key component of engineering that has a paid co-op program, allowing students to earn credits and work at the same time, as they get paid by an engineering employer. Throughout this program, students have the chance to gain beyond price experience and after graduation, they may be hired full-time.

The allure of Aerospace is further enhanced by the existence of various engineering organizations and education groups in Washington State that offer different scholarships:

— "The Washington Society of Professional Engineers" awards scholarships to local engineering students on an annual basis. The main aim of the Society is to advance the public welfare, while closely working with Washington engineering schools in order to promote academic achievement and licensing: conducting a unique coaching and competition program for 6th, 7th and 8th grade students in Washington as an example of their initiatives (Washington Engineer, 2017).

— "The Washington State Opportunity Scholarship" is awarded to students in the fields of math, science, health care, and engineering. WSOS supports low- and middle-income students pursuing high-demand majors, such as engineering, science or technology. Enterprises and the Washington State Legislature have merged efforts in order to achieve the promise of a more valuable education and more career opportunities for Washington students. As a result, they have generated an exclusive public-private partnership, including major employers like Boeing and Microsoft (WA Opportunity Scholarship, 2017).

In this manner, engineering and aerospace industry portrait themselves as a one of the highest-paying careers, attracting more and more students within (Community Attributes Inc., 2016). Selected students receive \$1,000 per year, for an extent of time that goes up to four years.

Boeing and various other aerospace companies pay greatly higher wages on average as to the state overall; in 2015, aerospace employees gained an average wage of \$107,000, while the state average wage of \$54,000.

Moreover, in 2016 "The State Board of Education" has certified 11 more statewide "Career and Technical Education" course frameworks in order to cover high school students' core subject graduation requirements, out of which 3 are "Core Plus CTE" courses, created via Boeing's efforts to generate a standardized aerospace-related curriculum for Washington high school students (Pedraza, 2016). In addition to the direct effect on the local economy, aerospace cluster creates, supports and fosters many jobs in other sectors such as retail and construction.

1.3. Country Cluster Profile

For decades the aerospace sector propels economic development in Washington State. During the last 5 years, the US (aerospace and defence) A&D cluster unquestionably managed to stand out from other influential sectors such as computers, electronic products or transportation equipment. While the latter performed a negative net trade balance, the A&D sector succeeded to reach a surplus of over \$76.0 billion in 2015, attaining the 1st rank in the US Trade balance contributions (Deloitte, 2016).

Year	2010			2015		
	Export	Import	Net trade balance	Export	Import	Net trade balance
Aerospace and defence	\$90,190	\$42,114	\$48,076	\$143,338	\$67,350	\$75,988
Agricultural products	\$60,232	\$26,094	\$34,138	\$62,934	\$35,898	\$27,036
Petroleum and coal products	\$61,423	\$72,523	-\$11,100	\$80,071	\$55,105	\$24,966
Food manufacturing	\$51,895	\$43,076	\$8,819	\$63,164	\$60,782	\$2,382
Chemical manufacturing	\$179,572	\$180,121	-\$549	\$194,182	\$218,183	-\$24,001
Electrical equipment and components	\$37,545	\$71,915	-\$34,370	\$60,103	\$107,458	-\$47,355
Machinery manufacturing	\$137,809	\$180,121	-\$42,312	\$138,778	\$218,183	-\$79,405
Transport equipment	\$190,924	\$245,036	-\$54,112	\$274,742	\$384,070	-\$109,328
Computer and electronic products	\$190,399	\$329,921	-\$139,522	\$204,626	\$380,044	-\$175,418

Table 1. US Net Trade Balance for major sectors (2010-2015)

