## Crisis and Resilience in Gender and Wages: The Manufacturing Sector in Mexico and on the Northern Border
## Crisis y resiliencia en género y salarios: el sector manufacturero en México y la frontera norte

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ABSTRACT

This study analyzes men's and women's wages in the manufacturing sector on Mexico's northern border, with a specific focus on the years 2005, 2009, and 2017. Salary profiles are estimated with spline regressions corrected for selection bias, based on disaggregated data from various issues of the National Occupation and Employment Survey (ENOE). The findings explain how women on the border enjoy an advantage over those from the rest of the country in terms of human capital. However, their wages are subject to certain *glass ceilings*. Men are resilient in this process and their wages recover faster than women's.

*Keywords*: 1. wages, 2. human capital, 3. spline regression, 4. northern border, 5. Mexico.


RESUMEN

Analizamos los salarios para mujeres y hombres en la manufactura de la frontera norte en México con énfasis en los años 2005, 2009 y 2017. Se estiman perfiles salariales con regresiones *spline* corregidas por sesgo de selección, con las bases desagregadas de las distintas emisiones de la Encuesta Nacional de Ocupación y Empleo. Los hallazgos explican la forma en la que las mujeres en la frontera presentan mayor ventaja que aquellas del resto del país en términos de capital humano. Sin embargo, en sus salarios están presentes algunos *techos de cristal*. Los hombres son resilientes al proceso y sus salarios se recuperan más rápidamente que los de la mujer.

*Palabras clave*: 1. salarios, 2. capital humano, 3. regresión *spline*, 4. frontera norte, 5. México.

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## INTRODUCTION[3]

Since the turn of the millennium, a downward trend has been observed in women's income –with respect to men's– in Mexico's northern border (NB) region, even though wage information in statistics provided by the National Institute of Statistics and Geography (Inegi) in Mexico reflects the impact of the 2009 economic crisis and the resulting decline in wages, which affected men to a greater extent. This process may be an indication of resilience in men's wages, as although men have experienced a decline in wages with respect to their female counterparts, the wage premium for women is still lower than for men.

In this vein, it is striking that, for women, the gap or inequality in wages appears to be pro-cyclical, meaning that greater economic growth has a more adverse impact on their wage, while with less growth comes better remuneration for women (which is counter-cyclical). Hence, men experience greater sensitivity to economic cycles as their wages increase during an expansion and decrease to a greater extent in a recession, as expertly shown by De la Roca (2014).

An analysis of wage behavior by gender, and wage components, in periods of economic crisis makes it possible to identify, in terms of human capital, the true impacts on wage determination and on the country's border region in one of its most dynamic sectors: the manufacturing sector.

This region, which was hit by the 2009 crisis, forms the basis for the study objective: to analyze wage levels and how they were affected before, during, and after the economic crises (2005, 2009, and 2017, respectively), by comparing the behavior exhibited by states on the NB and the rest of the country. For this reason, years were chosen based on the level of economic activity recorded: a year of strong economic growth at the beginning (2005), a year of severe crisis (2009), and a year with low yet consistent economic growth (2017).

It should also be made clear that for the purposes of this study, resilience by gender was interpreted as the capacity for adaptation of the population working in the manufacturing sector with respect to their salaries, distinguishing between the two sexes. This conceptual relationship was devised to restrict the scope of the study in light of developments during the period of analysis, excluding a deeper exploration of the broader concept of gender and resilience.

This study is guided by and seeks to provide a response to the following questions: If the 2009 crisis had a negative impact on salaries from a gender perspective, did this trend change after the crisis? What is the direction of the effect? In other words, does it favor women or men? And within the two groups, those least or most highly skilled?

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Our hypothesis is that a year of crisis like 2009 saw a decline in wage inequality with respect to the years before and after the crisis, with a similar trend occurring in the NB region and throughout the rest of the country. Given the greater effect of the crisis on the NB, one may expect this effect to be greater in the border region, to the detriment of men's wages, but that any negative effect would have dissipated by 2017 with salaries returning to pre-crisis levels.

To this end, a database was developed from recent occupation and employment surveys, which provided the employment structure and wages based on worker gender. The study took into account those in manufacturing jobs and a spline econometric model was specified to explain how the (non-linear) trend in men's and women's wages in the northern border region changes compared to the rest of the country.

In addition, groups of workers were disaggregated by gender and level of education to gain an insight into the impact of human capital on the labor market and generate viable public labor policy proposals with the goal of reducing or eliminating negative effects on productivity and career inertia for each level of education.

This paper is structured as follows. The first section briefly describes the frame of reference, based on the theoretical model of human capital, and briefly describes the empirical evidence. The second part explains the methodology employed, while the third presents the composition of the database together with the descriptive statistics. The fourth section gives the main findings and the conclusions of the study.

## THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Human capital theory, which was expertly described by Becker (1971), presents the general frame of reference and context that makes it possible to evaluate and model the different stages individuals go through in acquiring formal education and their impact as a whole with respect to the labor market and the supply and demand processes that come into play. As a result, one of the the theory's key areas of application lies in determining the wage premium within an economy.

Mincer's (1974) seminal study models salaries and establishes that it is differences in personal attributes (specifically those that can be tangibly measured such as grades and education, and intangible attributes such as certain behaviors or worker attitudes) that lead to both upward and downward variations in wages. This study is based on wage measurements for two groups of workers, for whom profiles are estimated with respect to their level of (formal) education to determine whether men's and women's incomes exhibit similar or different behavior based on level of education and training.

The analysis is based around the idea that individuals are valued in accordance with the average characteristics of a group, due to the fact that employers employ subjective considerations to make decisions, thus using gender as a proxy indicator of production

(Becker, 1993; McConnell, Brue, & Macpherson, 2003). It is worth clarifying that this divergence is not due to any personal preference on the part of employers, as they make objective and rational decisions with the sole aim of maximizing profit.


*Empirical Evidence*

A wide range of studies on Mexico's northern border region focus on the determinants of wages (Mayer-Foulkes & Cordourier, 2001; Mendoza & García, 2009; Varela & Retamoza, 2012; Popli, 2013; Sauceda & Varela, 2013; Castro & Morales, 2011; Camberos, Huesca, & Castro, 2013; Huesca & Ochoa, 2016).

Specifically, Mayer-Foulkes and Cordourier's (2001) research broke new ground in male-female wage gaps, finding that men earned up to 12% less in the lowest (poorest) decile, mainly due to educational shortcomings, while women in Mexico earned 15 to 18% less in wages than equally qualified male counterparts in non-poor groups. The study serves as a starting point for exploring how education has played a significant role in gender wage gaps that have, since then, worsened for women, rather than the gaps closing.

