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Artículos científicos

Dinámica del capital humano en la industria aeroespacial en México

Dynamics of Human Capital in the Aerospace Industry in Mexico

Dinâmica do capital humano na indústria aeroespacial no México

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Resumen

La industria aeroespacial es una industria manufacturera que se centra en el diseño, fabricación de fuselajes, concepción y producción de motores de aviación, así como sistemas eléctricos y mecánicos. Dado su impacto en otras aéreas de la economía, es conocida como una industria de industrias. En México, el desempeño de la industria aeroespacial en los años recientes ha mostrado un particular crecimiento derivado de la especialización de la mano de obra. Este artículo tiene como objetivo determinar y analizar la injerencia que tiene el capital humano en la producción de equipo aeroespacial en México. Se parte de la hipótesis de que el capital humano imprime a esta industria fuertes ventajas competitivas para localizarse en el país. La metodología empleada consiste en replicar un modelo empírico econométrico de regresión logarítmica. Los resultados previos indican un ambiente productivo favorable para dicha industria, caracterizado por un estricto control de calidad del sector laboral.

Palabras clave: capital humano, industria aeroespacial, productividad, ventajas competitivas.

Abstract

The aerospace industry is a manufacturing industry that focuses on the design, manufacture of airframes, conception and production of aircraft engines, as well as electrical and mechanical systems. Given its impact on other areas of the economy, it is known as an industry of industries. In Mexico, the performance of the aerospace industry in recent years has shown growth derived particularly from the specialization of the workforce. This article aims to determine and analyze the injection that human capital has in the production of aerospace equipment in Mexico. It is based on the hypothesis that human capital gives this industry strong competitive advantages to locate in the country. The methodology used consists of replicating an empirical economic model of logarithmic regression. The previous results indicate a favorable productive environment for said industry, characterized by a strict quality control of the labor sector.

Keywords: human capital, aerospace industry, productivity, competitive advantages.

Resumo

A indústria aeroespacial é uma indústria de manufatura que se concentra no projeto, fabricação de fuselagens, concepção e produção de motores de aeronaves, bem como sistemas elétricos e mecânicos. Dado o seu impacto em outras áreas da economia, é conhecido como uma indústria de indústrias. No México, o desempenho da indústria aeroespacial nos últimos anos mostrou um crescimento particular derivado da especialização da força de trabalho. Este artigo tem como objetivo determinar e analisar a interferência que o capital humano tem na produção de equipamentos aeroespaciais no México. Baseia-se na hipótese de que o capital humano confere a esta indústria fortes vantagens competitivas para se localizar no país. A metodologia utilizada consiste em replicar um modelo econométrico empírico de regressão logarítmica. Os resultados anteriores indicam um ambiente produtivo favorável para esta indústria, caracterizado por um rigoroso controle de qualidade do setor de trabalho.

Palavras-chave: capital humano, indústria aeroespacial, produtividade, vantagens competitivas.

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Introduction

The type of research proposed here is qualitative, since it involves statistical inference through the use of econometrics with the aim of determining the influence that human capital has on the production value of the aerospace manufacturing branch, and particularly hours actually worked in this industry.

The work factor is constantly evolving. It adapts and reorganizes itself at the speed of technological change. The concept of human capital is very broad, it can be approached from different perspectives. Education and training of the workforce is one of them; another is from human qualities in their relationship with economic growth. The focus of this work, however, opts for the perspective of productivity, since this precept refers to the skills, knowledge and efforts of people that increase the possibilities of production (Serrano, 1996).

Within the classical theory, human capital can be approached as one of the productive factors, the labor force (Cardona, Montes, Vázquez, Villegas and Brito, 2007). Smith (1994) already gave importance to human capital and underlined the role of education and the division of labor, as well as learning through experience. He emphasized the difference in natural talents between people, and the special abilities that differentiate individuals by their professions. In his attempt to understand and explain the division of labor, he argues that it is due to the quantity and complexity of manufacturing goods and the need to produce on a larger scale. In such dynamics, an effect of the division of labor within the production process causes an increase in production.

The theory of human capital is based on the assumption that the greater the education, the greater the increase in labor productivity, since the skills provided by education would allow the worker a better understanding of the processes in which their work is developed. work, which would increase the productivity of the workforce. If education makes an individual more efficient in the production of goods, there will be an increase in the quality of labor, and that this improvement will generate added value to the production process, which, in the background, will increase the income of the person who has been educated (Sen, 1998).

