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***Abstract*:** This paper presents a study whose main objective is to estimate human capital from an economic perspective for the state of Chihuahua, contributing to the proposal for the design of an econometric model that relates quantifiable elements at the aggregate level for a specific context and a specific period. The variables to be included in the study are conventional and alternative measures that have already been applied at the national , and international levels. The research is based on Jacob Mincer's theoretical framework, analyzing the importance of tertiary education attainment; the labor force; health conditions; technological conditions; economic conditions; and social conditions.

The sample focuses primarily on the ten municipalities with the largest populations in the state of Chihuahua, with the aim of obtaining better comparative results. A cross-sectional correlational methodology was implemented using secondary sources with a simple linear regression model on a base-10 scale expressed in ordinary least squares (OLS), using the statistical software STATA. This approach was chosen because the model seeks a precise relationship between the study variables and, to that end, refers to a specific point in time—a different number of observations for a specific time period (Bernal, 2010).

The methodology provides explanatory value given the behavior of the selected variables of interest, allowing for their partial or complete interpretation (Sampieri, 2004).

The results showed that all variables included in the model have a positive relationship with human capital, with some being more significant than others, such as education, the labor force, and social conditions; these are variables that deserve greater attention in each of the municipalities. The study also found significant disparities in investment allocated to social and economic development, and that even if technological conditions are advanced, economic conditions will remain unproductive.

The rationale for designing a simple linear regression econometric model allowed for analysis along two lines: assessment and forecasting. The first identified the degree of weakness or strength of each selected variable, while the second enabled a broader analysis than could be achieved through qualitative methods.

Keywords: Human Capital, Economic Development, Econometric Model

Abstract—This study presents research whose primary objective is to estimate human capital from an economic perspective for the state of Chihuahua, contributing to the proposal to design an econometric model that relates quantifiable elements at the aggregate level for a specific context and time period. The variables to be included in the study encompass both conventional and alternative measures that have already been applied at the national and international levels. The research is grounded in Jacob Mincer's theoretical framework and analyzes the importance of tertiary education attainment, the labor force, health conditions, technological conditions, economic conditions, and social conditions.

The selected sample focuses primarily on the ten most populous municipalities in the state of Chihuahua, with the aim of obtaining more robust comparative results. A cross-sectional correlational methodology was implemented, using secondary sources and a simple linear regression model with a base of 10 expressed through ordinary least squares (OLS), using STATA statistical software. This approach was chosen because the model seeks to identify precise relationships among the study variables, referring to a specific point in time with varying numbers of observations for a given time frame (Bernal, 2010).

The methodology provides explanatory value by capturing the behavior of the selected variables of interest, allowing for partial or comprehensive interpretation (Sampieri, 2004). The findings indicate that all variables included in the model exhibit a positive relationship with human capital, although some are more significant than others. For example, education, the labor force, and social conditions are variables that warrant greater attention in each municipality. Additionally, significant disparities were found in investment allocated to social and economic development. Even when technological conditions are strong, economic conditions can remain unproductive.

The rationale for using a simple linear regression econometric model allowed for analysis along two dimensions: assessment and forecasting. The first identified the degree of weakness or strength of each selected variable, while the second enabled a broader analysis that could not be achieved through purely qualitative means.

Keywords: Human Capital, Economic Development, Econometric Model

INTRODUCTION

The study of human capital has been one of the fundamental analytical pillars for understanding economic growth and regional development since the second half of the 20th century. Building on contributions from authors such as Mincer, Schultz, and Becker, human capital has established itself as an economic construct that links the accumulation of knowledge, skills, and abilities to individual and collective productivity, establishing a direct relationship with value creation and socioeconomic well-being.

However, developments in the literature have shown that the measurement of human capital goes beyond the individual perspective, posing methodological challenges when attempting to analyze it at aggregate levels, such as regions or municipalities. Although formal education remains the most commonly used indicator in traditional empirical models, there is a growing consensus on the need to incorporate complementary variables that comprehensively reflect the structural conditions affecting its accumulation, such as health status, labor force participation, access to technology, and the socioeconomic environment. In this regard, recent literature has highlighted the importance of analyzing human capital as a multidimensional phenomenon, particularly where territorial disparities shape development processes. The evidence suggests that factors such as the productive structure, public investment, and access to basic services generate significant differences in the distribution of human capital. Within this conceptual framework, the analysis of the case of Chihuahua takes on empirical and theoretical relevance. Although the state's average educational attainment levels are relatively close to the national average, it exhibits substantial inequalities among its municipalities, particularly in access to higher education, working conditions, and health care coverage. These gaps reflect an unequal accumulation of human capital that directly impacts regional productivity and opportunities for economic development.

The absence of a comprehensive indicator for assessing human capital at the municipal level constitutes a significant limitation for decision-making in both the public and private sectors. This shortcoming not only hinders the identification of the determinants of human capital in specific contexts but also restricts the design of strategies aimed at strengthening it.

