# International Migration and the Gender Wage Gap*

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**Abstract**

This article discusses the effect of mostly male international migration in the wage gap between females and males who remain in Mexico. We use historical distance through railroad networks to the border at the beginning of 20th century as an exogenous factor causing changes in the relative supply of males and females due to mostly male migration at the municipality level. A decrease in the relative supply by males tends to increase the wage gap between females and males, implying they are not perfect substitutes.

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## 1. Introduction.

The number of international migrants around the world has reached 232 million in 2013. Of these, about 11 million are migrants of Mexican origin in the United States over the age of 15 years, representing more than 10 percent of the Mexican population in that age group (OECD and UN, 2013). Because of the large proportion that these migrants represent in the economies of origin prior research has tried to establish the effect of these changes in labor supply on the wages of those who remain in Mexico (Aydemir and Borjas 2006; Hanson 2007; Mishra 2007). However, previous studies have not considered that the phenomenon is mostly male and the differential effect that this characteristic could have on males and females if they are not perfect substitutes in the labor market.

Mexico is still a country with relatively low female labor participation with only 44.3 percent of females in the labor market compared with 53.7 in Latin America and 51.3 around the world (UNDP 2013). However, in the past two decades Mexico has experienced an increasing participation of females in the labor market. Among urban households female labor participation went from 40 percent in 1988 to 57 percent in 2010 (Campos-Vazquez et al. 2012). This change in the labor force participation of females can be explained in part due to changes in the family structure caused by a predominantly male migration to the United States (Raphael 2012). The effect of changes in the relative supply of males and females on wages has not been tested independently in the case of Mexico, ignoring their effect on the wage gap between males and females, as well as its effect on the evolution of wage inequality. In this work we aim to establish the impact of changes in the relative labor supply between males and females on their wage gap. One of the obstacles faced to establish the effects on wages of the increasing female labor force participation is the

difficulty to find exogenous factors increasing that variable. Instead of factors affecting female labor participation, this article uses the exogenous component of labor migration to the United States as the main factor that modifies the gender composition in the Mexican labor market. This work exploits two peculiarities of Mexican migration to the United States. The first is the greater male involvement in the phenomenon. The second is the concentration of the migration in some regions of the country in early periods. This allows us to exploit the interregional variation in gender composition in the labor market due to different rates of migration over time. Specifically, we use interactions of the census period and distance to the border with the United States by rail at the beginning of the 20th century as instruments thinking that closeness to the border explains mostly male migration in earlier periods.

To our knowledge this is the first article analyzing the effect of changes in relative labor supply on gender wage gap in Mexico. The most related article with us in the context of a developed country is Acemoglu et al. 2004. They use differences in male mobilization rates in World War II at the state level as the main factor that modifies the labor participation of females in the United States and hence the relative labor supply between males and females. That article shows that greater female labor force participation affected negatively the wages of males and females, with a higher negative effect to females. A 10 percent increase in labor supply of females relative to males decrease wages by 7-8 per cent among females and by 3-5 percent among males. The effect on male is concentrated among unskilled. In a neoclassical theory of supply and demand results can be interpreted as males and females not being perfect substitutes in an aggregate production function..

Another related article is Freire 2011 that analyzes the effects of the relative changes of the labor supply between males and females on wages in Brazil. Rural-urban migration is the exogenous factor that produces changes in the relative supply in the urban economies. The article finds evidence that a greater female participation tends to increase the wage gap between males and females. Instead of using push factors in the source economy as instruments to changes in the relative supply of females and males in the urban destination economy, our work uses exogenous factors that will increase the international migration to the United States, mainly composed of male migrants, and analyze the effects on the source economy.

In addition to the direct effect of the relative supply of males and females due to the relative decrease in males in the economy, migration can also change the incentives of labor force participation. Among remittance recipient households there is evidence of a decline in the labor supply of females possibly due to a remittance income effect (Amuedo-Dorantes and Pozo 2006; Binzel and Assaad 2011; Hanson 2007). This could nullify the relevance of our instrument if predominantly male migration produces a similar drop in female labor force participation because changes in relative labor supply will be minimal or zero. However, a change in the relationship of males and females in the population can also have effects on incentives for female labor force participation out of households involved in the migration. A lower quantity of males may imply a lower expected probability of marriage, which could induce a greater labor force participation of females. Evidence from Mexico shows a positive impact of international migration on female labor force participation at state level (Raphael 2012). As will be shown, the net effect of migration is to lower the relative supply of males in our identification strategy.

Our empirical strategy uses data from the Mexican census of 1990, 2000 and 2010 in the municipalities between 10,000 and 100,000 inhabitants. In those municipalities is where international migration is higher and where tends to concentrate on males. To instrument changes in relative labor supply between regions and census periods we use interactions of the census period and distance to the border with the United States by rail at the beginning of the 20th century as instruments. Results indicate that the elasticity of substitution between males and females is high, but not perfect. In our favorite specification a 10 per cent decrease of labor supply of males causes an increase of 2.2 in the wage of females and a 3.6 increase in the wage of males. This implies an elasticity of substitution of 7.10 between males and females and a labor demand curve elasticity of 2.78 in the short term. This last result is close to previous literature using education experience cells at national level in the case of males for Mexican labor market (Aydemir and Borjas 2006; Mishra 2007). However, also shows that the effect is not the same among females. The results imply that the mostly male migration tends to have a positive effect on the wages of males and females who remain in Mexico in the short term; this effect is greater among males, increasing the gender wage gap. Previous literature on the US labor market has pointed out that males and females do not offer the same set of skills for the same level of education. Females tend to offer more cognitive and interpersonal skills rather than physical skills (Beaudry and Lewis 2014). Then, changes in the supply of one gender will affect more wages in the same gender. This can be a possible explanation if our results of not perfect substituibality are due to differences in skills between gender groups.

In the next section we provide a theoretical framework guiding interpretation of results. In section 3 we present data and the identification strategy. In section 4 we show the results. Finally, section 5 offer concluding remarks.