Mendoza and García's (2009) study set the tone for describing gender wage trends on Mexico's northern border. The authors calculated that women earned, on average, 12.4% less in wages than men, all other human capital attributes and characteristics being equal. They estimated that the northern region exhibited the lowest wage gap, at around 7%, while for central and southern regions this increased to 11.2% and 18.3% respectively, confirming a sustained context of gender income inequality.

Varela and Retamoza (2012) presented a study on human capital and wage differences for Mexico in the 2000-2009 period, in which they found that as the level of education of heads of households increases, so does their income. Similarly, it was shown that heads of households with permanent contracts earn higher incomes than those on temporary work contracts. Heads of households working in micro, small, and medium-sized businesses earned lower incomes, on average, than those in large organizations. As a result, Varela and Retamoza conclude that there are clear wage differences based not only on level of education but also the type of organization, business sector, and factors associated with social and territorial order in Mexico's geographic and economic landscape.

Sauceda and Varela (2013), on the other hand, analyzed the determinants of relative wages in the Mexican manufacturing industry from 1999 to 2008. Their main findings indicate that a demand for more skilled and unskilled labor had a direct impact on the increase in relative wages and pointed to a consistent, growing connection between exports and imports in these sectors, while determining that the subsectors with the highest relative wages are those with a greater proportion of skilled labor in relation to unskilled labor.

At a sectoral level, this is consistent with work by Castro and Morales (2011) and Camberos, Huesca, and Castro (2013) for the service sector, where sudden improvements

were observed in skilled wages, even for jobs involving high computer use, or non-routine jobs with respect to routine ones.

In this vein, recent evidence suggests that, in Mexico, the impact of technology in the labor market has not led to an increase in wages, but quite the contrary. This process of biased technical change has resulted in a decrease in wage inequality due to the sharp drop in income for more highly skilled workers with a higher level of education (Huesca & Ochoa, 2016).

Recent research on the gender wage gap is provided by Popli (2013), who centers the discussion on the relevance of informality and examines the decade from 1996 to 2006 in Mexico. Her study examines both formal and informal workers and identifies differences in wage distribution between the two groups.

Although research by Castro, Huesca, and Zamarrón (2015) is centered on the northern border and the manufacturing industry, their study does not determine pre- and post-crisis impacts on the two genders' wages. On the other hand, a study by Castro, Rodríguez, and Brown (2017), despite exploring the problem of wage inequality within a context of economic recession, fails to quantify or model behavior for different levels of education and, therefore, provides no knowledge of any changes this produces in wages and their possible effects on each gender during a period of economic crisis.

It is on this basis that this study is able to contribute to determine whether there exists a pro-cyclical or counter-cyclical effect and whether this effect is greater at higher levels of education in women's favor, or whether it translates into reduced impacts on men's wages.

Potential gender heterogeneity in income and wage distribution is recorded in work by Arceo-Gómez and Campos-Vázquez (2014), Pagán and Ullibarri (2000), Popli (2013), and De la Rica, Dolado, and Llorens (2008). The recent identification of the creation of *glass ceilings* or *sticky floors*, established in research by De la Rica, Dolado, and Llorens (2008), led Arceo-Gómez and Campos-Vázquez (2014) to join Pagán and Ullibarri (2000) and Popli (2013) in implementing methodologies that analyze gender wage differences along the distribution, with the aim of identifying these phenomena in the job market (De la Rica, Dolado, & Llorens, 2008). According to the definition offered by De la Rica, Dolado, and Llorens (2008), when the wage difference favors men, a *glass ceiling* is said to exist at the expense of women, while a *sticky floor* is observed when women's wages fail to increase despite higher levels of education. It is this hypothesis that this study seeks to test.

The above-cited studies identified a different distribution by gender, a potential *glass ceiling* in Popli (2013), and both in Arceo-Gómez and Campos-Vázquez (2014). Studies in recent decades on differences in wages and wage breakdowns have found the following:

1) Wage differences between men and women favor the former.

2) The wage inequality problem is complex and involves numerous factors.

3) Heterogeneity in the wage phenomenon (across time and space and by economic sector and worker group).

4) A substantial proportion of the gender wage difference cannot be explained by factor endowment (i.e. by productivity) but has reduced over time.

5) A lack of analysis for periods of crisis (which this study aims to help remedy).

## METHODOLOGICAL APPROACH

The literature review has made it possible to understand the situations and conditions of the problem of the labor market's response in relation to men's and women's earnings in a context of wage equality. In this vein, the content of this section is based on the joint use of a spline regression technique and Heckman's self-selection technique, enabling an econometric exercise that, to date and to our knowledge, has never been performed for Mexico or a region like Mexico's northern border. To that end, a model was established with exogenous variables that are interacted to determine the simultaneous impact of level of education and gender on wages (Greene, 2008).

The importance of correcting selection bias in an analysis of the determinants of wages for two groups has been a recurring subject of research, and has been no less relevant in Latin America (Rubli, 2012). In order to avoid any possibility of selection bias, we employed the classic method proposed by Heckman (1979) in which male and female earnings are modeled, considering the inactive population and calculating the traditional Mills ratio variable ($\lambda$). This ensured it was possible to select only active workers while excluding any influence from the inactive population on each group's wages.

Both methods enable us to obtain more statistically robust inferences and provide certainty that the estimations are free from bias, achieving calculations that are closer to the true value. The model to be estimated is the following:

$$\log y_{it}^{G} = \beta_0^{G} + \beta_{1t}^{G} S_i + \beta_{2t}^{G} X_i^{'} + \beta_{3t}^{G} \lambda_i + u_{it}^{G} \tag{1}$$

where $log\ y_{it}^{G}$ is the hourly wage in logarithms and the superscript G is the worker's sex. $S_i$ is the education variable, $\beta_{nt}^{G}$ the estimated coefficients, and $X_i^{'}$ the vector of the attributes used in the estimations; $\beta_{3t}^{G} \lambda_i$ is used as the inverse Mills ratio –the estimator that makes it possible to correct any potential bias in the sample selection– and $u_{it}^{G}$ is the error term that satisfies the usual conditions of normality.

In addition, it is necessary to calculate a model that is able to capture the continuity of the education variable in the regression. Otherwise, although the results would capture the mean effect by level of education for each group of workers, the continuous effect expected on wages would be lost. Indeed, in order to make comparisons between wage

predictions across each level of education, equation (1) has been changed as shown below, considering cut-off thresholds for each education group, expressed in equation (2) as follows:

$$
\begin{aligned}
Ln\, y_i^G = \beta_1^G + \beta_2^G S_i + \delta_1 d_1(S_i - t_1^*) + \delta_2 d_2(S_i - t_2^*) + \delta_3 d_3(S_i - t_3^*) \\
+\delta_4 d_4(S_i - t_4^*) + \beta_i^G X_i'^G + \beta_i^G\ _i^G + \varepsilon_i^G
\end{aligned} \tag{2}
$$

We proceeded to split the effects of the continuous education variable into four groups with the vector by levels as follows, with 6, 12, 17, and 24 for completed elementary, high school, professional, and postgraduate education respectively.