General Objective

To propose an econometric model of human capital in the state of Chihuahua, based on Mincer's theory and official data, that generates empirical evidence to inform decision-making at the municipal and state levels.

Specific Objectives

- To determine the components of human capital from an economic perspective for the most populous municipalities in the state of Chihuahua: Juárez, Chihuahua, Cuauhtémoc, Delicias, Hidalgo del Parral, Nuevo Casas Grandes, Camargo, Meoqui, Jiménez, and Saucillo.
- To formulate and estimate an econometric model using the Ordinary Least Squares method based on the Mincer function, using official secondary-source statistical data (INEGI).
- Compare and evaluate the results obtained across the selected municipalities using statistical techniques (STATA v.12), highlighting the factors that most influence human capital development.

Rationale

The accumulation of human capital is a determining factor in the economic and social development of regions. In the case of the state of Chihuahua, available indicators show significant gaps, which limit the improvement of strategies and decision-making in the state and municipal public sectors. The importance of this study lies in the fact that it provides an analytical framework for understanding the structure of human capital in Chihuahua from a simple economic perspective, integrating key variables such as educational attainment, health, labor force participation, and access to technology. It seeks to offer a complementary methodological tool for objectively and comparatively measuring human capital across municipalities, thereby contributing to the formulation of more targeted public policies.

The research has social and practical relevance, as it generates useful empirical evidence building on the work of Mincer, Schultz, and Becker, translating their theoretical contributions into a specific and current context with direct implications for regional economic policy; it is of interest to consultants, academics, and decision-makers in both the public and private sectors.

METHODOLOGY

This is a quantitative-correlational, cross-sectional study, as its primary objective is to measure the degree of relationship between two or more variables in a specific context and, in , at a single point in time.

Furthermore, it provides explanatory value, allowing for the interpretation of the behavior of the selected variables of interest, either partially or fully (Sampieri, 2004).

Based on the data collected and the research objective, Stata version 12 was used. This software enabled a robust and specific analysis tailored to the study's needs according to the variables.

This research analyzes the context of Chihuahua, compiling data from the National Institute of Statistics and Geography (INEGI) for the year 2015, with a sample selected from the ten municipalities with the largest populations. This approach was taken to facilitate a more accurate comparison of variables, based on the assumption that municipalities with larger populations tend to have a greater concentration of educational and employment opportunities.

In accordance with the inductive-deductive method described by Bernal (2010), a logical inference procedure enables a systematic transition from the particular to the general. Therefore, the model can be developed using a small sample—in this case, 10 out of 67 municipalities—while meeting the necessary criteria to obtain results that can, in turn, be interpreted with recognized reliability based on the observed data. Thus, for this study, the results depend primarily not on the sample itself but on the applicable variables available.

To carry out this process, we began with the specific objectives, first determining the population for each municipality; we then defined the variables and their measurable scope based on a review of the literature and empirical analysis of several foundational models, such as those by Barro and Lee, Mankiw and Weill, Noneman and Vanhoudt, Kyriacou, Benhabid, and Spiegel. Based on the above and following Mincer's framework, the proposed model can be expressed as:

$$CHM = \beta 0 + \beta 1EDUC1 + \beta 2HEALTH + \beta 3FLAB3 + \beta 4CT4 + \beta 5CE5 + \beta 6CS6 + \beta 7DE7 + \varepsilon$$

Where:

CHM = Human Capital (GDP per capita, taken as market value)

EDUC = Education (average level of schooling per municipality)

HEALTH = (Average life expectancy / Enrollment in IMSS and ISSSTE)

FLAB = Labor Force (Percentage of the economically active population)

CT = Technological Conditions (Percentage of the population with access to the internet, a computer, or a cell phone)

CE = Economic Conditions (The economic sector that most strengthens the municipality)

CS = Social Conditions (Public investment in social development)

DE = Economic Development (Public investment in economic development)

E = Error (residual of the parameters)

The model described above uses the Ordinary Least Squares (OLS) method under the assumptions established for linear regression (Gujarati, 1993).

DISCUSSION AND ANALYSIS OF RESULTS

One of the most important phases of this research is the interpretation of the results, as they provide context for the principles that underpin the importance and relevance of the selected variables.

Table 1. *Interpretation of linear regression according to the model.*

Especificación	Expresión	Interpretación
Nivel-Nivel	Yi=B1+B2X2i+Ui	Incremento de unidades en "Y" cuando aumenta una unidad "X" ambas aumentan en unidades de medidas originales
Log-Nivel	Log(Yi)=B1+B2X2i+Ui	Incremento porcentual en "Y" cuando aumenta una unidad "X" (B2*100)
Nivel-Log	Yi=B1+B2log(X2i)+Ui	Incremento en unidades en "Y" cuando aumenta en un 1% "X" (B2/100)
Log-Log	Log(Yi)B1+B2log(X2I)+Ui	Incremento porcentual en "Y" cuando aumenta un 1% "X"

Source: Author's *own work* (2026).