## 2. Theoretical Framework

To analyze the effect of an increase in the relative supply between males and females in the labor market due to male migration we follow closely the model in Acemoglu et al. 2004 adapted to changes in relative supply mainly due to male international migration. This framework builds on the general assumption of competitive labor markets, where demand and supply determine wages without rigidities. In a broad classification the framework is part of neoclassical theory. Assume we have an aggregate production function Cobb Douglas between capital $K_t$ and labor $L_t$ and that labor is composed of male $M_t$ and female $F_t$ through a constant elasticity of substitution function.

$$Y_t = A_t K_t{}^{\beta}[(1-\lambda)(\alpha_t^m M_t)^{\rho} + \lambda(\alpha_t^f F_t)^{\rho}]^{\frac{1-\beta}{\rho}} \quad (1)$$

The elasticity of substitution between male and female is equal to $\sigma_{mf} = \frac{1}{1-\rho}$ with $\rho \leq 1$ Assuming that the work is paid according to their marginal productivity in equilibrium, wages for females and males can be expressed as:

$$w_t^f = (1-\beta)\alpha_t^f \lambda A_t K_t{}^{\beta}\left[(1-\lambda)\left(\frac{\alpha_t^m M_t}{\alpha_t^f F_t}\right)^{\rho} + \lambda\right]^{\frac{1-\beta-\rho}{\rho}} (\alpha_t^f F_t)^{-\beta} \quad (2)$$

$$w_t^m = (1-\beta)\alpha_t^m(1-\lambda)A_t K_t{}^{\beta}\left[(1-\lambda)\left(\frac{\alpha_t^m M_t}{\alpha_t^f F_t}\right)^{\rho}+\lambda\right]^{\frac{1-\beta-\rho}{\rho}}(\alpha_t^f F_t)^{-\beta}\left(\frac{\alpha_t^m M_t}{\alpha_t^f F_t}\right)^{\rho-1} \quad (3)$$

In this setting we assume that $F_t$ and female $M_t$ are exogenous and $w_t^f$ and $w_t^m$ are endogenous. We are interested in how male migration affects the wages of males and females through changes in the relative labor supply. If we assume that the number of females in the labor market remains constant we need to know how changes in $\frac{M_t}{F_t}$ affects wages without considering effects through $(\alpha_t^f F_t)^{-\beta}$ in both equations. Using logarithms and deriving expressions (2) and (3) above with respect to $\log\frac{M_t}{F_t}$ we obtain:

$$\left.\frac{\partial \log w_t^f}{\partial \log\frac{M_t}{F_t}}\right|_{F_t} = -\beta s_t + \frac{1}{\sigma_{mf}} s_t \quad (4)$$

$$\left.\frac{\partial \log w_t^m}{\partial \log\frac{M_t}{F_t}}\right|_{F_t} = -\beta s_t - \frac{1}{\sigma_{mf}}(1-s_t) = \frac{1}{\sigma_m} \quad (5)$$

With $s_t = \frac{w_t^m M_t}{w_t^m M_t + w_t^f F_t}$, the participation of the wages paid to males in the total of salaries paid. Previous expressions show us that the effect of a change in relative supply on wages is not equal between males and females. Specifically, the difference is $-\frac{1}{\sigma_{mf}}$. When the elasticity of substitution tends to infinity, meaning that males and females are perfect substitutes in the production function, we can expect that the effect of a reduction of male population due to migration on wages is the same and positive for both males and females. On the other hand, if males and females are not perfect substitutes, we expect a higher positive effect on male wages due to a reduction of males supply. Previous literature about

the effect of international migration on wages in Mexico has ignored the effect of international on females or has considered that males and females are perfect substitutes (Aydemir and Borjas 2006; Hanson 2007; Mishra 2007). Intuitively, what expressions (4) and (5) indicate is that changes in the labour supply will have a greater impact on prices in the own market than in related markets. While more substitutes are skill groups more can be considered within the same market. This considers that other factors as capital remain constant. Also, the derivation of equations consider that changes in relative supply do not affect the evolution of specific productivity of males and females measured by $\alpha_t^f$ and $\alpha_t^m$, neither other determinants of wages as bargaining power of males and females.

## 3. Data and Empirical Strategy

Data for this study come from the expanded questionnaire of Mexican population census in 1990, 2000 and 2010.[1] These censuses have information on labor force participation and hours worked last week and wages in the current year, as well as other variables relevant such as age, years of schooling, sector of activity, locality size, indigenous population, among others. With these data we can build variables about hourly wages, relative population of males and females and the relative number of hours worked at municipality level.

International migration from Mexico to the United States is a phenomenon historically related to the distance to the border as well as to distance by railroad networks (Durand, Massey and Zenteno 2001). To facilitate the preliminary analysis of the relation of distance

[1] Data available at http://www.inegi.org.mx

to the border with international migration and other factors we have divided the country into 6 regions, following Hanson and Woodruff 2003. In the first panel of Table 1 we present descriptive statistics of the population aged 18-60 years according to the 1990 census and region. Knowing differences as we move from the border will allow discuss possible controls when using distance to the border as instrument for relative supply.

We can observe that as we move away from the North regions we find population with less schooling, a lower hourly wage, more population living in municipalities with less than 100,000 inhabitants and speaking an indigenous language. The share of population working in agriculture or industrial activities rises as the historical distance to the border increases. The exception to the patterns is the Mexico City Valley region, where the capital of the country is located, and the Yucatan region. Compared to other regions, Mexico City Valley has a better-educated population, lower proportion of rural and indigenous population as well as a smaller proportion of the population working in agricultural or industrial activities. However, the hourly wage tends to be lower than the prevailing in the North of the country. In Yucatan, the farthest region and with less population, wages are somewhat greater than in the South, but lower than in the other regions of the country; human capital, rural population and the share of workers in agricultural and industrial sectors tends to coincide with the Central region, but the presence of indigenous population closely resembles the data of the South.

Our identification strategy uses as an exogenous factor diminishing relative supply of males the migratory networks around the railways built at the end of the 19th century. The installation of the railways involved a decrease in the costs of transportation to the border, facilitating migration. The panel of historical data in Table 1 shows the average distance to

the border in each region, weighted by the population in the municipalities in 1990. We use data about the municipality distance to the nearest railway station and add the distance from the station to the border divided by 5 to capture the effect of the decrease in transportation costs. Then we get the minimum of that distance and the direct distance to the border. This instrument has been used to measure the impact of remittances on banking breadth at municipality level (Demirgüç-Kunt et al. 2011).

