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Artículos científicos

Impacto del COVID19 en la educación y empleo sobre la industria aeroespacial en México

Impact of COVID19 on education and employment on the aerospace industry in Mexico

Impacto do COVID19 na educação e emprego na indústria aeroespacial no México

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Resumen

La industria aeroespacial abarca desde el diseño de misiones espaciales, sistemas satelitales, sistemas de propulsión y lanzamiento espacial, así como el mantenimiento de los mismos. Para el funcionamiento de esta industria se requiere mano de obra altamente calificada, es decir, de ingenieros aeroespaciales, quienes son especialistas con conocimientos amplios en física, matemáticas y ciencias de la ingeniería para desarrollarse en el campo aeronáutico y espacial. El objetivo de esta investigación es analizar la estructura educativa y medir el empleo referente a la industria aeroespacial, así como medir el impacto que tuvo la pandemia *COVID-19* en el factor trabajo de esta industria. La metodología empleada implicó generar una regresión econométrica para analizar el incremento del personal empleado y una variable dummy que capturara el efecto de la pandemia, donde los resultados preliminares arrojan una tasa de crecimiento constante del empleo para luego tener un retroceso considerable a partir del inicio de la *COVID-19*.

Palabras clave: Industria aeroespacial, *COVID-19*, empleo, educación, ingeniería.

Abstract

The aerospace industry ranges from the design of space missions, satellite systems, ejection systems and space launch, as well as their maintenance; and for the operation of this industry, highly qualified labor is required, that is, aerospace engineers, who are specialists with extensive knowledge in physics, mathematics and engineering sciences to develop in the aeronautical and space field. The objective of this research is to analyze the educational structure and measure reference employment in the aerospace industry, as well as to measure the impact that the COVID19 pandemic had on the labor factor in this industry. The methodology used involved generating an econometric regression to analyze the increase in employed personnel and a dummy variable that captures the effect of the pandemic, where the preliminary results show a constant employment growth rate and then have a considerable setback from the beginning of the COVID-19.

Keywords: Aerospace industry, COVID19, employment, education, engineering.

Resumo

A indústria aeroespacial abrange desde o projeto de missões espaciais, sistemas de satélites, sistemas de propulsão e lançamento espacial, bem como sua manutenção. Para o funcionamento desta indústria é necessária mão de obra altamente qualificada, ou seja, engenheiros aeroespaciais, que são especialistas com amplo conhecimento em física, matemática e ciências da engenharia para se desenvolver na área aeronáutica e espacial. O objetivo desta pesquisa é analisar a estrutura educacional e medir o emprego na indústria aeroespacial, bem como medir o impacto da pandemia de COVID-19 no fator trabalho nessa indústria. A metodologia utilizada envolveu a geração de uma regressão econométrica para analisar o aumento do pessoal ocupado e uma variável dummy que capturou o efeito da pandemia, onde os resultados preliminares mostram uma taxa de crescimento do emprego constante e depois um recuo considerável desde o início da pandemia. COVID 19.

Palavras-chave: Indústria aeroespacial, COVID-19, emprego, educação, engenharia.

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Introduction

The aerospace industry in Mexico is constantly evolving, and its development is based on the grouping of clusters. A cluster is based on the cointegration of the government, the universities and the private initiative; This cointegration gives rise to the creation of industrial parks, where educational institutions function as an input to satisfy labor requirements. Therefore, these institutions need to generate specialized educational programs in the aeronautical and space area, thus forming a virtuous relationship between industry and academia.

The objective of this research is to analyze the educational structure of public and private universities that offer careers related to the aerospace industry in Mexico, study their level of employability, growth trends and what were the effects of COVID-19 on employment in the aerospace industry. Using multiple econometric regression, the employment growth rate for the aerospace sector is projected and how it was affected during the pandemic. The central hypothesis of this research proposes a direct relationship between the increase in university degrees related to the use of aerospace technologies and their student enrollment, with the increase in job openings, and which in turn encourage the growth of the aerospace industry in Mexico; denoting that the pandemic hit this industrial sector hard.

Therefore, specifically the research problem denotes how to position Mexico as one of the main countries dedicated to the manufacture of aerospace equipment, derived from having a comparative advantage in education and skilled labor.

The article is divided into ten sections: the first introduces the reader to the general panorama of employment and education; the second talks about the theory of human capital; in the third section, we denote the specifications of education for the aerospace industry; in the fourth part, they describe the organizations that support the aerospace industry; in the fifth part, the subject regarding the industrial location is touched on; in the sixth part, the consequences that the aerospace industry had due to COVID-19 are revealed; in the seventh part, the methodology is exposed; in the eighth, the results obtained are disclosed; to finally finish with the discussion and conclusions.