This restricts the estimators for the spline model, employing a constant and the covariates of the result of equation (2), with the following conditional expectation and corresponding continuous thresholds for education in expression (3):

$$
\begin{aligned}
E\left[Ln\, y_i^G | S_i\right] = \alpha^0 + \beta^0 S_i \ \ &\text{if } S_i < 6, \\
\alpha^1 + \beta^1 S_i \ \ &\text{if } S_i \geq 6 \text{ and } S_i < 12, \\
\alpha^2 + \beta^2 S_i \ \ &\text{if } S_i \geq 12 \text{ and } S_i < 17, \\
\alpha^3 + \beta^3 S_i \ \ &\text{if } S_i \geq 17 \text{ and } S_i \leq 24.
\end{aligned} \tag{3}
$$

Likewise, the values of each node or threshold that will change the slope of the continuous effect expected at each level of education will be the coefficients estimated with $\beta^0 S_i$ as incomplete basic-level education, $\beta^1 S_i$ for basic-level education, $\beta^2 S_i$ for high school, and $\beta^3 S_i$ in undergraduate to full postgraduate education (see Tables 3 and 4 in the results section for the coefficients obtained) in groups of male and female workers as follows:

$$
\begin{aligned}
d_1 &= 1 \text{ if } S_i \geq t_1^*, \\
d_2 &= 1 \text{ if } S_i \geq t_2^*, \\
d_3 &= 1 \text{ if } S_i \geq t_3^*, \\
d_4 &= 1 \text{ if } S_i \geq t_4^*.
\end{aligned} \tag{4}
$$

## DATABASE CONSTRUCTION

The information for this study comes from the database of the National Occupation and Employment Survey (ENOE) for the third quarter of the years 2005, 2009, and 2017. This database was narrowed down to workers in the manufacturing industry between 14 and 65 years of age, with working weeks of 15 to 60 hours. Hourly wages were determined at

constant August 2011 prices, based on the traditional consumer price index for the main metropolises and localities in the country.

Hourly wage was chosen with a view to using the most homogeneous variable possible, and four levels of education were considered: 1) no education and incomplete elementary education (less than 5 years of education); 2) full elementary and middle school education, with incomplete high school education (6 to 11 years); 3) full high school education with incomplete undergraduate studies (12 to 16 years); and 4) full undergraduate degree and postgraduate studies (16 to 24 years of education).

The other independent variables included in the vector are men's potential work experience, which was constructed taking into account the worker's age and deducting the age of entry into education, i.e. six years, and the number of years of formal education. For women, children were also included in the time deducted from work experience, producing a good proxy to calculate interruptions due to maternity. In both groups, the diminishing returns to human capital were accounted for with the square of experience (Mincer, 1974). For the marital status variable, two groups were established in the usual manner, firstly based on household headship –and therefore a commitment to provide for a family– and secondly in order to measure the effect of marital status on wage profiles. Those living with a partner, whether married or not, made up the benchmark group (with a value of one), while the remaining categories –such as those who were single, separated or divorced– constituted the remaining group. Urban and rural areas are controlled with the size of the locality, with workers in towns of over 15,000 inhabitants (urban and semi-urban workers) forming the benchmark group, and the remainder comprising rural workers and those in places with fewer than 15,000 inhabitants (semi-rural and rural workers).

*Descriptive Statistics*

The empirical study focuses on the northern border and the rest of the country, the former comprising the working population from the six states bordering the United States, which account for over 30% of GDP from the manufacturing sector as a whole in Mexico. From 2005 to 2017, based on data from the ENOE, the sector employed 34% of the region's workers (Inegi, 2005 to 2017).

The descriptive statistics in Table 1 show the most significant variables in the study. The table reveals that on the northern border, women account for 34% of employees in manufacturing, which is 2% higher than the national average. This may be due to the type of manufacturing activities in the region, which tend to accommodate female workers. However, there are also socio-cultural and demographic contrasts that establish a geographical distinction between regional and national labor dynamics. Despite this, it should be said that both at a national level and in the border region, there is a predominance of male workers in the industry.

A classification by level of education showed that 60% of the working population is from the second level established, meaning they completed elementary and middle school education but did not obtain a high school diploma. Similarly, as far as age range is concerned, the majority of workers (six out of ten) were between 19 and 40 years of age. This was observed in both men and women and for both geographic areas.

On another note, men had a mean experience of 19 years and women 17 years across both geographic areas, while women racked up 16 years of experience in the country and 18 on the northern border. As for labor force participation by categories of the control variable of marital status, heterogeneity was observed by gender and, to a lesser extent, between the geographic areas. The significant difference by gender is increased participation by those who are married, unmarried but living with a partner, separated and divorced, among whom there is a greater proportion of women in relation to men. This indicates that, for women, marital status is a significant determinant of participation in the labor force.

A comparison of hourly wage between regions found that on the northern border, workers of both sexes earned around 3 pesos more, although the number of hours worked per week was similar for both genders and regions. By gender, women's average hourly wages were about 20% lower than men's on the northern border; for the country as a whole, this figure is estimated at 18%. However, northern border workers enjoy wages on average 14% higher than the national average, closing the gender gap in the region in women's favor. This study argues that this problem has existed on the same scale now for 17 years, and that wages have remained, in real terms, stagnant.