Table 2. *Correlation results of the econometric model disaggregated by variable*.

Variable dependiente: log (pibper) proxy del Capital Humano en condiciones constantes.

Método: Mínimos Cuadrados Ordinarios

Muestra: 10

Variable Dependiente	Variable Independiente	Coeficiente	R^2	Significancia Prob>F
LogCH	educ	14.19%	43%	.0401
LogCH	esperida	3%	15%	.2644
LogCH	flab	3.51%	47%	.0295
LogCH	ct	1.64%	39%	.055
LogCH	ce	0.67%	.06%	0.4890
LogCH	cs	3.47%	70%	0.0026
LogCH	de	2.41%	21%	0.1844

Source: Author's *own work* (2026)

ANALYSIS OF RESULTS

Are the variables relevant to the model?

The answer is yes; the model can be explained using the available information. The education variable yields an R^2 of 43%, a variable that has been tested in multiple models and continues to have the highest coefficient for this regression. It is important to note that, even though some variables are highly correlated, their coefficients may lack representativeness; such as the case with the labor force: it has an R^2 of 47%, but its coefficient is only 3.51%. This is not surprising, given that the labor force for this study was defined as the Economically Active Population (EAP)— , which consists of the working-age population divided by the sum of the employed and unemployed populations.

Another interesting variable worth noting is social conditions, with an R^2 of 70% but a low coefficient of 3.47%. In other words, investment in social development is extremely important for the municipalities in the state of Chihuahua, but it lacks precision—this is attributed to the allocation and distribution of resources.

As for the variable representing technological conditions, its R^2 explains 39% of the variation in the dependent variable. An important point to emphasize in this regression is that, ideally, data on public investment in technology by municipality should be obtained; however, due to the lack of such data, the percentage of the population with access to technology was used instead. As for variables such as life expectancy, economic conditions, and economic development, their R^2 values remain much lower compared to the variables described above, although they retain a positive coefficient; the confidence intervals reject their significance—not because they lack a correlation, but because they depend on other factors such as inequality, the quality of healthcare systems, and intermittent self-employment, among others. For example, the economic conditions variable refers to the sector that most strengthens the municipalities—which, for the most part, remains the goods and services sector—with only three municipalities showing a slight commitment to the maquiladora sector.

Is the average level of education sufficient in the state of Chihuahua?