Source: Deloitte, 2016

2015	Importing country	A&D exports (US\$ billion)	Share of total exports	2010	Importing country	A&D exports (US\$ billion)	Share of total exports
1	China	\$16.48	11.5%	1	France	\$7.43	8.20%
2	United Kingdom	\$10.37	7.20%	2	Canada	\$6.90	7.70%
3	France	\$9.80	6.80%	3	United Kingdom	\$6.53	7.20%
4	Canada	\$9.05	6.30%	4	Japan	\$6.13	6.80%
5	Japan	\$8.01	5.60%	5	China	\$5.88	6.50%
6	Germany	\$7.11	5.00%	6	Germany	\$5.73	6.40%
7	Singapore	\$6.34	4.40%	7	Brazil	\$4.60	5.10%
8	UAE	\$6.27	4.40%	8	Singapore	\$4.07	4.50%
9	Brazil	\$4.85	3.40%	9	South Korea	\$3.42	3.80%
10	Mexico	\$4.62	3.20%	10	Turkey	\$2.59	2.90%
	Top 10 countries	\$82.90	57.80%		Top 10 countries	\$53.28	59.10%
	Total US exports	\$143.33			Total US exports	\$90.19	

Table 2. US Trading Partners (2010-2015)

Source: Deloitte, 2016

The US aerospace industry location always represented a considerable challenge, mostly due to both strategic reasons related to military aspects and research confidentiality (Terral and Jourdenais, 2001).

Washington state gained relevance in the aerospace cluster due to its' high delivery in terms of exports – 34.6 % of the total US A&D sector exports in 2015, registering a 109% increase in comparison with year 2010. Furthermore, by adding the California and Connecticut States, their combined gross exports will equal more than US\$73 billion, holding half of the entire US A&D exports.

Part 2. Washington Cluster Description

2.1. Profile of the cluster

Washington is a dominant force in the aerospace industry, producing more than 1,400 aircraft and unmanned aerial systems annually and building nearly 95% of all commercial aircraft in North America. 2015 is the year when 19% of total aerospace manufacturing employment in the United States was located in Washington. The state is an important hub for aircraft maintenance, repair and overhaul operations. (Accenture, 2011)

Boeing is one of the two largest aircraft manufacturers in the world, which has in Washington a deep and extensive tiered supply chain. The manufacturer supports in Washington various facets of aircraft production, including parts and system manufacturers and materials suppliers.

The aerospace industries also refer to aerospace parts, and in the case of Washington, the industry in this state includes approximately 650 companies located in 28 counties. They manufacture tools, composites, do the design, subassembly and repairs.

Washington's aerospace industry is mostly concentrated in two counties: King and Snohomish and a various range of support activities and aerospace manufacturers are spread across the rest of the state. Thus, King County is home to several Boeing facilities, such as final assembly lines for the 737 and P8 aircraft, while Renton plant is the place for final delivery preparations and test flights and Auburn is for components fabrication.

2.2. Competing clusters

Washington faces fierce competition from rival clusters. Besides the existing successful clusters such as Wichita, Texas, Seattle-Bellevue-Everett and Connecticut, there are more nurturing emerging ones such as South Carolina, Oklahoma or Florida. (PWC, 2013).

The Texas cluster puts the accent on increasing skills in workforce, from post-secondary training in welding and electronics to post-graduate engineering education. In addition to this, Texas also promotes networks between academia, public labs and the private firms, in order to understand common needs as well as solutions (Niosi, 2012). Moreover, Texas offers incentives, financing and cash so that they can attract businesses to the state. The state is centrally located with good access to major sea, air and rail freight hubs (Accenture, 2011).