Table 1. Descriptive Statistics from the Database, 2005, 2009, and 2017

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **2005** | | | | | |
| lwage | 22,556 | 2.59 | 0.68 | 0.009 | 7.217 |
| sex | 26,489 | 0.63 | 0.48 | 0 | 1 |
| border | 26,489 | 0.24 | 0.43 | 0 | 1 |
| exp_male | 16,189 | 19.05 | 12.94 | 1 | 59 |
| exp_female | 9,459 | 17.24 | 11.77 | 1 | 57 |
| status | 26,489 | 0.64 | 0.48 | 0 | 1 |
| Incomplete basic level | 26,443 | 0.14 | 0.35 | 0 | 1 |
| Full basic level | 26,443 | 0.63 | 0.48 | 0 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| High school | 26,443 | 0.18 | 0.38 | 0 | 1 |
| Professional | 26,443 | 0.05 | 0.23 | 0 | 1 |
| **2009** | | | | | |
| lwage | 18,237 | 2.90 | 0.68 | 0.005 | 9.813 |
| sex | 23,314 | 0.63 | 0.48 | 0 | 1 |
| border | 23,314 | 0.23 | 0.42 | 0 | 1 |
| exp_male | 14,240 | 19.88 | 13.19 | 1 | 59 |
| exp_female | 8,331 | 19.01 | 12.25 | 1 | 59 |
| status | 23,313 | 0.67 | 0.47 | 0 | 1 |
| Incomplete basic level | 23,284 | 0.13 | 0.34 | 0 | 1 |
| Full basic level | 23,284 | 0.61 | 0.49 | 0 | 1 |
| High school | 23,284 | 0.20 | 0.40 | 0 | 1 |
| Professional | 23,284 | 0.06 | 0.23 | 0 | 1 |
| **2017** | | | | | |
| lwage | 19,475 | 3.03 | 0.60 | 0.020 | 7.045 |
| sex | 27,176 | 0.63 | 0.48 | 0 | 1 |
| border | 27,176 | 0.28 | 0.45 | 0 | 1 |
| exp_male | 16,717 | 19.90 | 12.95 | 1 | 59 |
| exp_female | 9,676 | 19.16 | 12.34 | 1 | 58 |
| status | 27,173 | 0.69 | 0.46 | 0 | 1 |
| Incomplete basic level | 27,139 | 0.07 | 0.25 | 0 | 1 |
| Full basic level | 27,139 | 0.59 | 0.49 | 0 | 1 |
| High school | 27,139 | 0.27 | 0.45 | 0 | 1 |
| Professional | 27,139 | 0.07 | 0.25 | 0 | 1 |

Source: Own work based on data from ENOE 2005, 2009, and 2017, 3rd quarter (Inegi, 2005, 2009 and 2017).

## EMPIRICAL RESULTS

It is of relevance to determine whether the differences described above are due to human capital factors or returns on factor endowment. The following section reveals trends in wages and the outcomes of the empirical exercise employed, and analyzes the impact of women's human capital in relation to that of men, both for Mexico and the northern border. Also described is the effect produced by levels of education on the wage differential and the unexplained portion of this wage differential.

Graph 1 shows the logarithmic progression of hourly wages (Panel A) and the wage ratio between women and men (Panel B). It shows how from 2007 (before the crisis), and in the midst of the crisis (2009), the wage ratio in Panel B was lower –to the detriment of women– on the northern border, reaching 0.771 with respect to men's mean income; the wage ratio was higher, at 0.8, for the country as the whole and the rest of the states. Around 2017, wages are seen to stabilize for both groups of workers, both on the border and in the rest of the country, with no further decline observed and a quotient above 0.8 times men's wages –in other words, only just above wage levels in other areas during the year of crisis (see Panel B in Graph 1).

One likely reason for the fall in the wage ratio in 2009 is the very nature of the manufacturing sector in Mexico and its dependence on the United States as a market; that year saw a sharp drop in demand from the U.S. for Mexican products in the sector, which was felt especially hard in the border region.

Graph 1. Real Female-Male Wage Ratio in Mexico: Northern Border and Rest of Country, 2005-2017 (2011 pesos= 100)
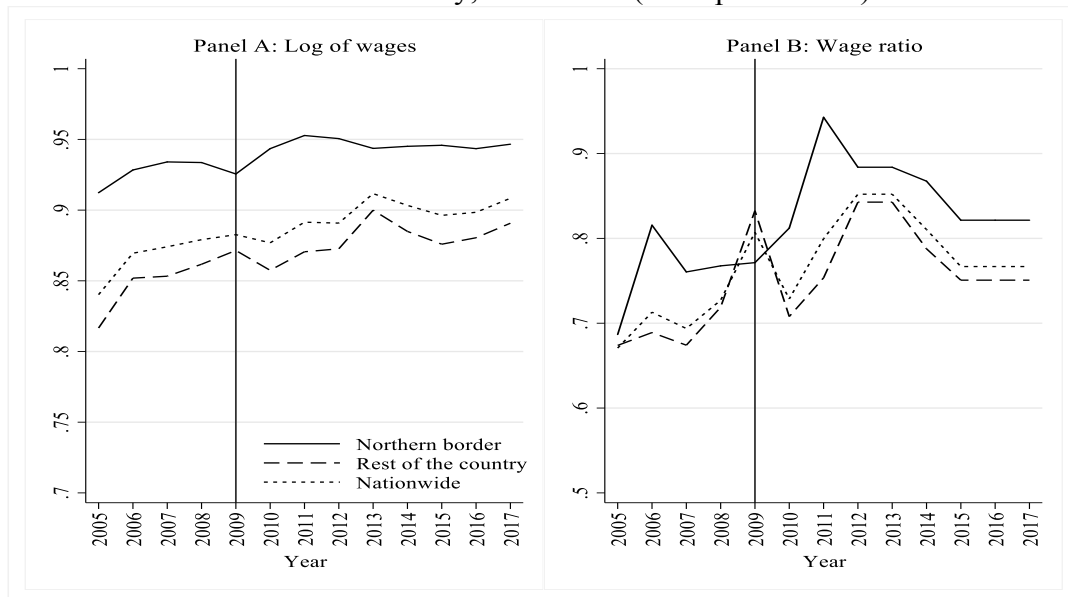


Source: Own work based on the ENOE carried out from 2005 to 2017 (Inegi, 2005 to 2017).

The findings from Graph 1 are as follows:

1) Throughout the period, with the exception of 2009, the wage ratio is better positioned in the border region (Panel A).

2) The gender wage ratio on a logarithmic scale levels out (Panel A) but a pro-cyclical trend is observed on the northern border.

3) Women's wages exhibit pro-cyclical behavior on the northern border, yet are counter-cyclical in the rest of the country (Panel B).

4) The best year in terms of reducing the wage gap was 2011 on the northern border, with a one-year time lag observed for the rest of country, for which it was 2012 (Panel B).

At this stage of the analysis, the wage difference between men and women reveals the existence of *glass ceilings* to the detriment of women (who never exceed the value of one), and *sticky floors* for women at times of economic crisis, which become all the more significant the more regions are dependent on the manufacturing sector. A wage gap of up to 10.7% was recorded in Mexico at the beginning of the period, and this gradually declined through to 2017. The hourly wage exhibits similar behavior in both parts of the country, and the higher salaries for women on the northern border are particularly noticeable.

Along these lines of empirical evidence, one region where wages should have improved most (also considering its geographical proximity to the USA) is the NB, yet there is evidence that this is not the case. In this regard, a recent study by Calderón, Huesca, and Ochoa (2017, p. 15) presents evidence showing how even the most highly paid skilled, abstract labor (which demands a higher level of schooling and complements the use of new technologies) does not come close to attracting the hourly wages paid for the same work in the United States. Hourly wages remained unchanged for the period from 2005 to 2012, with wages measured at purchasing power parity in the two countries (5.5 times greater for U.S. workers in the period). This points to a lack of wage convergence, although this falls outside the scope of this study.