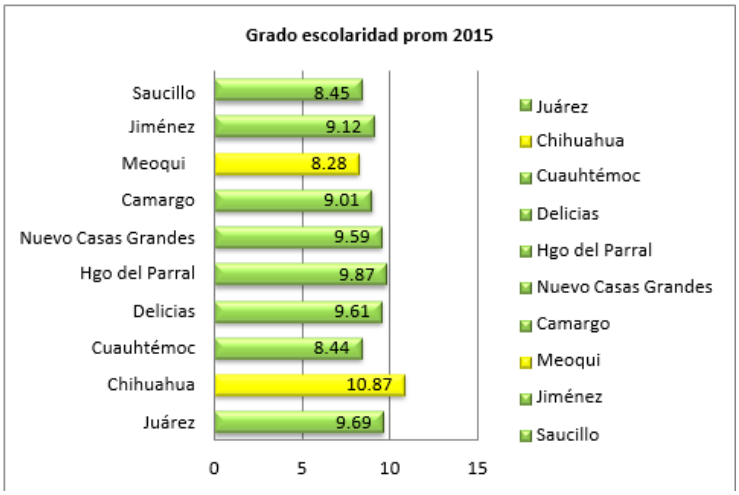


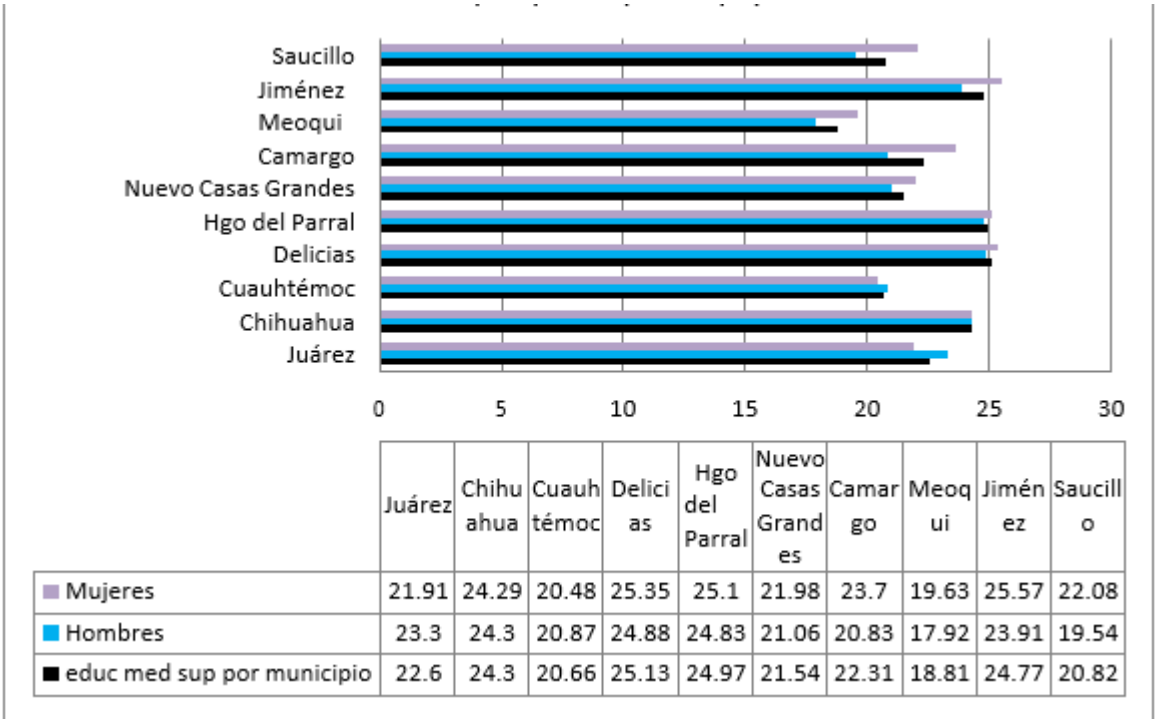
Figure 1. *Average level of education attained by municipality*.

Source: Author's *own analysis* (2026).

Based on the results obtained, the answer is that it is not enough; one need only look at Figure 1, which shows that the average level of education attained by the municipalities ranges from 8.28—the lowest, in the municipality of Meoqui—to 10.87—the highest, in the municipality of Chihuahua. Given that the

state-wide average is 9.5 grades—which represents just slightly more than completion of middle school—this means that upper secondary education is a key area of focus, as this is where most students drop out at the state level. It is worth noting the municipalities that exceed this level, namely: Nuevo Casas Grandes with 9.59; Delicias with 9.61; Juárez with 9.69; Hidalgo del Parral with 9.87; and Chihuahua with 10.87; On the other hand, the municipalities that fall below the state average are: Meoqui with 8.28; Cuauhtémoc with 8.44; Saucillo with 8.45; Camargo with 9.01; and Jiménez with 9.12.

Is the percentage distribution of the population in upper secondary education equitable?



	Juárez	Chihuahua	Cuauhtémoc	Delicias	Hgo del Parral	Nuevo Casas Grandes	Camargo	Meoqui	Jiménez	Saucillo
Mujeres	21.91	24.29	20.48	25.35	25.1	21.98	23.7	19.63	25.57	22.08
Hombres	23.3	24.3	20.87	24.88	24.83	21.06	20.83	17.92	23.91	19.54
educ med sup por municipio	22.6	24.3	20.66	25.13	24.97	21.54	22.31	18.81	24.77	20.82

Figure 2. *Upper Secondary Education by Gender, by Municipality*.

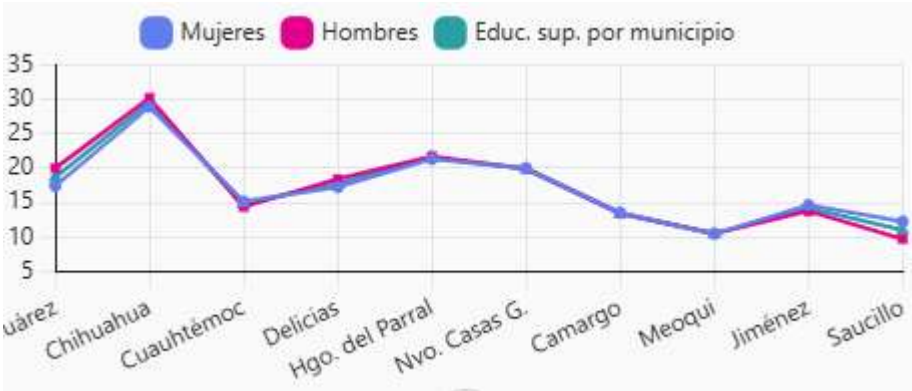
Source: Author's *own work* (2026).

Graph 2 focuses on the percentage analysis of upper secondary education—that is, the proportion of the population, broken down by gender, enrolled at this level. To better understand the situation in each municipality, the municipal average is compared to the state average, which stands at 21.43 for upper secondary education.