South Carolina is another state where Boeing has a considerable presence. The state was chosen for final assembly and delivery line for the 787 Dreamliner. (PWC, 2013) However, at the beginning of 2011, comparing with Washington, the state lacked funding and educational structure to serve another major aircraft program as the current labor pool did not contain enough skilled workers to satisfy Boeing's existing need regarding the 787 (Accenture, 2011)

Florida has been recently ranked first in the U.S for aerospace and aviation manufacturing attractiveness according to a report conducted by PwC in 2015. The strengths of this state are various such as well-developed infrastructure which include 22 airports with runways of 10.000 feet, as well as advanced space vehicle, payload processing and landing facilities. The state, similarly with Washington, benefits from a cost competitive environment, favorable tax structure, industry-specific incentives and workforce training programs. (Florida – The perfect Climate for Business, 2013)

2.3. Cluster Map

The aerospace sector in Washington is surrounded by an ecosystem of supporting industries. Electronic and mechanical component manufacturers, machine shops, composites manufacturers, training organizations, airlines, and air travel-related companies are important contributors to Washington's aerospace sector. In 2015, these industries represented a combined 42,310 jobs across the state, paid wages of \$2.9 billion, and received \$10.7 billion in revenue.

Aerospace-related industries are most heavily concentrated in King County, with more than half of the state's aerospace-related jobs. King County is also a major hub to numerous aerospace suppliers, which include:

- Orion Industries provides precision metal fabrication for the aerospace industry, and also has a social mission of helping individuals with barriers to achieve employment.
- Exotic Metals Forming Company LLC is an aerospace-related business in King County. The company manufactures metal sheets and specializes in aerospace applications. Exotic Metals Forming Company is a supplier for Boeing, Airbus, Pratt & Whitney, UTC and more, and has been awarded supplier excellence awards from Boeing and Pratt & Whitney. The company was selected to supply parts to Boeing for the 737 MAX. In 2015 they expanded, opening a facility in Airway Heights.
- Pacific Propeller is a parts manufacturer located in Kent. The firm specializes in maintenance and repair of propeller technology, used in both helicopters and airplanes. Their services are used by air transportation providers and military across the globe.
- UTC Aerospace Systems, a global firm specializing in a wide range of aircraft systems. UTC produces actuation systems, electric systems, engine components, interiors, landing gear systems, space systems and much more. With locations across Washington, this company is an important supplier for Boeing, and also works with Airbus, Bombardier and Comac. UTC has multiple locations in Everett, specializing in interiors, landing gear and aero- structures. An additional location in Spokane specializes in wheels and brakes.
- Toray Composites, a subsidiary of Tokyo-based Toray Industries, is located in Tacoma. Its products include carbon fiber and glass fiber fabrics and have been used in the production of the new Boeing 777X and the Boeing 787 Dreamliner as well as products for sports, recreational, and industrial manufacturers. (Economic Development Council of Seattle and King County, 2015)

An important element related to the main actors for the Washington cluster is represented by the education system. There are some series of training programs offered by the government for all students interested in this domain. Such examples of programs are represented by The Aerospace Joint Apprenticeship Committee, which offers combined supervised on the job training with college level classroom instruction. This type of programs are funded by the government and by the end of 2015, more than 4700 trainees have enrolled this initiative (Educating Engineers.com)



Figure 2. Cluster Map

*Source: Community Attributes Inc., 2016
(Own interpretation of data)*

2.4. History of the cluster

History of the aerospace cluster is almost entirely oriented around Boeing Company. However, in the past few years an increasing number of firms have appeared and they are destined for other companies doing final assembly of airlines.

The birth of the industry started in early 1916, when the Boeing Company was first created with just 21 employees. Benefiting from the congressional legislation which allowed the Post Office to contract private firms for airmail (Kelly Act of 1925), Boeing formed Boeing Air Transport in 1927, with routes to and from San Francisco and Chicago. The air carrier was an early predecessor of what is nowadays United Airlines. (Boeing Overview, 2016)

In later years, Boeing's operations in Washington played a critical role in the development of both commercial and military aerospace and space technologies. The model 247, which first flew in 1933, helped revolutionize passenger air travel due to the capability of flying 70 miles per hour faster than its competitors and being able to carry 10 passengers and 400 pounds of mail. However, the launch of the plane was simultaneous with the Great Depression so consequently it had little chance of commercial success. In terms of military development, in 1941, when the US entered the war, the B-17 Flying Fortress was already bombing missions over Germany for the British Royal Air Force. In 1944, the company was producing up to 20 bombers per day and Boeing employment swelled to 50000 people in the company's Seattle area plants, while sales summed \$600 million. (Boeing Overview, 2016)