Table 1 also shows some of the historical context in which the railroad networks were installed. The Mexican population had a different regional distribution than in 1990. We find that population was concentrated more in the Center North, Center and South regions in 1900. Center North went from 15 percent of total Mexican population in 1900 to only 10 per cent in 1990, while population in Center Mexico went from 47 per cent to 34 per cent. In these two regions we locate states with historically high migration to the United States. South region also experienced a reduction in their participation in total population from 13 to 10 per cent. The population living in small localities, less than 500 inhabitants, represented an important part of the total population, especially outside the Mexico City Valley. These historical features provide a possible explanation for the installation of migratory networks in the Center and Center North of the country instead of the closest border areas. In those years there was little population close to the border and was relatively dispersed in small villages. By their higher schooling probably they will demand higher wages. Then, despite the geographical proximity, could be costly to find low wage labor among a small and relatively dispersed population. From the point of view of the

contractors, the greater distance from the central areas could be offset by a relative ease to find potential low wage workers.[2]

Historical characteristics in Table 1 are correlated with the distance to the border and also could influence relative supply in the labor market and wages at the present. Indigenous population increases as we move from the border. As we have seen in Table 1, South and Yucatan regions tend to have a higher share of indigenous population and are the regions with the lowest wages. Table 1 also shows that literacy was higher in the North and in Mexico City Valley at the beginning of the 20$^{th}$ century and that the South was the region with the lowest indicator. Comparing with the data in 1990, we see a historical persistence of differences in human capital among regions. In the estimates we attempt to control for these variables to capture the effect of the instrumental variable on international migration and no other historical factors correlated with the distance to the border by rail at the beginning of the 20th century.

The importance of migrant networks to explain migration increases when we consider low income individuals with lack of access to credit. This constraint only can be overcome through informal mechanisms of credit by prior migrants. It is also possible that high-income individuals migrate with his whole family. Then, it is expected that the effect of the historical distance on relative population and hours worked between males and females is more noticeable in the municipalities or metropolitan areas with lower income, generally small municipalities with high rural population or small cities. This can be seen in Table 2. The proportion of the Mexican population between 18 and 60 years decreased in municipalities with population fewer than 100,000 inhabitants, going from 4.8 per cent in

[2] The interpretation is close to Durand, Massey and Zenteno 2001.

in 1990 to 4.1 percent in municipalities with less than 10,000 inhabitants and from 28.9 percent to 26.6 percent in municipalities between 10,000 and 100,000 inhabitants. This occurs after excluding those municipalities being part of bigger metropolitan areas. The change is higher if we concentrate only in males, going from 4.9 to 4.1 percent in the smaller municipalities and from 29.3 to 26.4 in municipalities between 10,000 and 100,000 inhabitants. The last two rows show migration data between 1995 and 2010 data by size of municipality. 51.8 per cent of international migrants that left at least one member of their household in Mexico come from municipalities with less than 100,000 inhabitants. In addition, male involvement in this migration is much greater in this type of municipalities, reaching 54.4 of male migration. Therefore, our analysis focuses on municipalities with population less than 100,000 inhabitants. We also exclude municipalities with population less than 10,000 inhabitants since the hours worked variable is constructed from a sample of 10 percent of the population and female labor participation is low, which threats with higher measurement error in small municipalities. We include 960 municipalities or metropolitan areas that accounted for about 34 percent of the population in Mexico in 1990 and 28.9 of population aged 18-60.

### *3.1.Preliminary evidence*

Our identification strategy weights that migratory networks at the beginning of the 20th century have produced a late incorporation of the outermost municipalities or metropolitan areas to migration to the United States. The influence of the historical distance to the border in the evolution of the relation between males and females in the population and hours

worked can be seen in Figure 1. The y axis shows the change in population of males divided by the population of females (panels a.1 and b.1) and the change of hours worked by males divided by the hours worked by females (panels a.2 and b.2) at municipality level between 1990 and 2010, in municipalities with a population between 10,000 and 100,000 inhabitants. Horizontal axis represents the historical distance to the border in thousands of kilometers. Figure 1 allows analyzing changes according to the historical distance to the border in the population and hours worked between males and females. Each point represents a municpality weighted by the size of their labor force between 18 and 60 years; also includes a trend line of the data. Panels a.1 and a.2 shows what happens in all municipalities between the established population limits. As the distance to the border increases, we find a decrease in the relative population of males between 1990 and 2010, consistent with the incorporation of the farthest municipalities to a mostly male phenomenon of migration.

The slope of regression line in panel a.1 is -0.061 (s.e. 0.014). The coefficient multiplied by the mean distance to the South states imply that in southern states the ratio of male population has decreased in 2.4 percent taking the border as reference between 1990 and 2010. The slope in panel a.2 is –0.390 (s.e.0.064). This implies that in southern states the relative supply of males in the labor market has decreased in approximately 15.9 per cent between 1990 and 2010. In both cases slopes are statistically significant. Together the data show that besides the direct effect on relative supply due to mostly male migration, there exists another effect due to higher changes in supply of females as we move from the border. This is consistent with changes in incentives to labor force participation among females in response to migration of males as identified in Raphael 2012. Panels b.1 and b.2

show that this relationship is maintained if we omit the analysis of the farthest region, the Yucatan Peninsula, which until the recent period is characterized by low rates of migration. Slopes in this case are -0.110 in the case of population ratio and -0.720 in the case of the logarithm of relative hours worked. Also, coefficients are statistically significant and imply changes close to double between the border and southern States. It seems that the weakening of distance to the border as a factor preventing migration has not reached Yucatan Peninsula. Then, we omit this region in the empirical strategy.

To observe the relationship between the distance to the border and changes in relative wages between males and females in the metropolitan areas between 10,000 and 100,000 inhabitants we build Figure 2. Each dot represents the combination of historical distance and the change in the gender wage gap between 1990 and 2010 at municipality level. The graph shows the change in the wage gap between males and females in each municipality obtained using an OLS regression of the logarithm of wages with a dummy for males as explanatory variable after controlling by age, age squared and schooling. Fitting these points we find an increase of the gender gap as we move to the more remote municipalities. The coefficient of regression is 0.221 (s.e. 0.038). This parameter, multiplied by the distance to the South, implies that the adjusted wage gap increased by approximately 9 log points in municipalities in the South with respect to the border between 1990 and 2010. This is not due to the farthest metropolitan areas of the Yucatan Peninsula. Without those municipalities coefficient becomes 0.412 (s.e. 0.056), implying an increase of 17 log points.

Altogether figures 1 and 2 suggest that a decrease in the relative amount of hours worked by males increases the wage gap. Figure 3 provides additional preliminary evidence. It shows the relationship between the change in the relative amount of hours worked and the

change in the wage gap between 1990 and 2010. The relation suggested by the graph is that a greater decrease in the number of hours worked by males increases the wage gap, consistent with no perfect substitution between males and females in the labor market. In the empirical strategy below we find similar results.