Relationship between employment and education

The relationships between education and work are a current topic of discussion among researchers, and there is extensive literature on this subject. Among these, Eijs and Heijke (1996) stand out, who analyze the relationship between education and employment, finding a positive correspondence between educational level and earnings, where agents

always seek to maximize their benefits in an imperfect labor market, with mismatches between the partial training and occupation.

Another piece of research worth describing is that of Corica and Otero (2014), raising the tensions between the labor market and the educational system; concluding that workers who have a high degree of educational specialization and who develop in their training area are better paid, where education continues to be rewarded in the labor market. Likewise, the study by Planas (2014) stands out, which analyzes the educational market and the labor market, showing that these markets are totally different, imperfect, as well as with different actors.

In the case of Mexico, the relationship between the returns to education is a function of the salary level and, in turn, determined by the worker's skills; generating two aspects: those workers with a high level of study but whose perceptions are lower than those with the same level of schooling and the underemployed, which are employees who have a lower level of preparation than required and their perceptions are higher than others with the same level of experience (Verdugo and Verdugo, 1989).

The labor market in Mexico has been shaken by the incipient economic growth in the last six-year terms, as well as by the economic crises that worsened the distribution of income, unable to generate new jobs at the speed that universities generate professionals. Guerrero, Schettino and Urzúa (2000) warn that the gross domestic product (GDP) has to grow at higher rates to balance the labor market.

Some of the premises that the labor and educational market has are four:

a) The skills that the labor market needs are general and focused on the independence of individuals (Bonal, 2009).

b) Competitiveness is determined by the quality of the workforce.

c) Labor is rigid and immovable on a global scale (Carnoy, 2002).

d) There is an increase in salary disparities in relation to technical and professional skills (Bonal, 2009).

Then, there must be a strategic investment in human capital, and in turn the labor market must be deregulated and mechanisms created to develop qualified employment. There is significant evidence that one of the greatest attractions for the capital factor is the reduction in labor costs (Bonal, 2009).

Béduwé and Planas (2003) studied the reciprocal consequences between education and work and indicated that the production of graduates graduated from universities is not very elastic to the economic situation of the country in question, since

the actors who are rational do not consider factors of an economic nature. to decide to start a professional career.

Finally, for A d'Iribarne and P. d'Iribarne (1993), the relationship between academic training and employability is based on the resolution of social strata, where the educational system develops skills and aptitudes, but also mobility and social stagnation.

Human capital theory

Knowledge is constantly evolving; it is a fundamental intangible resource of organizations, and information and communication technologies (ICTs) play an essential role in collecting and managing information (La Torre-Martínez, et al., 2016). Similarly, manufacturing processes are constantly evolving thanks to technological changes, so to adapt, the workforce requires new educational skills (Coll, 2011).

Thorne and Pellant (2007) denote that companies are in a constant struggle to attract human talent, seeking to have a qualified workforce in the technological areas of R&D. In this sense, the aerospace industry requires three types of specialized workers: technical maintenance personnel, flight personnel, and manufacturing personnel. Each one of them has knowledge, certifications, and operating permits that are different from any other type of worker in other industries, which makes them unique workers of their kind (Hualde, Viveros, and Dominguez, 2014).

The theory of human capital indicates a dependent correspondence between the supply of graduates and the demand of the labor markets in the quantities and specialties that the educational system offers (De Ibarrola et al., 2014). This confirms the thesis of Mallet et al. (1997), that "in terms of educational level requirements, demand follows supply".

Companies, in order to better manage changes in production systems, raise the educational level. Coll (2011) called this a way of constituting "competence reserves" in companies. In other words, with the evolution of technology, at a certain moment, workers will require better and greater technical skills to accomplish a task, but companies that have created a pool of skills will be able to more easily face a change in production processes. To understand this point, we start from the premise that "the skills needs of the labor market are not the same as the needs of companies at a given moment", since the requirements of the labor market cannot be defined in the long term. through the needs of organizations in the present (Coll, 2011).

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Education in the aerospace industry in Mexico

Today, society is experiencing radical technological changes, where the generation, understanding and transfer of new knowledge is essential. We are currently living in a knowledge-based society, in which one of the pillars is academic education, so educational programs must be focused on mastering technical skills, innovation, research and, above all, management.

Precisely in the aerospace industry, one of the most important factors is qualified labor, so it is essential that educational programs integrate skills and develop skills that facilitate the incorporation of graduates into the labor market. Then, the need arises for this industry to have specialists with advanced technical knowledge, at the postgraduate level, since having a master's degree in this matter deepens the knowledge and skills for solving problems that involve technological innovation in the design and manufacturing processes of aerospace equipment (UNAQ, 2022).