To speak of human capital is to speak of both education and experience, as well as the training provided by the work activity, which brings to the table a human capital based on knowledge. And it shows that human capital is a differentiating element in the long term, since the experience obtained is directly related to the time assigned to a specific job (Cardona et al., 2007).

The factors that affect regional productivity are human capital and technological externalities, which are associated with agglomeration, and which directly affect productivity growth (Lotero, Restrepo and Franco, 2004). The preceding discussion leads us to place the influence of the human factor as the first trigger of the industrial location process (Precedo and Villarino, 1992).

The heavy dependence of this industry on research and development is a prerequisite for aeronautical technical progress; at the same time that it cannot survive without massive injections of capital funds to cover start-up costs, product design, marketing and sales (Van Liemt, 1995).

Michael Porter and human capital within competitive advantages

The fundamental part of human capital is in managing knowledge, as this is a factor that influences obtaining better productive results for companies. How is knowledge defined in this field? Knowledge is a set of information, rules, interpretations and connections placed in a context so that companies make better decisions, increase their management capacity and manage technology. It should be noted that learning is the ability to accumulate knowledge necessary for the formation of technological capabilities (De La Torre, Ramos and González, 2016).

Arellano (2015) explains knowledge management as a set of techniques and methods that help to substantially increase the intellectual capital of an organization to solve problems and encourage the formation of competitive advantages. Under this statement, knowledge management has become a resource for companies to create value. In addition, with the arrival of new competitors in the sector, it has become clear that creativity and the ability to solve problems are essential elements to obtain a competitive advantage and face new problems and challenges.

Now, there are two types of knowledge: tacit and explicit. The first is based on the technique and cognitive activity, that is, part of the fact that man knows how to perform a task or work, derived from the experiences acquired in life. Explicit knowledge can be expressed with words, data, numbers... alludes to the scientific method. On the one hand, tacit knowledge is transmitted through socialization, part of the person-to-person experience;

on the other, the explicit one is the engineering knowledge obtained in educational institutions (De La Torre *et al.*, 2016),

In the particular case of workers in the aerospace industry, they usually have previous experience in the automotive industry. Indeed, De La Torre et al. (2016) conducted a study in which they found that 90% of the workers who work in the aerospace industry come from the automotive industry, since it has machinery similar or equal to that used in the aerospace industry.

The foregoing reveals the existence of transversal skills between the automotive industry and the aerospace industry, since they are skills typical of the same professional environment, necessary to effectively exercise any profession related to design for manufacturing, engineering development and systems integration, among others. others, who demand an innovative professional profile, namely, electromechanical engineers, mechanical engineers, electronic engineers, mechatronics engineers, industrial engineers and computer systems engineers, since these profiles present generic and specific skills that classify them as workers of the knowledge, with analytical skills, problem-solving skills that require complex thinking skills and technological adaptation (Vargas and Vargas 2014).

Some basic principles for regional development are found in Porter's (1991) theory of competitive advantage, which conveniently serve to illustrate territorial problems in the new post-industrial economic system. There, the locations that develop a greater invention have a superior attractiveness, for which reason one can speak of a locational economy of innovation as a new version of the neoclassical economies of agglomeration.

Some other outstanding competitive advantages are: a well-established innovative attitude, the aptitude and decision of the companies' management to consider the needs and commercial potential from a long-term perspective, a growing technological concentration of production, road infrastructure, ports and airports and, last but not least, education (Agtmael, 2007).

Then, the benefits that can occur as a result of industrial location are mainly related to the exchange of information, which generates a common knowledge base that perpetuates agglomeration. For the aerospace industry, the location of various industries represents particularities that denote the degree of maturity of the aerospace clusters and, consequently, the probability that location economies will be glimpsed. (Villarreal, Sánchez y Flores, 2016).

Education in the work factor

Production includes human relations between people and groups in a specific institutional framework, not simply technical relations between factors. According to Precedo and Villarino (1992), human interaction is essential for individuals to develop their capacity, since these relationships allow a society to flourish: from small villages to majestic cities.