A non-parametric estimation is given below in Graph 2, which shows Kernel wage distributions for each group considered in the study in its natural state, with no functional restriction of any kind imposed (Silverman, 1986; Duclos & Araar, 2006).[4]

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[4]The estimation of Kernel wage density functions by subgroup was conducted in STATA 15 using a Gaussian Kernel optimal bandwidth.

Graph 2. Wage Density in Mexico by Gender:
Pre-Crisis (2005), Crisis (2009), and Post-Crisis (2017)
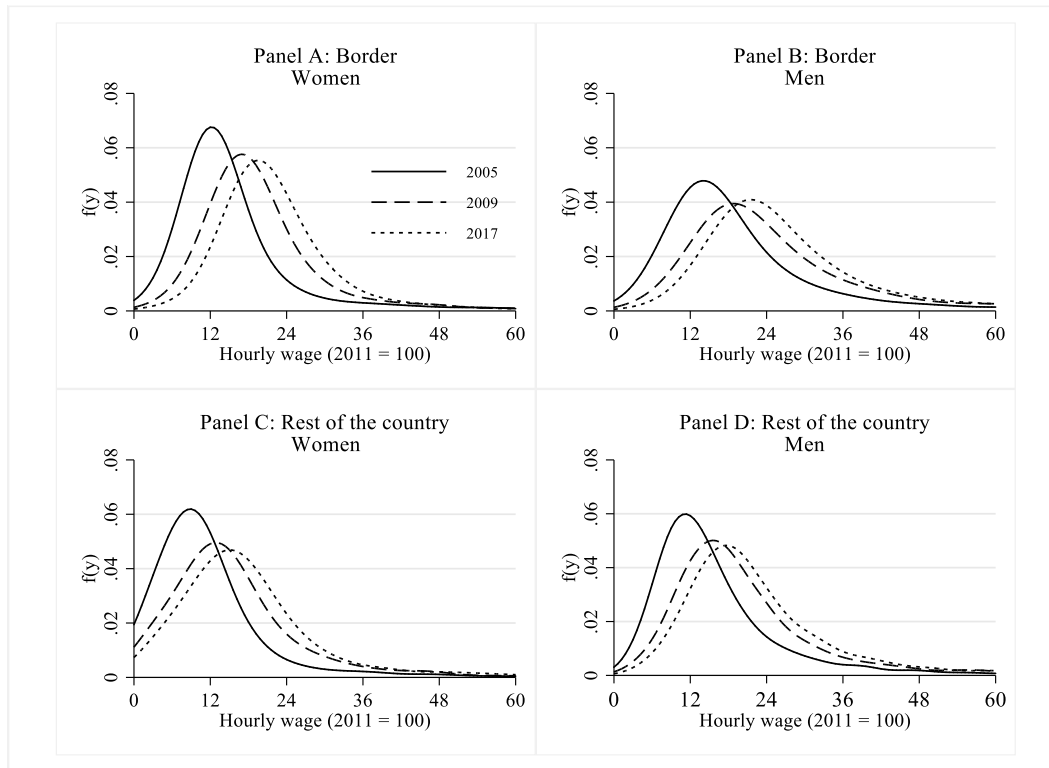


Source: Own work based on the ENOE carried out from 2005 to 2017 (Inegi, 2005 to 2017).

Graph 2 shows the estimations of wage density functions in Mexico for the northern border and the rest of the country in the first year of analysis (2005), the year of crisis (2009), and the post-crisis year (2017), by gender. On the northern border, Panels A and B show that women's salaries are further to the right then the distributions for men, indicating lower mean earnings. A greater concentration can also be observed around the mode, which does not exceed 19.4 pesos an hour (less than the mode for men, at 22 pesos).

The graph reveals that real mean earnings increased at a faster rate before the crisis than afterwards. In the post-crisis year 2017, women's wages can be seen to move further to the right, and men's wages do not cross over at any point, an indication that wages have also declined in the distribution for men, but to a lesser extent than for women.

Panels C and D show the situation in the rest of country, and it is easy to note that changes in wages were similar but had less impact on women (see Panel C). However, at lower wage levels, there is a greater decline in women's wages, as all wage densities are situated further to the left than their counterparts in Panel D.

At this point it is possible to conclude, based on Panels A and C, that women in manufacturing on the northern border are better positioned than those in the rest of the country. Furthermore, it is clear to see that the 2009 crisis hit women severely, and as of 2017 the recovery in wage levels is barely sufficient. The density function of real wages moved further to the right, to levels between 30 and 40 pesos an hour, but to a lesser extent than for men (Panels A and B).

At this stage of data analysis, it is difficult to make inferences on the causes and impacts, in terms of human capital, in men's and women's wage profiles in manufacturing –even with an estimation of the Kernel density functions of their wages, showing the full distribution patterns for both groups in this sector. The next step, then, is to proceed with the estimations of the econometric models to show the results obtained and confirm evidence that will make it possible to establish whether wage differences to the detriment of women are offset, to some extent, by a higher level of schooling and job experience.

Models were calculated with equations (1) and (2), producing statistically significant and robust coefficients with the expected signs (see Tables 3 and 4), and a comparative analysis was performed between the two regions under study. Over the estimated period, the result was similar for the northern border and the rest of the country (see Table 2), as women were shown to earn less than men. In addition, it was noted that this represented real wage differences of 6% to 7% on the border and from 6% to 11% in the rest of the country, which was explained by a greater/lesser effect on returns to schooling for each year completed over the 2005-2017 period.

Table 2. Results for the Manufacturing Industry, 2005-2017
(Expressed as the Natural Logarithm and Percentage Change)

| Region: | Rest of the country (OLS) | Northern border (OLS) | Rest of the country (Heckman) | Northern border (Heckman) |
|---|---|---|---|---|
| Log of mean hourly wage in men: | 3.0074 | 3.1558 | 2.8352 | 3.1136 |
| Log of mean hourly wage in women: | 2.6659 | 2.9654 | 2.6576 | 2.8999 |
| Wage difference by gender:* | -0.1135 | -0.0603 | -0.0626 | -0.0686 |

Note: */ Calculated as the gender ratio = [(Log women's wage / Log men's wage)-1].
Source: Own work based on the ENOE carried out from 2005 to 2017 (Inegi, 2005 to 2017).

The presence of a selection bias takes on relevance when performing calculations, and slight changes were found in the least squares (OLS) models, with the exception of an overvaluation observed in men's wages, enabling us to assert confidently that the results are robust and consistent with the estimates made by Heckman (1979).