As can be seen, the municipality of Delicias has a higher enrollment rate than any other municipality at this level relative to its population, at 25.13; followed by Hidalgo del Parral at 24.97; Jiménez at 24.77; Chihuahua at 24.3; Juárez at 22.6; Camargo at 22.31; and Nuevo Casas Grandes at 21.54.

An important point to note at this level is the percentage distribution of the population by sex. In Figure 2, the purple line represents women; the blue line represents men; and the black line represents the municipality as a whole. Note that, of the ten selected municipalities, upper secondary education predominates among men in only three of them: Juárez, Chihuahua, and Cuauhtémoc. On the other hand, upper secondary education has a greater influence among women in the municipalities of Delicias, Parral, NCG, Camargo, Meoqui, Jiménez, and Saucillo.

Is the percentage distribution of the population at the higher education level equitable?



	Juárez	Chihuahua	Cuauhtémoc	Delicias	Hgo del Parral	Nuevo Casas Grandes	Camargo	Meoqui	Jiménez	Saucillo
Mujeres	17.43	28.93	15.17	17.25	21.33	19.97	13.52	10.46	14.66	12.27
Hombres	20.02	30.21	14.39	18.43	21.73	19.92	13.43	10.51	13.75	9.74
educ sup por municipio	18.7	29.54	14.8	17.81	21.52	19.94	13.47	10.49	14.22	11.01

Figure 3. *Higher education by sex by municipality*.

Source: Author's *own analysis* (2026).

Higher education is more prevalent among men in the municipalities of Juárez, Chihuahua, Delicias, Hidalgo del Parral, and Meoqui. Meanwhile, for women, the population is concentrated in the municipalities of Cuauhtémoc, NCG, Camargo, Jiménez, and Saucillo. It is worth noting that at the upper secondary level, the percentage distribution is higher for women; however, it decreases at the higher education level.

Is fertility a determining factor in human capital?

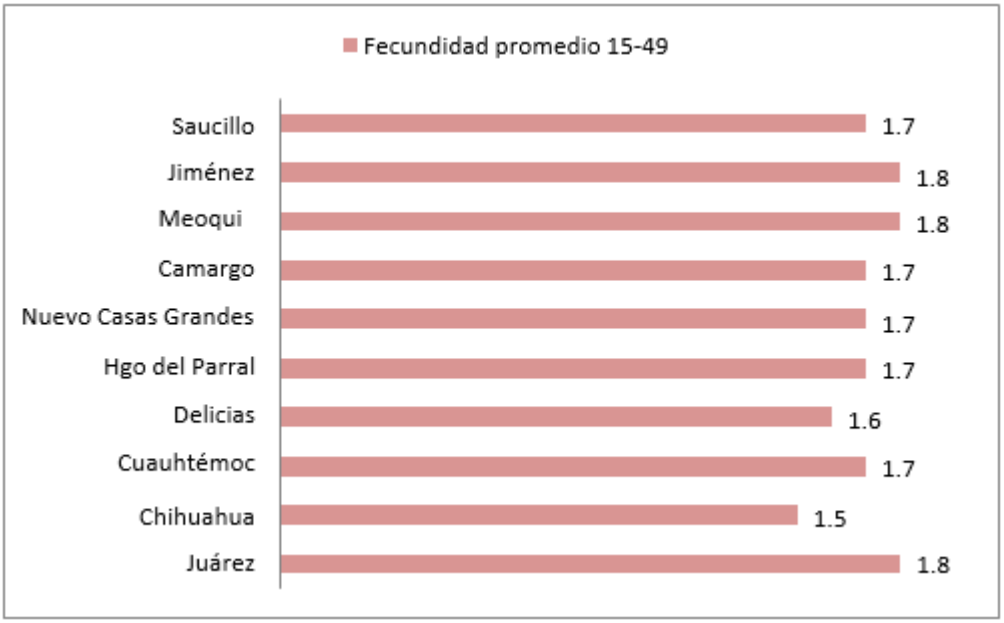


Figure 4. *Average fertility rate by municipality*.

Source: Author's *own work* (2026).

Referring to Becker's studies, it notes that there is an inverse relationship with individual income and, therefore, with the average level of education in a given population, indicating that a high fertility rate has a negative impact on the development of human capital within families. Although these may be assumptions rather than absolute truths, we decided to include this variable in this study, since it has been incorporated as such in some neoclassical econometric models. For a comparative analysis, we use the state-level indicator, with an average fertility rate of 1.7 children at the state level.

The municipalities with fertility rates above this level—at 1.8—are Jiménez, Meoqui, and Juárez; followed by the municipalities of Saucillo, Camargo, NCG, Hidalgo del Parral, and Cuauhtémoc, all at 1.7; Delicias at 1.6; and Chihuahua at 1.5. It should be noted that Chihuahua and Delicias have a higher average level of education than the state average.

Is the labor force key to human capital development?