Recent studies carried out by the United Nations Educational, Scientific and Cultural Organization (Unesco) and the Organization for Economic Cooperation and Development (OECD) aim to measure the economic returns of educational investments in the workplace . Of course, they start from the assumption that the return on investment in education is greater than investment in the industrial sector, since this increases productivity and increases the competitive advantages of a country (Bajo, 1991), so that investment in education is always a good investment.

Education, which is nothing more than the generation and application of workers' knowledge, forms differentiating elements of development and economic growth. In effect, capital and labor are replaced to give rise to a new economy based on knowledge. The industrial economy is left behind in order to achieve the optimization of organizational processes to increase production (Rincón, 2017).

In the last 20 years, Mexico has become the world's leading recipient of investments for manufacturing from the aerospace industry, since it captured nearly 33 billion dollars, a volume greater than the United States, China, Russia and India. With this, the country became a strategic site for this activity, reported the consulting firm Deloitte (Martínez, Barajas and Ruiz, 2012), which implies a great opportunity in terms of job creation.

The development of the aerospace industry requires the progress of the talent of those who work in it, hence the importance of the existence of educational and training programs to forge the knowledge and skills of workers in this industry (Macías, Zárate and Rosiles, 2014).

Now, the sources of recruitment of human capital used for the aerospace industry, particularly in Mexicali, Baja California, resort, in the first instance, to internal sources: they offer the vacancy to the personnel that they already have, in this way reducing the risk of failure of the candidate, since he has previously been trained. On the other hand, in those foreign contracts, the hiring time depends on the degree of specialization that is sought. While for workers with secondary and high school education the selection process is short, for workers with a bachelor's and master's degree the process is longer (Macías et al., 2014).

So, the aerospace industry is a catalyst for economic development in the regions where it is installed. This is because it promotes the generation of qualified work, since it entails specialized manufacturing processes and thus promotes the transfer and creation of knowledge. A local development model represents a cluster of theoretical ideas that try to explain a complex reality of the economy within a defined space and time, whose development processes establish relationships of cause and effect in economic elements, which brings with it changes in development policies. regional development and industrialization (Manet, 2014).

Labor and productive restructuring

The theory of productive restructuring and regional development suggests that activities are not randomly distributed, but rather tend to be concentrated, preferentially, in certain regions. This explains why some companies are located near natural resources, or next to the markets they are going to supply, to reduce transportation costs, which can significantly influence the final cost (Baena, Sánchez and Montoya, 2006).

The companies dedicated to the aerospace industry, each of them, although belonging to the same sector, have different production models to carry out the work. Each company defines the skills that its workers must have, although generically they have similar skills and values. Be that as it may, the growth of the aerospace industry requires greater professional skills, whether technical, methodological, social and participatory of the workers. It should be clarified that here professional competencies are understood as the set of knowledge, procedures, skills and abilities that are personal and complement each other; in a way that helps the individual act effectively in professional situations (Velázquez and López 2015).

In its beginnings, the operations of the aerospace industry were carried out by a mixed group between Mexican and foreign engineers; But today, with the specialization of human capital and a higher professional level, with master's and doctorate studies among Mexican engineers, the local workforce has surpassed the foreign workforce. The creativity and capacity of local labor has allowed the resolution of problems and challenges required by the aerospace industry (Arcos et al., 2017).

For example, in Baja California, in the aerospace sector, Hualde and Carrillo (2007) documented the installation of the Mexicali Research & Technology Center, where research and development of engine components and instrumentation is carried out. This center has staff with bachelor's, master's and doctorate studies. (Velázquez y López 2015).

Methodology

For the analysis of time series there are techniques known as multiple regression analysis, whose objective is to analyze the causality of things or events; From this we can identify which independent variables (causes) explain a dependent variable (result), compare and check causal models, as well as predict values of a variable, that is, from some characteristics approximately predict a behavior or state subsequent. But in order to make this adequate analysis of our model to be developed, the observations must comply with four assumptions: linearity, homoscedasticity, independence and normality.

Strictly speaking, in statistics linear regression or fit is a mathematical model used to approximate the dependency relationship between a dependent variable (Y), the independent variables (Xi) and a random term (ε).

As in simple linear regression, the ß coefficients will designate the increase in weight by the equal increase in the corresponding explanatory variable. Therefore, these coefficients will indicate the weights corresponding to the units of measurement of each variable X.