Today, Mexico is a pole of attraction for investment in the aerospace sector, which is why more highly trained human capital is required to fill positions at a technical, professional, research and technological development level. There are currently several educational programs in the country aimed at developing human resources in the field of aerospace engineering, both at a technical and professional level, including master's degrees and doctorates. To mention the most important, the following stand out:

In the north of the country, the UACH (Autonomous University of Chihuahua) has a degree in Aerospace Engineering, which is based on the field of engineering, highlighting materials engineering, mechanics, orbital dynamics, design for applications in the modeling, and especially for the development of requirements related to the aerospace industry (UACH, 2022). Likewise, the UABC (Autonomous University of Baja California) teaches a degree in Aerospace Engineering, in which its graduates specialize in designing, modeling aerospace structures and components, optimizing the manufacturing processes of said sector. (UABC, 2022).

The UNAQ (Universidad Aeronáutica en Querétaro) is located in Querétaro, which has extensive academic programs aimed at developing professionals and researchers for the maintenance of the aerospace industry; three of higher technical training: aeronautical maintenance, in aeronautical manufacturing and maintenance in the glider and motor area; three engineering degrees: Aeronautical Engineering in Manufacturing, Engineering in Aeronautical Mechanical Design and Engineering in Electronics and Control of Aircraft Systems, a Specialty in Valuation of Aeronautical Assets and a Master's Degree in Aerospace Engineering (UNAQ, 2022).

Like UNAQ, CONALEP (The National College of Technical Professional Education) trains specialized technicians to provide solutions to the expectations of the aerospace industry in Mexico, so this institution is constantly updating its technical careers related to the sector, with the aim of advancing together with technological trends worldwide; the evolution of their study programs maintains a close link with the needs of the labor market and the needs of the aerospace industry (CONALEP, 2022).

Currently, CONALEP has 312 schools throughout the country, of which 50 schools are devoted to aerospace careers, training a total of approximately 16,000 technical professionals on average per year in careers such as: ministries, high-specification painting for aircraft, telecommunications and aeronautical operation (CONALEP, 2022).

While in the center of the country, the INAOE (National Institute of Astrophysics, Optics and Electronics) stands out with the Master's and Doctorate in Space Science and Technology; supported by four basic pillars: astrophysics, optics, electronics and computer science. Achieving that its graduates are experts in issues related to satellite positioning and navigation systems, such as the integration of nanosatellites, the development of flight simulators and radars. It should be noted that INAOE has a strategic alliance with CRECTEALC (Regional Center for Space Science and Technology Education for Latin America and the Caribbean) to promote the study of space sciences in the Latin American region. (INAOE, 2022).

UNAM (National Autonomous University of Mexico) has a degree in Aerospace Engineering. In the 2020-2021 school year, the total number of applicants to enter this degree was 1,540 people, while the offer only had 137 places; that is, the percentage of acceptance was approximately 9%, with a gender distribution of 35% women and 65% men (UNAM, 2022).

On the other hand, the IPN (National Polytechnic Institute) in addition to having a career in Aeronautical Engineering, has a Master's Degree in Aeronautical Engineering. These programs train specialized professionals who contribute to the innovative development of the aerospace industry, specifically in the maintenance and production of the sector (IPN, 2022).

Private universities have also joined in generating specialized human capital for the aerospace industry, such is the case of UPAEP (Universidad Popular Autónoma del Estado de Puebla). Offering Aerospace Engineering, it forms qualified human capital to design, systematize and optimize processes related to the manufacture of aerostructures,

navigation systems, mechanical components and electronic-computing devices of the aerospace electronic manufacturing industry (UPAEP, 2022).

Therefore, given the number of universities that teach a degree related to the aerospace industry, Mexico is presenting a process of expansion in the educational system. Table 1 below shows a summary of the academic degree taught regarding aerospace engineering.

Table 1. Degree of education taught.

University	technical career	Engineering/Bachelor	Specialty	Master	PhD
UACH		x			
UABC		x			
UNAQ	x	x	x	x	
CONALEP	x				
INAOE				x	X
UNAM		x			
IPN		x		x	
UPAEP		x			

Note: Own elaboration

Organizations that support the aerospace industry in Mexico

The FEMIA (Mexican Federation of the Aerospace Industry) located in Mexico City, the COMEA (Mexican Council of Aerospace Education), whose headquarters by 2023 will be in Sonora, the AFAC (Federal Civil Aviation Agency) located in the City of Mexico and the AEM (Mexican Space Agency) also located in Mexico City, are autonomous organizations that support educational institutions. They encourage the development and growth of the aerospace industry, holding forums, seminars, conferences, as well as alliances and cooperation agreements with companies and educational institutions from other countries in order to contribute to the increase in trade and the growth of said aeronautical industry.