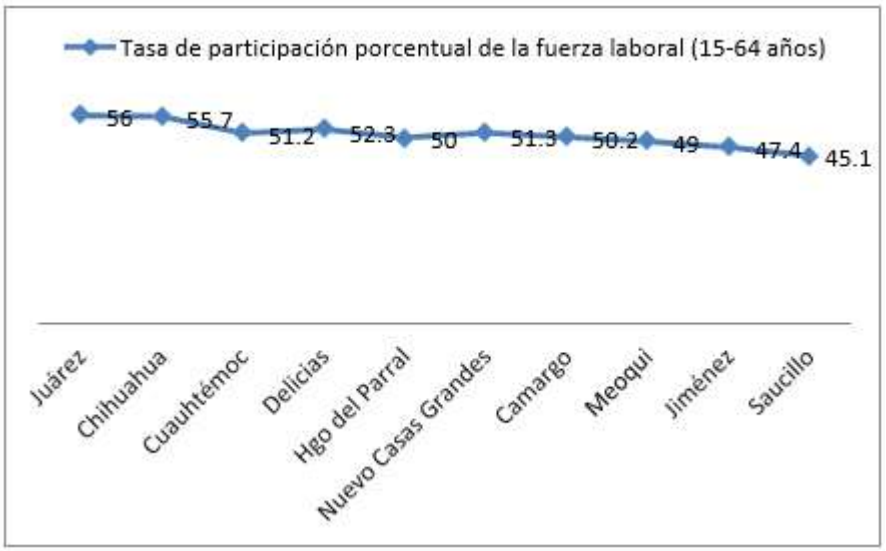


Figure 5. *Percentage labor force participation rate*.

Source: Author's *own analysis* (2026).

Analysis: The labor force is essential to the development of human capital. Figure 5 shows the economically active population; the state average is 51.7%, meaning that Juárez (56%) and Chihuahua (55.7%) are the main contributing municipalities.

Are the primary, secondary, and tertiary sectors important for human capital?

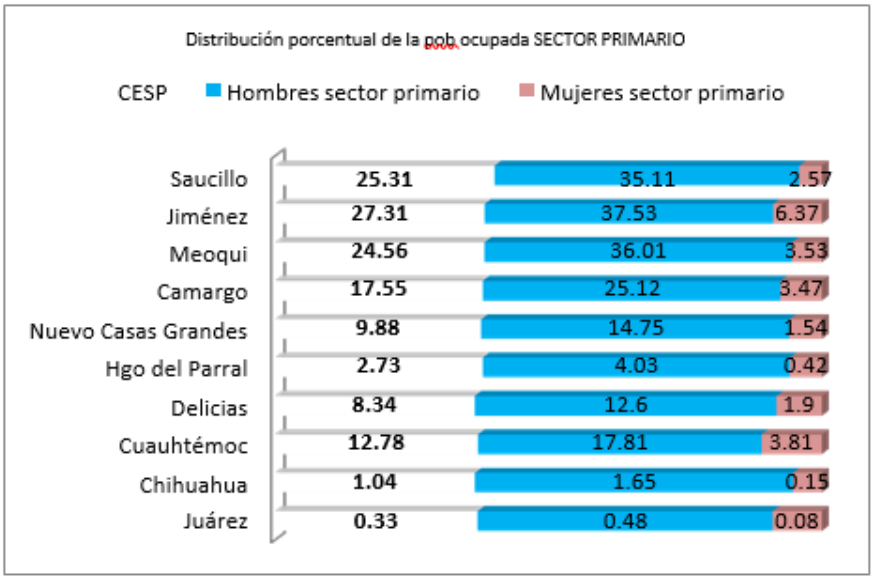


Figure 6. *Percentage distribution of the employed population in the primary sector by sex, by municipality*.

Source: Author's *own work* (2026).

The graph shown refers to the primary sector, also known as the agricultural and livestock sector, which consists of farming and livestock activities. It accounts for a portion of the employed population. The blue bar represents the percentage of men, the pink bar represents the percentage of women, and the remainder is the total number of people engaged in this activity by municipality. As can be seen, the blue bar is much more prominent than the pink bar; therefore, the agricultural sector is more heavily represented by men. It should be noted that this sector has the lowest share in the state of Chihuahua due to multiple factors, one of which is geographical conditions rather than government intervention.