As worldwide demand for air travel was increasing in the 1960s, Boeing introduced several types of planes, creating a family of airplanes to serve every need. Variants of 737, the most popular jet from Boeing, and the 747, its jumbo set, are still rolling off the production lines. In 2001, Insitu launches SeaScan, an unmanned aerial systems (UAS) designed to help fisherman locate and track schools of tuna. The technology is adapted a year later to create ScanEagle, ushering in the age of UAS design and production in Washington State (Conway, Pedersen, 2006).

2.5. Cluster performance

Starting 2005, the aerospace industry revenues have been on an increasing direction, peaking in 2014, when generated \$69.9 billion in business revenues. Aerospace activities directly supported 93,800 workers in 2015.

Industry employment has remained fairly stable in recent years. From 2012 to 2015, the industry employment declined by 400 jobs, or roughly 0.4% of total industry employment. Together with aerospace-related industries like carbon-fiber manufacturers, flight training and navigational equipment manufacturers, the industry employed 136,100 workers in 2015. In 2015, the industry had a total economic impact to the Washington state economy of 252,800 jobs and \$94.7 billion in business revenues.

For every direct job in aerospace, an additional 1.7 jobs are supported through indirect and induced effects elsewhere in the state economy (Drewel, B., 2013). Some of the largest industries affected through secondary (indirect and induced) impacts include the retail sector, wholesale trade, construction, and waste management services.



Figure 3. Aerospace Industry Revenue (billions of dollars, 2005-2016)
Source: Washington State Department of Revenue, 2016 (own interpretation of data)

2.6. Cluster competitiveness

The business environment in Washington is an attractive one, which does not tax personal or corporate income. The tax credits, deferrals, abatements and rate reductions focus specially on such areas as high-tech R&D, aerospace manufacturing and medical device manufacturing. (Economic Development Council of Seattle & King County, 2015).

Furthermore, there are seven tax incentives available to aerospace businesses, including aerospace manufacturers, businesses involved in aerospace development, component manufacturers, and certain other entities.

These incentives cover B&O taxes and Sales & Use taxes paid on certain items. Notably aerospace manufacturers are eligible for reduced B&O taxes and may be exempt from Sales & Use taxes that would normally apply to construction of aerospace manufacturing buildings.

In 2015, tax incentive users reported \$326.8 million in savings from aerospace tax incentives, according to the Washington State Department of Revenue.

The Boeing Company represents the vast majority of aerospace economic activity in Washington State, as measured in jobs, revenues, and wage outlays. In 2015, Boeing Commercial Airlines (BCA), the largest segment of Boeing's activities in Washington, employed an estimated 69,000 workers, including manufacturing facilities in Everett, Renton, Auburn, Frederickson, and Seattle-Tukwila, with estimated wage outlays (including benefits) of \$9.4 billion. The company was the primary source for exports, including to overseas airlines in China, Japan, and the Middle East.

For the past 10 years, with the growth in airplane deliveries, Boeing's global market share improved from 31% in 2008 to 45% in 2014. We believe that Boeing will be able to sustain these levels in the coming years.