Additionally, COMEA promotes the development of the skills and abilities of the human capital that the sector demands. With the help of FEMIA, they promote the attraction of foreign investment. The educational institutions that make up COMEA participate in the academic training of technicians, engineers, administrators and researchers who actively participate in regional economic development (COMEA, 2022).

COMEA was created in 2007 as a complementary body to FEMIA, and its raison d'être is to manage actions that contribute to fostering human capital in the aerospace

sciences by designing careers and study plans, as well as encouraging and developing programs for the development of the aerospace industry in Mexico (COMEA, 2022).

Location of development zones of the aerospace industry

The theory of location tries to find out what are the optimal places to locate economic activity. This theory arises with the works initiated by David Ricardo, Alfred Weber and Alfred Marshall. It develops the concept of comparative advantage, which considers that companies will be located in that place that generates an additional benefit when settling in, such as lower costs, access to skilled labor or abundant raw materials.

Ricardo (1959) considers that countries engage in trade for two reasons, either out of necessity or convenience, and they will tend to import those goods whose production is difficult for them. He considers that all commodities are produced by capital or labor, where comparative advantages originate from marginal labor differences.

On the other hand, Weber (1929) and Marshall (1949) study agglomerations and industrial districts, denoting the existence of an industrial region that exerts a force of attraction for companies, decreasing relative production costs. Its goal is to minimize transportation costs to markets, as well as to sources of raw materials.

With globalization, the labor factor has become more important for countries, since it serves as an attraction for companies, by acting as a generator of knowledge, making companies competitive. For this reason, specialized labor plays an important role in the growth and development of a country.

According to the Ministry of Economy, the aerospace sector generates an average of about 450 billion dollars per year, being an important source of generating highly qualified jobs. The aerospace industry is characterized by the incorporation of new technologies that integrate greater added value within its production chains, specifically in the design and manufacture of aerostructures (SE, 2022).

That said, the aerospace industry is one of the most important and dynamic on the planet in terms of economic benefits. Its production chains require constant innovation, being a high-tech industry, making it necessary to have specialists in processes related to the manufacturing of parts that the sector requires.

In Mexico, the two most important development poles focused on the aerospace industry are the first, located in the state of Baja California, where there are a large number of companies dedicated to the aerospace industry. The second state is Querétaro, which is home to the transnational Bombardier, being the third largest aerospace manufacturer in the world and opening operations since 2005. Currently, Bombardier in its industrial

complex in Mexico produces landing systems, electronic components, turbine components, fuselages , clothing, stabilizers and wiring systems for its aircraft, mainly for its Q400 and Global Express models.

This industry represents approximately 1/8 of the workforce in the sector throughout the country (Chavarría, 2011). Additionally, as mentioned in previous paragraphs, Querétaro has the only university in Mexico specialized in the aerospace sector, and also has an industrial park dedicated to this industry located within the international airport of this state.

Affectations of COVID-19 in the aerospace industry

COVID-19 is a disease caused by the coronavirus family that originated in the Wuhan province of China. Due to its high level of contagion, it spread rapidly throughout all countries (CEPAL, 2020).

The economic crisis generated by the COVID-19 pandemic has produced imbalances between supply and demand due to changes in variables such as production, consumption, savings and investment, consequently affecting national production downwards or, what is itself, decreasing the gross domestic product (GDP) (Sánchez and López-Herrera, 2020).

The COVID-19 pandemic had a strong impact on the production of aerospace equipment, where aviation was one of the sectors hardest hit due to the application of sanitary measures and border closures, greatly reducing the number of flights. At the beginning of 2020, there were 14,000 aircraft grounded out of the 21,000 that were flying in 2019 (López, 2021).

Methodology

In order to understand the behavior of the employment factor in the aerospace industry and its effects during the COVID-19 pandemic, this research is based on an econometric analysis that considers the following variables: employment in the aerospace industry, time expressed in months and a binary qualitative variable of ones and zeros to capture the effect of COVID-19. From this, employment growth was determined, so our model is expressed as follows:

$$Y\beta_0 + \beta_1 X_1 + \beta_2 X_2 + u$$

As:

Y = Personnel employed in the aerospace industry.

X1 = Time measured in months.

X2 = Dummy quantitative variable, 1 for the duration of the pandemic and 0 for not.