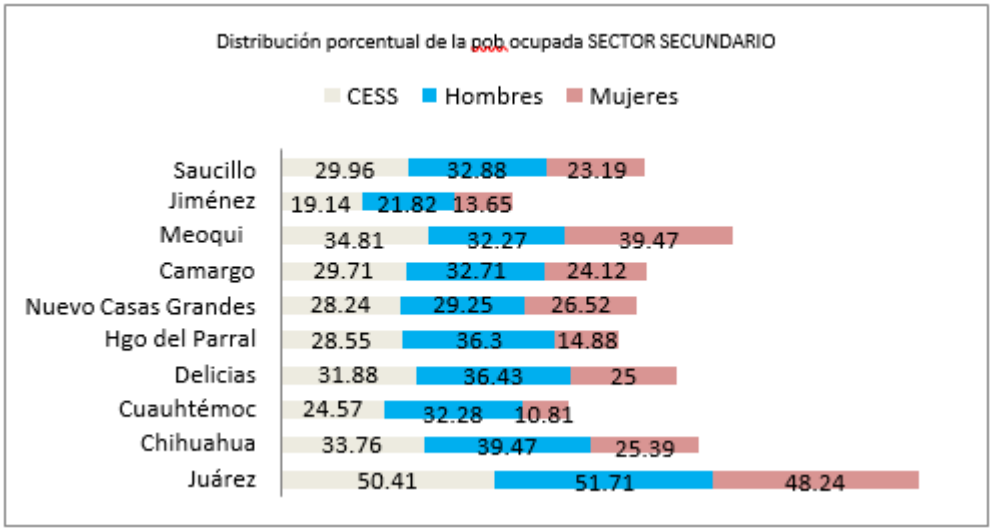
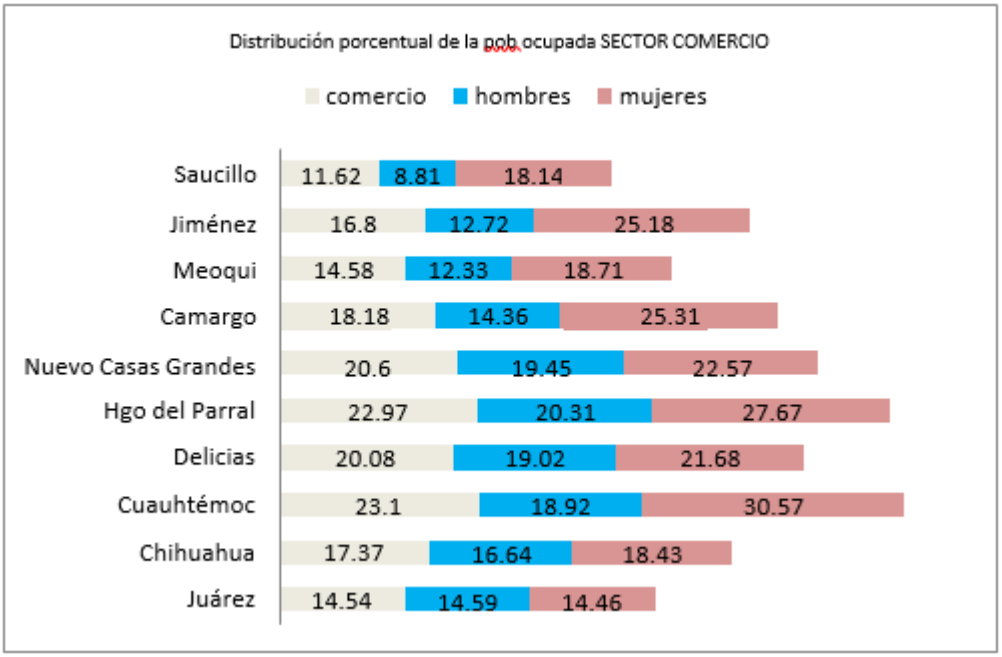


Figure 7. *Percentage distribution of the employed population in the secondary sector by sex, by municipality*.

Source: Author's *own work* (2026).

The secondary sector, also known as the industrial sector, is one of the sectors that most strengthens the state of Chihuahua, as it is characterized by manufacturing (light maquiladora industry). Note that the graph shows the percentage distribution by sex (men and women); Meoqui is the only municipality where women predominate, at 39.47%, while men account for 32.27%. For the remaining nine municipalities, the blue bar leans toward this sector, but to a lesser extent; the difference is not significant when compared to the primary sector.



Graph 8. *Percentage distribution of the employed population in the commercial sector by sex, by municipality*.

Source: Author's *own work* (2026).

Figure 8 shows that, in nine of the ten municipalities studied, the employed female population is concentrated in the commercial sector, as indicated by the pink bar. It is interesting to note that in Juárez, the employed population is evenly distributed between men and women; in fact, the blue bar represents a slightly higher percentage at 14.59, while the pink bar stands at 14.46. As in the industrial sector (see Figure 7), this indicates that in the municipality of Juárez, both the industrial and service sectors are proportional to the labor force.