Now, every model must be supported, so the Cobb-Douglas function will be taken as the starting point. Thus, we will demonstrate how to convert, through appropriate transformations, non-linear relationships into linear relationships, in a way that makes it easier to work within the framework of the classical linear regression model. The various transformations discussed there in the context of the two-variable case easily extend to multiple regression models; the transformations with a multivariate extension of the log-linear model of two variables (labor input and capital input), and the Cobb-Douglas production function, in its stochastic form (Gujarati and Porter, 2009).

Thus, we have the following equation:

$$Y = \beta_1 X2^{\beta 2} X3^{\beta 3} e^u$$

As:

- Y = Production.
- X_2 = labor input.
- X_3 = capital input.
- e = Base of natural logarithm.

For model purposes, since we only want to measure the influence of labor, the capital input will be = 1, which allows us to modify our Cobb Douglas equation without altering its fundamental structure.

In order to respond to our objective, it was estimated in such a way as to identify the determinants that have a significant impact on labor competitiveness (measured in terms of production) in the aeronautical industry.

We start from the following simple production function:

$$Y = f(X_{1,} X_2)$$

In this formula, Y is output, X1 is the number of workers, and X2 is the hours worked. In its stochastic form we can express this function as follows:

$$Y_t = \beta_0 X_1^{\beta_{1t}} X_2^{\beta_{2t}} e^{u_t}$$

And in this case, e is the base of the natural logarithm and ut, the error term. Transforming the model into its logarithmic form, we obtain:

$$lnY_t = ln\,\beta_0 + \beta_1\, ln\, X_{1t} + \beta_2 X_{2t} + u_t \text{x}\, lnY_t = \beta_0 + \beta_1\, ln\, X_{1t} + \beta_2 X_{2t} + u_t$$

Así, finalmente, $\beta_0 = \ln\beta_0$.

In the previous econometric relationship, the variables were specifically measured as the total value of manufacturing production of manufactured products (Y), total employed personnel (X1) and hours worked (X2), all referring to the aerospace equipment manufacturing branch .

The data was obtained from the Monthly Survey of the Manufacturing Industry [EMIM] (2013) for the period January 2007 to June 2017.

To correct any situation of serial correlation, the proposed model was estimated in first differences:

$$\Delta Y = \beta_0 + \beta_1 \Delta X_1 + \beta_2 \Delta X_2 + u_t (1)$$

Taking into account the above, the hypothesis was formulated in the following terms: there is a positive and statistically significant relationship of the employed personnel on the production value of the aerospace manufacturing branch:

$$H_0: \beta_1 = 0 \text{ vs } H_1: \beta_1 > 0$$

There is a positive and statistically significant relationship between the hours worked and the production value of the aerospace manufacturing branch:

$$H_0: \beta_2 = 0 \text{ vs } H_1: \beta_2 > 0$$

The variables used come from the economic surveys published by the National Institute of Statistics and Geography (Inegi) from 2007 to 2017 (from January 2007 to June 2017 with a total of 126 observations for each variable) in its EMIM, which provides relevant information on the conjuncture behavior of the main economic variables of the country's manufacturing sector. In our particular study, the sector that becomes relevant is 336, dedicated to the manufacture of transportation equipment, and more specifically subsector 3364, dedicated to the production of aerospace equipment, classified based on the Classification System North American Industrial (Scian) and built based on the concept of production function. Thus, establishments that have similar production processes are classified in the same class of activity, a system adopted by Mexico, the United States of America, and Canada.

Starting from the particular to the general, it must be considered that the manufacturing establishment is defined as any economic unit that, in a single location, delimited by buildings and fixed installations, combines resources under a single owner or control to develop, on its own or (maquila), activities of assembly, processing and total or partial transformation of raw materials that result in the production of new goods and related services, mainly included in a single class of economic activity.

Results

Dozens of regressions were run until the most efficient model was obtained. The series are seasonally adjusted and comply with all relevant statistical specifications. The results are presented in table 1.