Where the data were obtained from the National Institute of Statistics and Geography (INEGI), from its monthly survey of the manufacturing industry contained in the economic information bank, with a study period that goes from January 2013 to July 2013. 2022.

Results

A multiple regression was run, where the results are presented in Table 2.

Table 2. Multiple regression model to determine the employment growth rate in the industry and the effects of COVID19.

Variable	Coefficient
Constant (C)	21460.65***
Time (X_1)	73.19295***
COVID19 (X_2)	-6312.339***
R^2	0.4734

Own elaboration in E-views based on EMIM 2013-2022

Nota: ***significant 10%, **significant 5%, *significant 1%.

The intercept (the point of origin), that is, the constant C, which indicates the starting value, since this amount is autonomous from the other variables, so when all the variables are worth 0, Y will be worth 21,460 employees, so that the industry dedicated to the manufacture of aerospace equipment begins with favorable conditions in terms of employability.

Regarding the variable X1 in terms of economic interpretation, we can denote that for each month that passes, the number of workers employed in the aerospace industry increases by 73, ceteris paribus.

On the other hand, the variable X2 in terms of economic interpretation, we can denote that this value determines captures the effects that employment in the aerospace industry had due to the pandemic, giving us to understand that COVID19 brought the loss of 6312 jobs for this specific industry. ceteris paribus.

From Table 2 we can see that the value of the R-square = .4734, so in general

terms we can infer that the model fits to a good extent.

Discussion

Education is a fundamental element for the development of the aerospace industry, and it is necessary to have this factor at adequate levels, that is, at a balance point where there is no unemployment or overemployment, in order to cover the needs of the industry. In short, as Rodríguez (2016) mentions, a solid underpinning of the aerospace industry and a series of services related to it can be achieved through a set of enablers, typical of industrial location theories, among others: proximity to markets, skilled labor, sufficient availability of public infrastructure and means of communication, government support and the development of an industrial concentration or clusters.

The final results of the study are clear: from 2013 to 2020 there was a preponderant growth rate in employment in the aerospace industry in Mexico, giving rise to a boom period. After this period and during the pandemic, there was a reduction in the hiring of the workforce; On the contrary, at all times there was an increase in the educational offer related to aerospace sciences, where the success story highlights UNAQ, created in 2007 and which today is a consolidated university that meets the demand for human capital required by the cluster. aerospace of the state of Querétaro.

Conclusions

Absolutely no country with a developed aerospace industry was able to avoid the economic crisis generated by the COVID-19 pandemic, not even economies like the United States or Europe; absolutely everyone was affected by the economic crisis, with the difference that some countries were more affected than others.

COVID-19 has had negative impacts on the world economy; all industrial sectors have been affected by the pandemic, some to a greater extent than others. On the other hand, the aerospace industry was one of the sectors hardest hit due to sanitary restrictions between countries, which brought losses for airlines derived from the drop in passenger transportation. However, although freight transportation increased, it did not offset the drop in civilian transportation, and airlines cannot subsist on freight transportation alone.

Therefore, there is a disincentive to purchase aircraft, canceling orders already placed, consequently bringing a decrease in aircraft production, mainly wide-body aircraft, manufactured mainly by companies such as Airbus, Boeing and Bombardier. Then, the production of the supply chain that supplies parts and components to these large

aerospace transnationals stopped. At this point, there were already a large number of staff cuts due to the lack of contracts and orders, thus affecting the level of employment in this industry, as the results of this investigation show.

Future lines of research

Although this research touched on and measured the economic loss caused by the COVID-19 pandemic regarding the increase in unemployment in the aerospace industry, this study may lead to replicating the research, but this time with other industries, such as the automotive industry. , food, petrochemical, etc., to later make an evaluation of which sector was most affected by the pandemic.

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Recursos	Jesús Castillo Rodríguez 50% Antoniana Ivanova Boncheva 50%
Curación de datos	Jesús Castillo Rodríguez 50% Antoniana Ivanova Boncheva 50%
Escritura - Preparación del borrador original	Jesús Castillo Rodríguez 50% Antoniana Ivanova Boncheva 50%
Escritura - Revisión y edición	Jesús Castillo Rodríguez 50% Antoniana Ivanova Boncheva 50%
Visualización	Jesús Castillo Rodríguez 50% Antoniana Ivanova Boncheva 50%
Supervisión	Jesús Castillo Rodríguez 50% Antoniana Ivanova Boncheva 50%
Administración de Proyectos	Jesús Castillo Rodríguez 50% Antoniana Ivanova Boncheva 50%
Adquisición de fondos	Jesús Castillo Rodríguez 50% Antoniana Ivanova Boncheva 50%