*3.2 Empirical Strategy.*

We estimate the following regression based in the theoretical model in Section 2 and equations (4) and (5) that shows the relationship between the logarithm of relative supply and the logarithm of wages for males and females:

$$\log w_{ist} = \alpha_s + \gamma_t + g_i + X_{ist}\beta_t^g + \theta \log \frac{M_{st}}{F_{st}} + \varphi m_i \log \frac{M_{st}}{F_{st}} + u_{ist} \qquad (6)$$

The equation estimates hourly wages for individual i in municipality s and period t males and females jointly. $\alpha_s$ is an effect for each municipality. This allows controlling for fixed differences in wages between municipalities. $\gamma_t$ is an effect for each census period. $g_i$ represents an effect for males. $X_{ist}$ is a set of individual or municipality control variables. We allow $\beta_t^g$ vary in each of the three census periods and according to the sex of the individual. The parameters of interest are $\theta$ and $\varphi$. The first measures the elasticity of wages with respect to the relative supply of males. The second uses the interaction $m_i \log \frac{M_t}{F_t}$ to measure if there is any further effect in the elasticity for males. According to the theoretical framework presented in the previous section, the difference in elasticities between males and females corresponds to the following identity between the estimated and the structural parameters. $\varphi = -\frac{1}{\sigma_{mf}}$. In addition, the common effect has the following

relationship $\theta = -\beta s_t + \frac{1}{\sigma_{mf}} s_t$. We allow clustered errors at municipality level to avoid overrejection rates of null hypothesis detected in panel data using difference in difference methods (Bertrand et al. 2004; Cameron et al.2008).

To identify the effect of relative supply on wages, it is necessary that their changes are exogenous. In this research, we use the mainly male migration to the United States as a factor that alters the relative supply exogenously. It is possible that the current migration decisions are not exogenous to the evolution of wages. The decision to migrate depends on a comparison between the wages of the source and destination economies, among other factors. An increase in wages could inhibit the migration and modify the relative supply. Then, international migration wouldn't be an exogenous factor and we can´t interpret instrumental results in a more causal manner. However, the evolution of migration to the United States has causes not related to contemporaneous wages. Migratory networks had historical origins as the densely populated places which were located near the railway lines in past times. To avoid endogeneity between the current migration and wages will use the distance between the municipality or the metropolitan area and the border with the US through railway lines in 1900 as instrumental variable, following Demirgüç-Kunt et al. (2011).

In the first stage, we use the interaction of the historical distance to the border with the census periods and the interaction of the historical distance with the dummy of sex and census period as instruments in the following way:

$$\log \frac{M_{st}}{F_{st}} = \mu_s + \mu_t + \mu_i + X_{ist}\beta_t^g + \delta_t D_s Y_t + \omega_t m_i D_s Y_t + \varepsilon_{ist} \qquad (7)$$

$$m_i \log \frac{M_{st}}{F_{st}} = \pi_s + \pi_t + \pi_i + X_{ist}\beta_t^g + \rho_t D_s Y_t + \vartheta_t m_i D_s Y_t + \epsilon_{ist} \qquad (8)$$

We have the same controls that in main equation and effects for municipality, census period and gender. The instruments are interactions of distance to the border of municipality $D_s$ with census period $Y_t$ , and the interactions of the dummy for males $m_i$ with distance to the border of municipality $D_s$ and census period $Y_t$ . Parameters $\delta_t$, $\omega_t$, $\rho_t$and $\vartheta_t$ capture the differential effect of distance to the border as census period changes on the relative supply. Given their lowest wages the incentives for migration are higher as we move south of the border, but costs associated with the greater distance to the border also inhibited the migration process in its early stages for these poor municipalities. We expect that as the distance to the border increases we find a greater relative supply by males in 1990 and that this relationship tends to weaken in 2000 and 2010 when incentives to migrate and the great surge of Mexican migration to the United States in the 80s and 90s tend to overcome costs for low wage migrants. If we concentrate in females ($m_i = 0$) , and substituting equations (7) and (8) in (6), historical distance and their interactions only affect female wages through parameters $\delta_t$ in equation (7). We expect that, taking $\delta_{1990}$ as baseline, $\delta_{2000}$ is negative and $\delta_{2010}$ more negative, that is, a lower effect of distance in relative supply of males as time advance.

## 4. Results.

Table 3 presents the results of equation (6) with different sets of controls, both in ordinary least squares (OLS) and instrumental variables (IV). In the column (1) we include sex, an effect for each municipality and for each census period, without additional controls.

Results from ordinary least squares show that φ is negative and and θ positive. The results of instrumental variables show that both φ and θ are negative. However the sum of both, barely differs of OLS. The specific effect on males' wages is similar in OLS and instrumental variables. According to the theoretical framework exposed in section 2, results of instrumental variables are consistent with an elasticity of substitution between males and females of $\sigma_{mf} = 8.05$, or $\rho = .88$ . The elasticity of labor demand in the short run for males $\sigma_m$ can be obtained in two ways from the results. The first is the inverse of the sum of φ and θ. This is the estimated $\sigma_m$ in Table 3. The second is by using equation 5 which requires an estimate of the elasticity of substitution between males and females $\sigma_{mf}$, and data about $\beta$ and $s_t$. The first corresponds to the share of income paid to capital and the second to the proportion of the wages paid to males. We use $\beta = \frac{1}{3}$ and $s_t = .7606462$ that is the data in the sample for 2000 Census. $\sigma_m$ calculated with this method is shown in the row Implied $\sigma_m$ in Table 3. If the estimates actually correspond to structural parameters of the Mexican economy both ways to get $\sigma_m$ should match. We add a row with the result of the test of equality of both methods. In the first column of Table 3 the evidence is that both methods give results statistically non different. Table 1 also shows F statistics of the instruments in equations 7 and 8. In both cases the set of instruments are jointly significant in the first stage with F statistics far above 10. However, when we test the hypothesis that the instruments were correctly excluded from the first stage using a Hansen J statistic, we find evidence against the null that the instruments were correctly excluded from the main equation.

To determine whether the results of the first stage are consistent with a progressive relaxation of migration networks as source of migration differences at municipal level we

need to observe the results of the parameters $\delta_{2000}$ and $\delta_{2010}$ in equation 7. These parameters show the effect of the historical distance in the relative supply taking females as reference. In estimation we use the year 1990 as the base group. Negative and statistically significant value of the parameter $\delta_{2000}$ indicates that in 2000 the relative labour supply of males was lower than in 1910 as we move away from the border, consistent with a progressive relaxation of migratory networks built around the construction of the railway at the beginning of the 20th century to promote male migration in small municipalities. The result of the $\delta_{2010}$ parameter indicates a lower relative supply of males as the historical distance increases in 2010 compared with 2000 and 1990, which is consistent with a further relaxation of migratory networks built around the construction of the railway at the beginning of the 20th century as factor explaining migration in small municipalities.