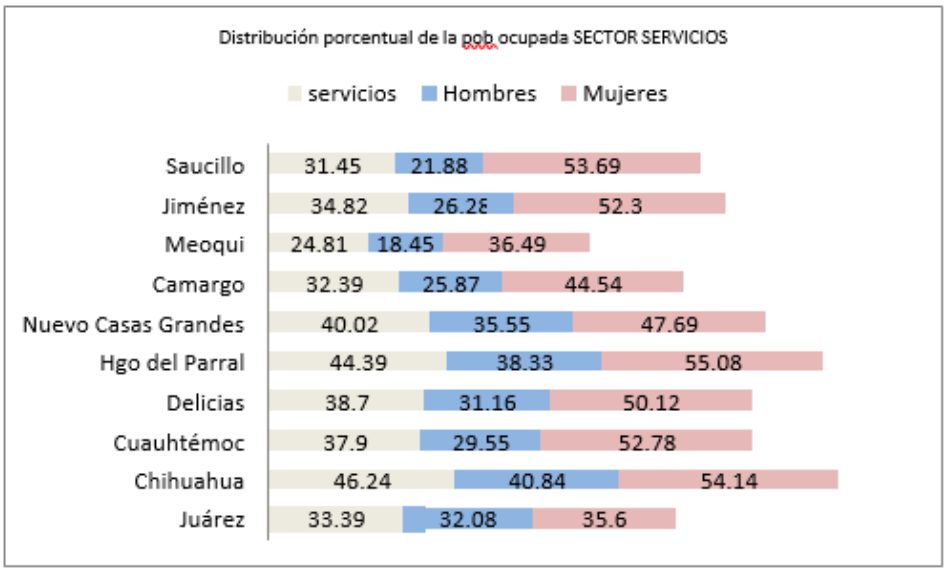


Figure 9. *Percentage distribution of the employed population in the service sector by sex, by municipality*.

Source: Author's *own compilation* (2026).

The service sector is one of the sectors with the highest concentration of female labor force participation; it encompasses a wide range of employment opportunities. It is important to note that, at the state level, this is the sector with the greatest economic potential for both men and women; however, the industrial sector is more significant. This is because the commerce and services sector has a high degree of informality, where aggregate production is not accounted for as such. The municipalities of Meoqui and Juárez show a higher percentage distribution toward the industrial sector than toward the other sectors (primary, trade, and services).

The results highlight the importance of factors that, while not fully representative of human capital, are implicitly involved as determinants. It is worth noting that a variable can have different dimensions, which makes correlation models even more interesting, since joint and individual regressions can be performed to yield different results and, consequently, more accurate interpretations.

CONCLUSIONS

Based on the research conducted—taking into account the available data, its scope and limitations, as well as the reviewed literature—it can be concluded that human capital in the ten selected municipalities of the state of Chihuahua exhibits significant structural asymmetries that limit its capacity for accumulation and, consequently, restrict development opportunities. In this regard, the study successfully fulfills its primary

objective by proposing and validating an econometric model that enables the identification and assessment of determinants of human capital in heterogeneous municipal contexts. Furthermore, it is acknowledged that, although there are variables of a qualitative nature or those that are difficult to quantify—which go beyond the analytical scope of this study—the model developed constitutes a robust tool for formulating diagnoses and providing strategic guidance for public policies and private-sector actions.

In particular, education, the labor force, and social conditions emerge as factors of special relevance, which aligns with the theoretical foundations of the economics of human capital and, specifically, with Mincer's arguments regarding the influence of educational investment on productivity and development processes.

Similarly, the evidence obtained reveals a significant discrepancy between progress in social development and the results observed in terms of economic development. Although relatively favorable technological conditions and a growing share of the service sector are identified in some municipalities, these factors have not been sufficient to translate into substantial increases in human capital.

With regard to the research questions, it is concluded that one of the main obstacles to strengthening human capital in the analyzed municipalities lies in the limitations of the education system, particularly at the upper secondary and higher education levels. The results point to the need to design strategies that not only promote access to these educational levels but also ensure student retention, completion of studies, and the effective integration of graduates into regional labor markets. In this context, the application of the simple linear regression model enabled the development of a complementary explanatory and predictive analysis, providing empirical evidence to identify the strengths and weaknesses of the variables studied.

FUTURE WORK

This study identified determinants of human capital and proposed an analytical model applicable to the municipal context of the state of Chihuahua. It is important to recognize that the complexity inherent in this construct extends beyond the dimensions considered in this research. Consequently, there are variables and areas of analysis that, due to methodological limitations, lack of available information, or temporal scope, could not be incorporated into the developed model . However, this limitation does not imply a disregard for their relevance, but rather a recognition of the multidimensional and dynamic nature of human capital as a subject of study.

From this perspective, the research serves as a starting point for future lines of study that expand the

explanatory scope of the phenomenon by incorporating new variables, methodological approaches, and contexts of application. The analytical flexibility of the proposed model allows for its adaptation and refinement as research needs and the socioeconomic conditions of the environment evolve. However, any subsequent effort must preserve the fundamental premise that guides this work: the need to strategically value human capital as an essential asset for economic and social development, reaffirming that it should be understood as a comprehensive investment aimed at improving quality of life.

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