In comparative terms, Rubli's (2012) study shows significant differences in positive selection bias between Argentina, Brazil, and Mexico, with the greatest difference found between Argentina and Mexico, which was up to twice as large to the detriment of Mexico. Evidence from our study found a highly statistically significant similarity in the positive selection bias (lambda variables) as a result of the need to correct the selection bias in both models.

Table 3. General Econometric Model by Gender and Selection Bias Correction in the Manufacturing Sector in the Rest of the Country (Pool 2005-2017)

| Variable | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Coefficient | z-statistic | Prob. | Coefficient | z-statistic | Prob. |
| *Hourly wage logarithm* | | | | | | |
| *Constant* | 1.4658 | 1281.82 | 0 | 1.7835 | 1333.98 | 0 |
| *Experience* | -0.0446 | -656.52 | 0 | -0.0288 | -379.7 | 0 |
| *Experience* $^2$ | -0.0003 | -514.79 | 0 | -0.0003 | -314.32 | 0 |
| *Marital status* | 0.0867 | 318.32 | 0 | 0.0257 | 73.29 | 0 |
| *ted1* | 0.0749 | 948.31 | 0 | 0.0483 | 554.88 | 0 |
| *ted2* | 0.0707 | 1008.13 | 0 | 0.0478 | 622.8 | 0 |
| *ted3* | 0.0715 | 1155.95 | 0 | 0.0532 | 783.55 | 0 |
| *ted4 Bachelor's degree or >* | 0.0804 | 1426.99 | 0 | 0.0692 | 1096.47 | 0 |
| *Selectivity* | | | | | | |
| *Marital status* | 0.0003 | 0.61 | 0.54* | 0.0034 | 3.17 | 0 |
| *Area* | -0.3861 | -500.74 | 0 | -0.3697 | -317.44 | 0 |
| *Children* | N/A | N/A | N/A | 0.2328 | 232.88 | 0 |
| *Constant* | 1.3027 | 1671.94 | 0 | 1.2839 | 1190.01 | 0 |
| */athrho* | 0.7371 | 766.98 | | 0.6148 | 483.07 | 0 |
| */lnsigma* | -0.652 | -2779.2 | 0 | -0.7213 | -2412.9 | 0 |
| $\rho$ *(rho)* | 0.6274 | | | 0.5475 | | |
| $\sigma$ *sigma* | 0.5209 | | | 0.4861 | | |
| $\lambda$ *lambda* | 0.3268 | | | 0.2661 | | |
| *Obs.* | 157,904 | | | 94,898 | | |

*Note: Coefficients significant to 1%. * Non-significant coefficient.*
*N/A: Not applicable.*
Source: Own work based on the ENOE carried out from 2005 to 2017. (Inegi, 2005 to 2017).

Table 4. General Econometric Model by Gender and Heckman Selection Bias Correction in the Manufacturing Sector on the Northern Border (Pool 2005-2017)

| Variable | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Coefficient | z-statistic | Prob. | Coefficient | z-statistic | Prob. |
| *Hourly wage logarithm* | | | | | | |
| *Constant* | 1.6476 | 788.39 | 0 | 2.3077 | 1083.46 | 0 |
| *Experience* | -0.0477 | -395.22 | 0 | -0.0181 | -151.42 | 0 |
| *Experience* $^2$ | -0.0003 | -253.11 | 0 | -0.0002 | -133.08 | 0 |
| *Marital status* | 0.056 | 120.79 | 0 | 0.0117 | 23.69 | 0 |
| *ted1* | 0.0763 | 540.97 | 0 | 0.032 | 235.02 | 0 |
| *ted2* | 0.0722 | 576.45 | 0 | 0.0293 | 243.63 | 0 |
| *ted3* | 0.0731 | 660.1 | 0 | 0.0343 | 319.26 | 0 |
| *ted4 Bachelor's degree or >* | 0.0818 | 813.16 | 0 | 0.0535 | 540.24 | 0 |
| *Selectivity* | | | | | | |
| *Marital status* | -0.0565 | -41.68 | 0 | -0.0105 | -4.92 | 0 |
| *Area* | -0.4508 | -179.59 | 0 | -0.5139 | -128.04 | 0 |
| *Children* | N.A. | N.A. | N.A. | 0.1816 | 89.63 | 0 |
| *Constant* | 1.6902 | 665.02 | 0 | 1.7773 | 443.38 | 0 |
| */athrho* | 0.6627 | 328.71 | 0 | 0.7151 | 322.34 | 0 |
| */lnsigma* | -0.7248 | -1812.34 | 0 | -0.8978 | -1899.3 | 0 |
| $\rho$ *(rho)* | 0.5802 | | | 0.6138 | | |
| $\sigma$ *sigma* | 0.4843 | | | 0.4074 | | |
| $\lambda$ *lambda* | 0.281 | | | 0.2501 | | |
| *Obs.* | 55,004 | | | 29,669 | | |

*Note: Coefficients significant to 1%. * Non-significant coefficient.*
*N/A: Not applicable.*
Source: Own work based on the ENOE carried out from 2005 to 2017. (Inegi, 2005 to 2017).

Unlike in Argentina, where women appear to exhibit greater jumps in earnings due to better life planning inasmuch as they delay starting a family and play a greater role in the country's labor market (Rubli, 2012), the results for Mexico and the country's northern border indicate that wages for women with basic-level education –compared to professionals– exhibit jumps in each segment (a change of slope) and are less responsive in comparison to the response produced and detected among their male counterparts. In other words, in Argentina, the women of the new millennium possess qualities that have enabled

them to access increased wages that are more in line with their level of education, while the wage premium appears to respond more slowly in Mexico as a result of higher levels of formal education.

The results are complemented with a projection of wage profiles by gender, based on an econometric estimation using the spline technique in Graph 3 for the northern border region and the rest of the country, respectively. Graph 3 shows how at the height of the economic crisis (Panels A and C), more highly educated women were less affected by the crisis in the northern border region, while the rest of the country experienced a decline regardless of level of education, with women's estimated wages below those of men for all levels of education.

The results of this study are in line with findings by Popli (2013) and confirm that women on the country's northern border faced a *glass ceiling* in times of crisis (in 2009) as they never exceeded male wage levels regardless of their level of education. The exception is women with professional qualifications in the rest of the country, who earn higher wages than their male counterparts. However, a *sticky floor* is observed in a post-crisis context (2017) when, in the absence of a crisis, wage levels remain unchanged and do not, in real terms, catch up with men's wage levels, which do recover –and at a faster rate– on the country's NB.

In the rest of the country, it may not be possible to confirm the *sticky floor* hypothesis in the context of an economic crisis when women attain the very highest levels of education, as women from this group have achieved increased wage levels, outearning men (with wage levels up to 5 on the logarithmic scale in Panel C), while in the absence of a crisis, their wages quickly fall again, plainly validating the hypothesis of a *glass ceiling* for women.