Historical data of Table 1 show that distance was correlated with factors possibly affecting wages and labor supply. It is possible that changes in relative supply between 1990 and 2010 are due not to the historical distance, but to other possible factors correlated with it and whose effect on wages of males and females has also changed in recent decades after controlling by fixed effects at municipality level and the temporal trend of variables. This would violate the exclusion criterion required for a more causal interpretation of instrumental variables as happens in column (1). By example, the entering into force of North American Free Trade Agreement (NAFTA) in 1994 could affect municipalities according to the distance to the border, possibly improving wages in the closest areas, also could change incentives for females to participate in the labor force due to sectoral changes in labor demand. Moreover, this could promote migration of the southern municipalities with relatively low wages in 1990. Then, the interaction of historical distance and census

period will be not an exogenous factor changing relative supply of males. To try to capture these possibilities and other features correlated with distance affecting wages and the relative labor supply, we include a set of interactions of region with census periods.

In Table 1 we also see that as the distance to the border grows the share of indigenous population increases. If recent changes in social norms about labor force participation have been taking place among indigenous population, this could be correlated with the interaction of historical distance and census periods. At the same time, the evolution of wages in municipalities with high indigenous participation might have a different behavior due to military conflicts in indigenous regions after 1994. This could affect differently male and female wages, by example, if social programs target males´ income to inhibit their enrollment in rebel groups. By that we add the percentage of population speaking and indigenous language interacted with the census period and the sex of individuals. In addition, it is possible that the distance to the border is only one indicator of differences in the size of municipalities which could affect the possibilities of participation and wages in different way depending of gender. Southern municipalities typically have a higher number of municipalities. By that we add a set of interactions between the size of municipality in 1990 with gender and census period.

The results of OLS and IV including these effects are shown in column (2). Again, in OLS we find that $\varphi$ is negative and $\theta$ positive with small changes in their values. However, the results in instrumental variables are substantially different to those found in the previous specification. Now, the absolute value of $\theta$ is much greater. This has important implications when compared with column (1). The sum of $\varphi$ and $\theta$ represents the total effect on the wages of males due to an exogenous decline in labor supply caused by migration. The

inverse of this sum is the elasticity of aggregate labour demand in the short term. Values and of φ and θ imply an elasticity of labour demand for males in column (1) of -5.04 and in column (2) of -1.82. Conducting a test in column (2) the direct calculation of male labor demand elasticity is statistically different that the implied elasticity in equation (5). The joint significance of the instruments exceeds the value of 10 in the statistical F for the first stage as in column (1). Now the test of exogeneity of instruments shows more evidence that the instruments were correctly excluded of the main equation, however the null of correct exclusion is still rejected. Results of $\delta_{2000}$ and $\delta_{2010}$ are consistent with a progressive relaxation of migration networks built around the railroad infrastructure at the beginning of 20th century.

The same specification of column (2) is carried out in column (3), but modifying the definition of distance. Instead of considering railway costs represented 1/5 of the cost in other ways at the beginning of the 20th century, is considered one smaller, 1/3 reduction. This is the lower limit of cost reduction by railways constructed at the beginning of 20th (Demirgüç-Kunt et al. 2011, 236). The estimate of the elasticity of substitution between males and females is equal to 7.10, similar to the previous specifications and significantly different from zero. The elasticity of labour demand in the case of males is no different if calculated using estimates of φ and θ or using the calculation implicit in equation 5. The estimate implies that is the elasticity of labor demand is close to - 3.51 or - 2.78. There is also evidence that the interactions between the distance, the census period and sex were properly excluded from the main equation of wages. As in previous specifications, the results of $\delta_{2000}$ and $\delta_{2010}$ show a progressive relaxation of early migratory networks to explain the patterns of migration in recent years.

The variables of age and education affect individual wages. Their inclusion in our identification strategy, however, is problematic. Previous literature has shown that international migration affects the incentives for the formation of human capital, with differential effects according to sex (McKenzie and Rapoport, 2011). Then, inclusion of education as a variable on the right side of the equation of wages cold confound the effect of instrumental variable in the gender composition of the labour force due to international migration witth their differential effect in education of genders. A similar argument could arise for age; international migration is normally composed of young individuals. In addition, it could exert effects on the labor force participation of females depending of age group. Then, the results of the columns (3) should be interpreted as effects on the wage gap including their effect through changes in incentives to the accumulation of human capital and in the composition of age groups in the labor force. With the previous consideration in mind in column (4) we include age and age squared and schooling in the specification in column (2). The results for the elasticity of substitution between males and females and the elasticity of labor demand for males show no substantial changes compared with column (3). However, exclusion restriction fails to hold according to the exogeneity test.

*4.1.Gender Wage Gap by Skill.*

The Mexican migration to the United States has been characterized by a low participation of individuals who have completed college education. Therefore, we expect that the effects on relative supply are stronger among low-skilled workers. International migration, however, also has effects on the accumulation of human capital. It is therefore difficult to

carry out an analysis by level of qualification without strong exogeneity concerns. Then, the evidence below regarding the effect on different levels of qualification is only descriptive. Figure 4, panels a.1 and a.2 shows the correlation between the historical distance to the border and the change in relative supply for population with more than 12 years of schooling (skilled) and among those with less or 12 years of schooling (unskilled). The line represents the fitted values of a simple regression using the size of the labour force at that level of qualification as weight. What the graphical evidence shows is that the relative supply of skilled workers does not change with distance from the border; the modification of the relative supply in previous sections comes from the less skilled. This is consistent with Mexican international migration coming mainly from workers with less than a bachelor degree.

In column (5) of Table 3 we perform the same test as in column (4), but only for individuals with less or 12 years of schooling. Results for elasticity of substitution between males and females are lower in IV estimates, going from 7.62 to 4.97. The elasticity of labor demand for males is not statistically different in the two methods, but estimated $\sigma_m$ tends to higher in this specification than in the previous three columns. The endogeneity test shows evidence that interactions of historical distance, census period and the sex variable were properly excluded from the main equation. Results in column (5) further suggest that not perfect substituibility holds within skill experience cells.