Tabla 1. Modelo de regresión lineal múltiple para medir la producción de la industria aeroespacial

Variable	Coeficiente	Error Estándar	Estadístico-t	Probabilidad
C	-0.003309	0.012402	-0.266851	0.79
X_1 = *LREMU-LREMU(-1)*	0.553101	0.17608	3.14119	0.0021
X_2 = *LHORAST-LHORAST(-1)*	0.417458	0.227208	1.837336	0.0686
F (2… 126)	11.97072			
Probabilidad > F	0.000018			
R-cuadrado	0.164048			
R-cuadrado ajustado	0.150344			

Fuente: Elaboración propia

The results of the estimation of equation (1) are presented below:

$$\Delta Y = -0.003 + 0.55\,\Delta X_1 + 0.42\,\Delta X_2$$
$$(0.012)\ (0.17)\ (0.22)$$

The t-statistic for X1 is around 3.14 and, therefore, we reject the null hypothesis H0: β1 = 0, at a significance level of 5%, which confirms our hypothesis that there is a positive and statistically significant relationship of the employed personnel on the production value of the aerospace manufacturing branch.

The t-statistic for X2 is approximately 1.84 and, therefore, we reject the null hypothesis H0: β2 = 0, at a significance level of 5%, therefore, it is verified that there is a positive and statistically significant relationship of the hours worked on the production value of the aerospace manufacturing branch.

Discussion

The results of the investigation are clear. As the work of Vargas and Vargas (204) demonstrates, the development of the aerospace industry in Mexico is directly related to the formation of human capital, since this sector requires a skilled workforce and professional performance that have safety criteria and a high degree of precision, since it requires the development of complex, high-tech products for their design, development, manufacturing and maintenance.

Likewise, the results obtained here confirm a positive and statistically significant relationship between the employed personnel and the value of production in the aerospace industry. The foregoing agrees with the conclusions of De la Mora, Alarcón, and López (2018), who established that the aerospace industry is a catalyst for economic development in the regions where it is installed because it promotes the generation of qualified work, since it involves processes of specialized manufacturing, and thus promotes the transfer and creation of knowledge.

Then, as the aerospace industry consolidates, the formation of human capital in a multidisciplinary and collaborative way is required in disciplines such as aerospace engineering, aeronautical engineering, mechanical engineering, mechatronics engineering, industrial engineers, electronics, telecommunications. , computing and informatics, in materials and even civil engineers.

Conclusions

In this time of continuous changes in the model of international specialization of manufactured goods and services, emphasis should be placed on improving labor mobility both between industries and professions and between geographic regions.

Growth and development in a certain sense are measured by competitiveness, the level of production achieved and the ability of the industry to increase its penetration of world markets through exports. As demonstrated in the study carried out, production depends on the interaction of the work factor with the organization. Likewise, it is required that the industry reaches a high level of productivity and quality that allows it to sustain a strategic competitive advantage and generate highly efficient and effective production networks that allow it, in turn, to accelerate collective learning processes.

Consequently, for an industry or region to maintain its levels of competitiveness, it must focus on the competitive advantages it develops both internally and externally.

A significant industrial base denotes benefits that firms gain from being part of the same system, as their grouping forms integrated labor markets with a specialized labor force, as well as a domino effect of spillover from the level of production. In this perspective, the concentration of firms specializing in the manufacture of goods for the aerospace industry promotes the competitiveness and growth of the industry, which are key elements to increase productivity.

The objective of the work was fulfilled, and it consisted of understanding how the labor factor influences regional development and the production of the aerospace industry in Mexico. The results show that this factor, measured by the number of workers and the number of hours worked, has a positive effect and is statistically significant on the value of production in this branch. Therefore, it is decisive to stimulate the productivity of said industry, since the workers who are more exposed to an investment with a higher technological degree can be more productive. The study carried out was approached in an empirical and explanatory way, since a deeper analysis would imply incorporating other factors of competitive advantages.

One way to increase the productivity of the workforce is to improve the education and quality of the workforce, or you can opt for the progressive introduction of technology in production processes through mechanization and automation, focusing on the maximization of profits for companies, where the immediate implications of this are the substitution or reduction of labor. But that any type of investment made will be reflected in an increase in the product/work ratio; although if the second option is chosen, it will lead to a decrease in jobs and an obsolescence of activities traditionally carried out by workers.

Future lines of research

This research is a first approximation to understand the competitive advantages that Mexico can have in a manufacturing branch as dynamic as aerospace, so a more complete study will consist of incorporating other relevant factors of competitive advantage in order to analyze the effect of these on aerospace manufacturing production.

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