Graph 3. Spline Wage-Education Profile for Men and Women.
Border and Rest of Country, 2009 and 2017
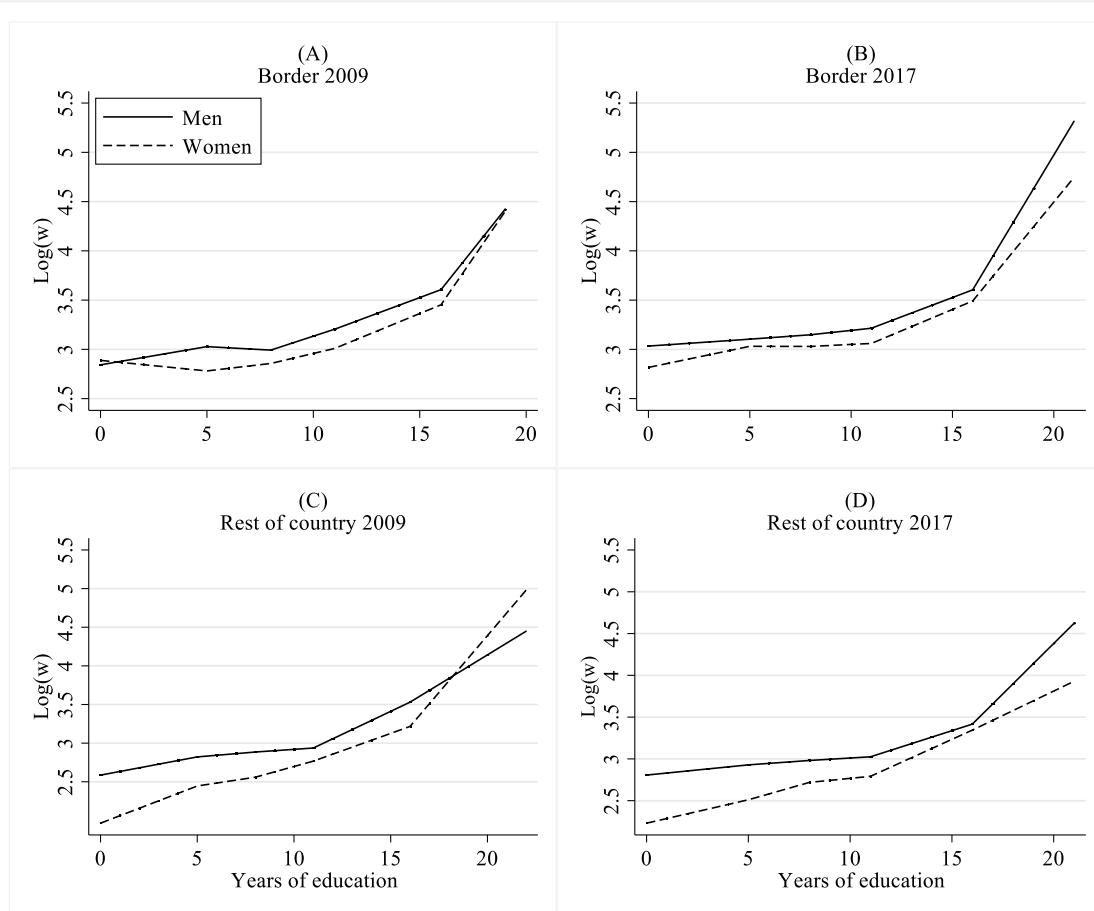


Source: Own work based on formulae (3) and (4).

Certainly, in times of greater economic growth, the results show that women are more greatly affected and, in any case, men's wages are more responsive as they increase. Economic expansions compensate men for losses in wages during economic depressions, while women's wages contract to a greater extent during an expansion. This same phenomenon occurs in Spain, as described by De la Roca (2014), as a result of an employment structure that is more rigid for men, and in which women respond more quickly to offers of employment. However, women's wages are not as quick to recover, or at least not to the same level as men.

De la Roca's (2014) work, unlike the estimation method employed in this study, introduces firstly a fixed effects regression model controlled by the trend in the country's economic cycle, and secondly, a coefficient that measures on a semi-logarithmic scale the effect of *cyclicality* (or the impact of employment and wage elasticity on the cycle),

approximated by the percentage change in wages in response to an increase of one percentage point in the unemployment rate by gender.

What his study found was that in the case of Spain, a decline of one percentage point in the unemployment rate is associated with a reduced increase in men's real wages of just 0.38%, so less than one unit. His calculation for women (which supports the results obtained for Mexico) is that, at just 0.26%, the degree of cyclicality is far lower than for men. As a result, women's capacity to access increased wages is greatly reduced, despite a higher recruitment rate in the cycle. This points to the existence of *glass ceilings* for women in Spain.

Thus, in Mexico and on its northern border, women employed in a sector such as manufacturing exhibit a reduced capacity to increase their earnings, both in the short and long term, and conditions are in place that allow us to demonstrate and determine that more highly educated women are only just able to match men's wage profiles –but they are able to do so more quickly in a context of economic crisis.[5]

The spline regression is thus a useful tool in designing wage policies as it detects non-linear variations within heterogeneous groups that exhibit identical levels of training and education, and which are differentiated in this case only by the mean effects of the set of attributes and characteristics innate to workers and considered in the model.

## CONCLUSIONS AND RECOMMENDATIONS

This study provides evidence of long-standing wage differences by gender both on the northern border and in the rest of the country. The results are presented for the manufacturing sector over an analysis period from 2005 to 2017, and by applying non-parametric techniques together with spline regression, it was possible to vary the slope of the effects of schooling on each group of workers. Yields are higher for men, with education yielding an 8% increase for men compared to 6.9% for women in the rest of the country, over the period studied, while on the northern border, the premium for a higher level of education was 8.1% and 5.3% respectively.

Although education does help to increase women's wages, it does so to a lesser extent than for men. Similarly, it was found that female workers were harder hit by the crisis than

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[5]For Spain, and without including worker fixed effects and occupation indicators, De la Roca (2014) found that semi-elasticity for men dropped from 0.379 to 0.292, but for women the drop was much steeper (from 0.221 to 0.054). The explanation is that the skill composition of more highly educated women in the country varies more along the cycle (and intra-group inequality increases), and therefore, the author warns, women who are poorly skilled or less skilled than men will be more greatly affected, unless they accept a higher rate of unemployment during low phases of the cycle in order to recoup, to some extent, their wages.

their male counterparts, with men displaying greater resilience as their wages recover better than women's once a crisis has been overcome. The evidence has confirmed that in a sector as vulnerable as manufacturing –due to the foreign demand for production– women face a *sticky floor* situation during financial crises as their wages do not overcome the decline in men's wages in the manufacturing labor market, while they experience a *glass ceiling* in the absence of a crisis, when their wages remain at the same level.