*4.2.Discussion.*

Some implications of the results should be discussed for its interpretation. Previous literature has shown that in an advanced economy like the US males and females with the same level of education offer a set of different skills in the labour market, with females developing tasks that require relatively more intellectual skills and males tasks requiring more physical skills (Beaudry and Lewis, 2014). This could be an explanation for our findings. However, it is also possible that the results may be due to the increase in the labor force participation of females with lower unobserved abilites. Since international migration causes a significant change in the labor force participation of females, it is not possible to distinguish between the above explanations from our results. Further research is required to do so. Another possible source of wage gap increase is that international migration allows males to acquire skills in the US labour market to a greater extent than females. Census data does not provide an accurate measure of all return migrants. Then, it is not possible to fully control for this possibility. Finally, the structural interpretation of the obtained parameters rests on the assumption that the number of hours worked by females remains relatively constant. Mexican international migration is not exclusively male; females also migrate in the municipalities of analysis. This would affect wages through the element the element $(\alpha_t^f F_t)^{-\beta}$ in the equations (2) and (3) and the interpretation of the common element $\theta$ in our estimates. However, this would not affect the estimation of $\varphi$, the parameter needed to establish the degree of substitutability between males and females which is the aim of this research. In addition, it is possible that the number of hours worked by females remains relatively constant due to the increase in its labor force participation.

Migrants are regularly younger than non-migrant population. Then, it is possible that the effects found in Table 3 are also met in a younger population. Table 4 explores this

possibility. We reply specifications of Table 3, but only with individuals between 18 and 40 years. The results do not differ substantially from that found using the full sample. There is evidence of a not perfect substitutability between males and females in an aggregate production function. Point estimates differ just slightly from that found in Table 3 column by column. We found the greatest evidence of that instruments were properly excluded from the main equation again in columns 3 and 5, although in column 3 we cannot reject the null at conventional levels of confidence. Again the coefficients of the first stage, $\delta_{2000}$ and $\delta_{2010}$, show that as the census periods advance the relative supply of males decreases in the more remote municipalities, which is consistent with a progressive relaxation of the importance of the migratory networks built at the beginning of the 20$^{th}$ century around the railroad networks as a determinant of international migration.

## 5. Final Remarks.

In this article, we have found that substitutability between males and females is not perfect in the Mexican labor market. Using local markets in small cities we find a similar effect of migration on males who remain in Mexico that utilizing cells of education experience at national level as in Mishra 2007. The effect of a 10 per cent labor supply decrease of males due to migration is an increase in hourly wages of 3.6 per cent for males and a 2.2 per cent increase for females in the short term. Results of imperfect substitutability between males and females imply that the mostly male migration has increased the gender wage gap between males and females. Then, even when mostly male migration to the United States have been causing a higher labor demand participation for females Rapahel 2012, the effect

on the gender wage gap is non positive. Multiplying the effect of distance on relative supply by the mean distance of South municipalities, in our favorite specification relative male labor supply was 15 per cent higher in municipalities in the South compared with those at the border due to historical distance in 1990. This means a higher gender wage gap in 2 percentage points (0.15*0.15) in 2010 compared with 1990, after a surge in migration in that region. Our results also imply that direct comparisons between households receiving and not receiving remittances could be misleading and have to be taken cautiously given that migration and remittances have effects at municipality or other levels of aggregation.

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**Table 1. Descriptive statistics.**

| | North | Center North | Center | México City Valley | South | Yucatan |
|---|---|---|---|---|---|---|
| **1990** | | | | | | |
| Share Mexico Population | 0.17 | 0.10 | 0.34 | 0.24 | 0.10 | 0.05 |
| Schooling | 7.33 | 6.25 | 5.76 | 7.84 | 4.45 | 5.81 |
| Mean Log Hourly Wage. | 3.35 | 3.14 | 3.09 | 3.30 | 2.76 | 2.96 |
| Rural | 0.21 | 0.43 | 0.45 | 0.06 | 0.75 | 0.39 |
| Indigenous Population. | 0.01 | 0.04 | 0.07 | 0.03 | 0.28 | 0.27 |
| Agriculture and Industry Workers. | 0.50 | 0.57 | 0.59 | 0.40 | 0.67 | 0.55 |
| **Historical Data** | | | | | | |
| Distance | 64.3 | 165.2 | 195.9 | 170.1 | 407.3 | 692.8 |
| Share Mexico Population | 0.10 | 0.15 | 0.47 | 0.11 | 0.13 | 0.04 |
| Rural | 0.47 | 0.47 | 0.42 | 0.14 | 0.37 | 0.43 |
| Indigenous. | 0.03 | 0.04 | 0.1 | 0.09 | 0.36 | 0.39 |
| Literacy | 0.27 | 0.18 | 0.2 | 0.28 | 0.1 | 0.17 |

**Notes.** North: Baja California, Coahuila, Chihuahua, Nuevo León, Sonora and Tamaulipas. Center North: Aguascalientes, Baja California Sur, Durango, Nayarit, San Luis Potosí, Sinaloa and Zacatecas. Center: Colima, Guanajuato, Hidalgo, Jalisco, Michoacán, Morelos, Puebla, Querétaro, Tlaxcala y Veracruz. . México City Valley: Distrito Federal and Estado de México. South: Chiapas, Guerrero, Oaxaca; and Yucatán: Campeche, Quintana Roo, Tabasco and Yucatán. Historical distance is the minimum of the distance in kilometers and the sum of the distance to the nearest railroad station from the municipality and the distance from the railroad station to the border divided by 5. Indigenous Population represents population speaking and indigenous language. Agriculture and Industrial Workers represent the share among employed population. Historical data comes from 1900 and 1910 Mexican Census. Share Mexico Population: share of population living in the area 1900. Rural: population living in localities with less 500 inhabitants 1910. Indigenous: population speaking an indigenous language 1910. Literacy: Population with reading or writing abilities 1900.

**Table 2. Migration and Municipality Size**

| | Total Population 1990 (Thousands) | | | |
|---|---|---|---|---|
| | <10 | 10-100 | 100-1000 | >1,000 |
| Population 1990. Ages 18-60 | 0.048 | 0.289 | 0.326 | 0.337 |
| Population 2010. Ages 18-60 | 0.041 | 0.266 | 0.356 | 0.338 |
| | | | | |
| Males 1990. Ages 18-60 | 0.049 | 0.293 | 0.324 | 0.335 |
| Males 2010. Ages 18-60 | 0.041 | .0264 | 0.355 | 0.341 |
| | | | | |
| Migration 1995-2000 | 0.068 | 0.450 | 0.290 | 0.192 |
| Migration Males 1995-2000 | 0.070 | 0.474 | 0.283 | 0.173 |

Notes: Data comes from 1990, 2000 and 2010 Mexican Census expanded questionary sample using expansion factors. Data considers metropolitan areas as one municipality according to classification of SEDESOL, CONAPO and INEGI 2004.