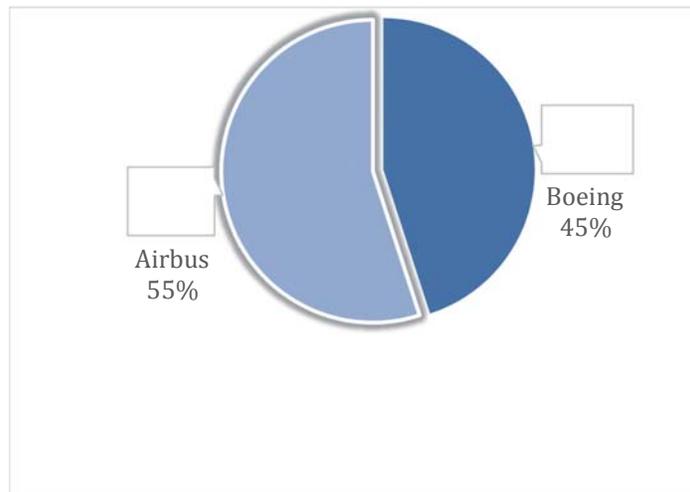


Figure 4. Market Share

Source: Own interpretation of data

In terms of revenues, in 2014, at a global level, Airbus maintains the leadership, gaining 57% of the total revenues.

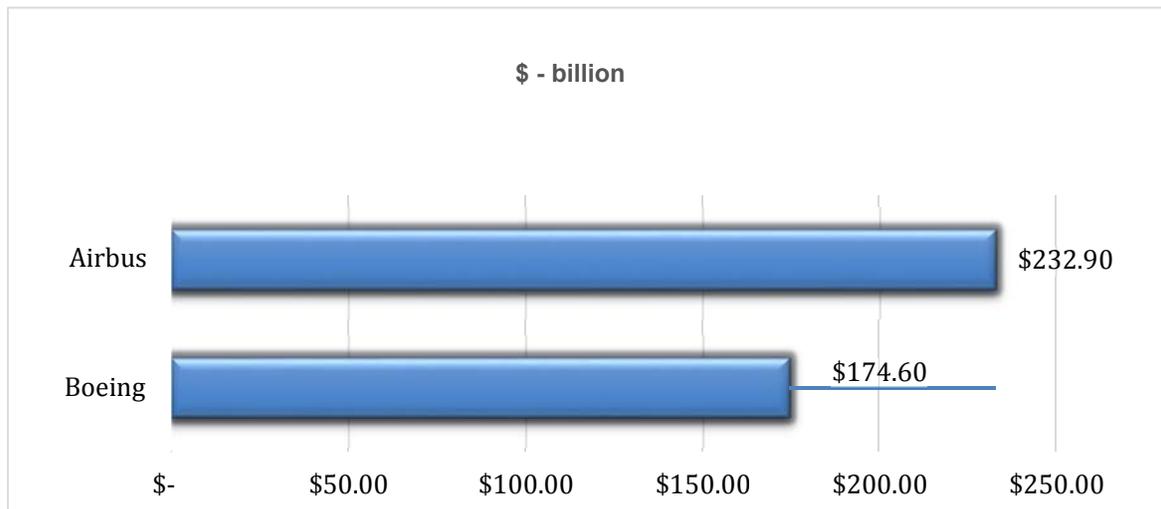


Figure 5. Airbus and Boeing revenues in year 2014
Source: Own interpretation of data

2.7. Key issues facing the cluster

One factor that contributed significantly to the performance of the cluster was represented by the incentives and the grants offered by the government in order to create training programs for all undergraduate students interested in this domain. Regarding this, a refusal from the state to continue the contribution will lead to a decrease in the skilled labor force in this domain.

Another aspect is the preference of the manufacturers for other areas to develop their business or to choose suppliers from other states, leading to a decrease in the performance of the cluster. This preference is due to the skilled labor force as well as the cooperation between the private and public sector, leading to trainee programs for youngsters.

2.8. Conclusions

Washington State is one of the leading forces in the aviation industry. Benefiting from government support, the companies manage to hire competent work force and to innovate and offer new products on the market.

The key factor that triggers the performance of the cluster is represented by the government support, which leads to an increase in the number of students interested in this field as well as incentives offered to the companies working in this area.

It might be useful for the companies not to depend that much on this assistance and to create their own system of attracting youngsters to this area. Will the aerospace industry continue to engage participants within its ramifications if the government's incentive steps outside the equation? It remains a topic that requires further research.

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