The inclusion of women in higher education is of great relevance, as it is a priority to continue to empower women with a view to their inclusion in business and employment policies that work in their favor, since education is slow to contribute –in the short term– to wage improvement for women.

These observations demonstrate the relevance of understanding and gaining an insight into the impacts of formal education with respect to employment not just in the manufacturing industry, but in other sectors with high wage dispersion and heterogeneity. Indeed, the manufacturing sector encompasses a wide range of branches that are, in turn, diverse and may remunerate workers differently. As a result, this study provides various avenues for further, more in-depth research drawing on these findings as a starting point. The approach employed here may also be replicated in other sectors and branches of economic activity, and specific types of occupations, with the goal of anticipating which sectors and occupations are most or least responsive on the basis of workers' sex, thereby determining men's and women's degree of resilience in the labor market.

Translator: Joshua Parker

## REFERENCES

Arceo-Gómez, E. O., & Campos-Vázquez, R. M. (2014). Evolución de la brecha salarial de género en México. *El Trimestre Económico*, *81*(323), 619-653.

Becker, G. S. (1971). *The Economics of Discrimination*. United States: The University of Chicago Press.

Becker, G. S. (1993). *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*. United States: The University of Chicago Press.

Calderón, C., Huesca, L., & Ochoa, G. (2017). Análisis comparativo de la desigualdad salarial entre México y Estados Unidos. *Investigación Económica*, *76*(300), 3-31.

Camberos, C., Huesca, L., & Castro, D. (2013). Cambio tecnológico y diferencial salarial en las regiones de México: un análisis de datos de panel para el sector servicios. *Estudios Fronterizos*, *14*(28), 187-211.

Castro, D., Huesca, L., & Zamarrón N. (2015). Discriminación salarial por Género en la industria manufacturera de la frontera norte de México, en el periodo 2005-2011. *Nóesis. Revista de Ciencias Sociales y Humanidades*, *24*(47), 50-80.

Castro, D.,  & Morales, B. (2011). Evolución de la desigualdad salarial regional en México, 1994-2003. *Frontera Norte*, *23*(45), 35-65.

Castro D., Rodríguez, R. E., & Brown, F. (2017). La brecha salarial por género y recesión económica en la frontera norte de México. In D. Castro & R. Rodríguez (Coords.), *Mercado laboral: México y frontera norte* (pp. 46-72). Mexico: Plaza y Valdez Editores.

De la Rica, S., Dolado, J. J.,  & Llorens, V. (2008). Ceilings or floors? Gender wage gaps by education in Spain. *Journal of Population Economics*, *21*(3), 751-776.

De la Roca, J. (2014). Wage cyclicality: Evidence from Spain using social security data. *Revista SERIES*, *5*(2-3), 173-195.

Duclos, J. Y., & Araar, A.  (2006). *Poverty and Equity. Measurement, Policy, and Estimation with DAD*. Boston: Springer.

Greene, W. (2008). *Econometric Analysis*. New York: Prentice Hall.

Heckman, J. (1979). Sample Selection Bias as a Specification Error. *Econométrica, 47*(1), 153-161. DOI:10.2307/1912352.

Huesca, L., & Ochoa, G. (2016). Desigualdad salarial y cambio tecnológico en la Frontera Norte de México. *Problemas del desarrollo*, *47*(187), 165-188.

National Institute of Statistics and Geography (Inegi). (2005). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Formato en Microdatos, (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved August 14, 2018, from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

(Inegi). (2006). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Instituto Nacional de Estadística y Geografía. Formato Microdatos (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

(Inegi). (2007). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Instituto Nacional de Estadística y Geografía. Formato Microdatos (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

(Inegi). (2008). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Instituto Nacional de Estadística y Geografía. Formato Microdatos (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

(Inegi). (2009). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Instituto Nacional de Estadística y Geografía. Formato Microdatos (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

(Inegi). (2010). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Instituto Nacional de Estadística y Geografía. Formato Microdatos (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

(Inegi). (2011). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Instituto Nacional de Estadística y Geografía. Formato Microdatos (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

(Inegi). (2012). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Instituto Nacional de Estadística y Geografía. Formato Microdatos (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

(Inegi). (2013). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Instituto Nacional de Estadística y Geografía. Formato Microdatos (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

(Inegi). (2014). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Instituto Nacional de Estadística y Geografía. Formato Microdatos (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

(Inegi). (2015). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Instituto Nacional de Estadística y Geografía. Formato Microdatos (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

(Inegi). (2016). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Instituto Nacional de Estadística y Geografía. Formato Microdatos (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

(Inegi). (2017). Encuesta Nacional de Ocupación y Empleo. Población de 15 años y más de edad. Instituto Nacional de Estadística y Geografía. Formato Microdatos (*dta*) para Software *Stata* al segundo semestre con soporte digital. Retrieved from https://www.inegi.org.mx/programas/enoe/15ymas/default.html#Microdatos

Mayer-Foulkes, D., & Cordourier, G. (2001). La brecha salarial y la teoría de igualdad de oportunidades: Un estudio de género para el caso mexicano. *El Trimestre Económico*, *68*(269), 71-107.

McConnell, C. R., Brue, S. L., & Macpherson, D. A. (2003). *Contemporary Labor Economics* (6th ed. adapted). Spain: McGraw-Hill/Interamericana de España.

Mendoza, E., & García, C. (2009). Discriminación salarial por género en México. *Problemas del desarrollo*, *40*(156), 77-99.

Mincer, J. (1974). *Schooling, Experience and Earnings*. New York: Columbia University Press.

Pagán, J. A., & Ullibarri, M. (2000). Group Heterogeneity and the Gender Earnings Gap in Mexico. *Economía Mexicana. Nueva Época*, *9*(1), 23-40.

Popli, G. (2013). Gender Wage Differentials in México: A Distributional Approach. *Journal of the Royal Statistical Society Series A*, *176*(2), 295-319.

Rubli, A. (2012). La importancia de corregir por el sesgo de selección en el análisis de las brechas salariales por género: un estudio para Argentina, Brasil y México. *Ensayos Revista de Economía*, *31*(2), 1-36.

Sauceda, A. L., & Varela, R. (2013). Salarios relativos y dinámica manufacturera en México. *Análisis Económico*, *28*(69), 130-148.

Silverman, B. W. (1986). *Density Estimation for Statistics and Data Analysis*. London: Chapman and Hall.

Varela, R., & Retamoza, A. (2012). Capital humano y diferencias salariales en México, 2000-2009. *Estudios Fronterizos*, *13*(26), 175-200.