**Table 3. Relative Gender Supply and Wages. Age 18-60**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| OLS | | | | | |
| θ | 0.051 | 0.078 | 0.078 | 0.027 | 0.054 |
| | (0.019)*** | (0.021)*** | (0.021)*** | (0.017) | (0.017)*** |
| φ | -0.176 | -0.206 | -0.206 | -0.135 | -0.157 |
| | (0.011)*** | (0.013)*** | (0.013)*** | (0.011)*** | (0.011)*** |
| IV | | | | | |
| θ | -0.074 | -0.389 | -0.219 | -0.239 | -0.071 |
| | (0.093) | (0.214)* | (0.197) | (0.170) | (0.159) |
| φ | -0.124 | -0.159 | -0.141 | -0.131 | -0.201 |
| | (0.015)*** | (0.039)*** | (0.035)*** | (0.032)*** | (0.034)*** |
| Estimated $\sigma_{mf}$ | 8.05 | 6.29 | 7.10 | 7.62 | 4.97 |
| Estimated $\sigma_m$ | 5.04 | 1.82 | 2.78 | 2.70 | 3.68 |
| Implied $\sigma_m$ | 3.56 | 3.46 | 3.51 | 3.54 | 3.34 |
| p value (Im. $\sigma_m$=Es. $\sigma_m$) | 0.51 | 0.02 | 0.60 | 0.47 | 0.86 |
| F Eq. 7 | 42.52 | 13.53 | 16.59 | 13.44 | 12.67 |
| F Eq. 8 | 267.26 | 80.13 | 127.31 | 80.04 | 77.30 |
| P value Exog. Test | 0.00 | 0.07 | 0.17 | 0.00 | 0.15 |
| $\delta_{2000}$ | -0.47 | -0.32 | -0.33 | -0.32 | -.32 |
| | (0.168)*** | (0.222) | (0.197)* | (0.222) | (0.231) |
| $\delta_{2010}$ | -0.51 | -0.38 | -0.36 | -0.38 | -0.39 |
| | (0.141)*** | (0.185)** | (0.167)** | (0.185)** | (0.200)* |
| N | 1,785,251 | 1,785,251 | 1,785,251 | 1,785,251 | 1,599,038 |
| Reg x Year Effects | | Yes | Yes | Yes | Yes |
| Size x Year x Sex | | Yes | Yes | Yes | Yes |
| Indigenous x Year x Sex | | Yes | Yes | Yes | Yes |
| Age | | | | Yes | Yes |
| $Age^2$ | | | | Yes | Yes |
| Schooling | | | | Yes | Yes |
| Historical Distance | High | High | Low | High | High |
| Sample | All | All | All | All | Unskilled |

All columns include as covariates a dummy of sex, effects for each Census period and fixed effects for each municipality. Clustered standard errors at municipality level in parenthesis. Municipalities with population between 10,000 and 100,000 inhabitants with the exception of Yucatan region. Size is the total population in 1990. Indigenous is the share of population speaking an indigenous language in 1990.* $p$<0.1; ** $p$<0.05; *** $p$<0.01. Historical distance High is the minimum of the distance in kilometers and the sum of the distance to the nearest railroad station from the municipality and the distance from the railroad station to the border divided by 5. Historical distance High is taken from Demirgüç-Kunt et al. 2011 as in Table 1; Low divides the distance from the railroad station to the border by 3. Unskilled is population with less than 16 years of education

**Table 4. Relative Gender Supply and Wages. Age 18-40**

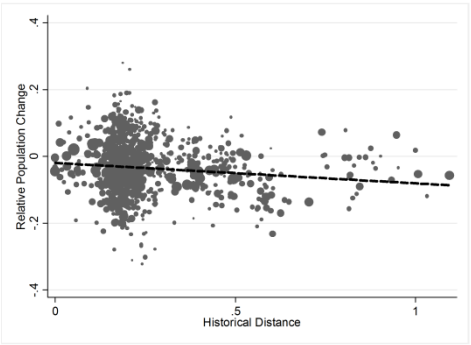
| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| OLS | | | | | |
| θ | 0.046 | 0.073 | 0.073 | 0.030 | 0.050 |
| | (0.018)** | (0.020)*** | (0.020)*** | (0.017)* | (0.016)*** |
| φ | -0.176 | -0.201 | -0.201 | -0.131 | -0.146 |
| | (0.012)*** | (0.013)*** | (0.013)*** | (0.012)*** | (0.011)*** |
| IV | | | | | |
| θ | -0.055 | -0.291 | -0.166 | -0.148 | -0.051 |
| | (0.080) | (0.168)* | (0.169) | (0.140) | (0.140) |
| φ | -0.128 | -0.186 | -0.157 | -0.153 | -0.209 |
| | (0.016)*** | (0.039)*** | (0.037)*** | (0.034)*** | (0.037)*** |
| Estimated $\sigma_{mf}$ | 7.82 | 5.37 | 6.38 | 6.52 | 4.79 |
| Estimated $\sigma_m$ | 5.46 | 2.10 | 3.10 | 3.32 | 3.85 |
| Implied $\sigma_m$ | 3.55 | 3.38 | 3.47 | 3.48 | 3.32 |
| p value (Im. $\sigma_m$=Es. $\sigma_m$) | 0.39 | 0.07 | 0.80 | 0.91 | 0.77 |
| F Eq. 7 | 51.60 | 15.96 | 19.11 | 15.82 | 15.42 |
| F Eq. 8 | 254.12 | 86.30 | 135.40 | 86.24 | 82.48 |
| P value Exog. Test | 0.00 | 0.01 | 0.05 | 0.00 | 0.20 |
| $\delta_{2000}$ | -0.57 | -0.45 | -0.42 | -0.45 | -0.45 |
| | (0.167)*** | (0.220)** | (0.197)** | (0.220)** | (0.230)* |
| $\delta_{2010}$ | -0.67 | -0.48 | -0.42 | -0.48 | -0.46 |
| | (0.141)*** | (0.187)** | (0.170)** | (0.187)** | (0.205)** |
| N | 1,248,837 | 1,248,837 | 1,248,837 | 1,248,837 | 1,115,732 |
| Reg x Year Effects | | Yes | Yes | Yes | Yes |
| Size x Year x Sex | | Yes | Yes | Yes | Yes |
| Indigenous x Year x Sex | | Yes | Yes | Yes | Yes |
| Age | | | | Yes | Yes |
| $Age^2$ | | | | Yes | Yes |
| Schooling | | | | Yes | Yes |
| Historical Distance | High | High | Low | High | High |
| Sample | All | All | All | All | Unskilled |

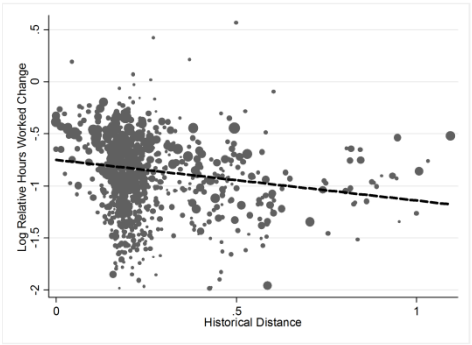
All columns include as covariates a dummy of sex, effects for each Census period and fixed effects for each municipality. Clustered standard errors at municipality level in parenthesis. Municipalities with population between 10,000 and 100,000 inhabitants with the exception of Yucatan region. Size is the total population in 1990. Indigenous is the share of population speaking an indigenous language in 1990.* $p<0.1$; ** $p<0.05$; *** $p<0.01$. Historical distance High is the minimum of the distance in kilometers and the sum of the distance to the nearest railroad station from the municipality and the distance from the railroad station to the border divided by 5. Historical distance High is taken from Demirgüç-Kunt et al. 2011 as in Table 1; Low divides the distance from the railroad station to the border by 3. Unskilled is population with less than 16 years of education

**Figure 1. Distance, Population and Hours Worked**

*a. Municipalities between 10,000 and 100,000 inhabitants.*

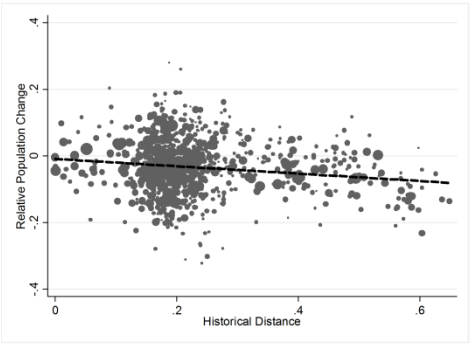
a.1 Population | a.2 Hours Worked

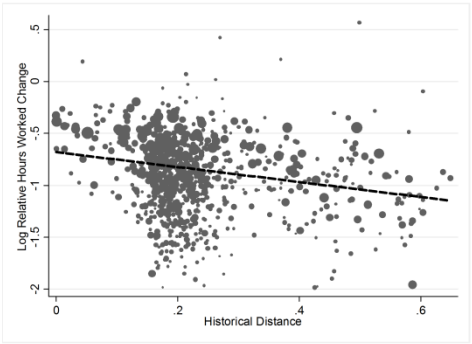



*b. Municipalities between 10,000 and 100,000 inhabitants. No Yucatan*

b.1. Population b.2. Hours Worked.

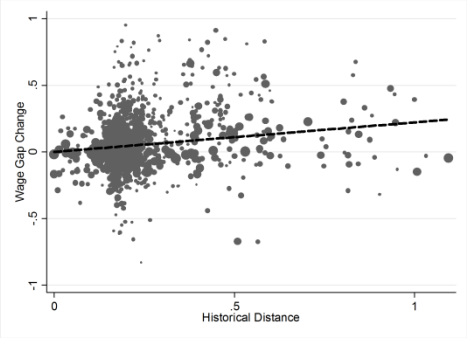


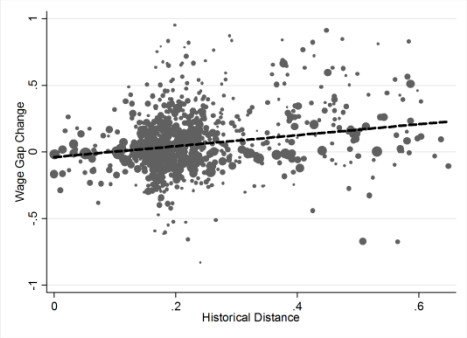

Notes: Historical distance represent thousands of kilometers. Linear fit weighted by total labor force.

## Figure 2. Historical Distance and Wage Gap

Mexico



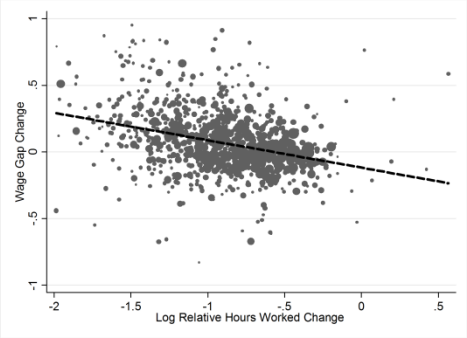

No Yucatan



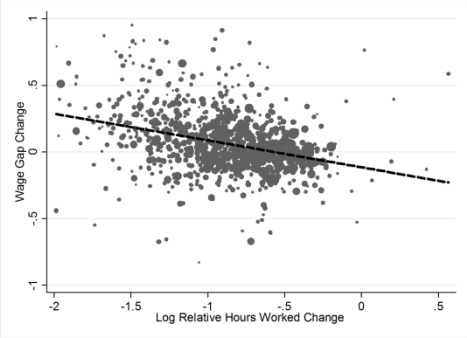

Notes: Historical distance represent thousands of kilometers. Linear fit weighted by total labor force.

## Figure 3. Hours Worked and Wage Gap

Mexico




No Yucatan

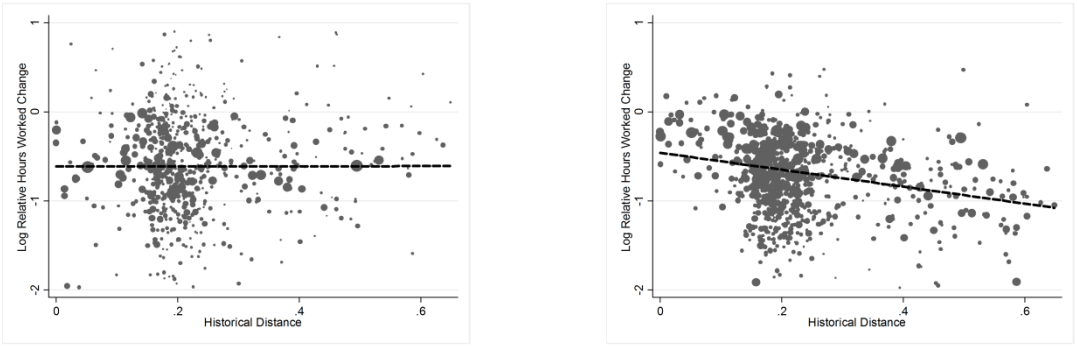



Notes: Linear fit weighted by total labor force.

**Figure 4. Historical Distance and Gender Wage Gap by Skill**

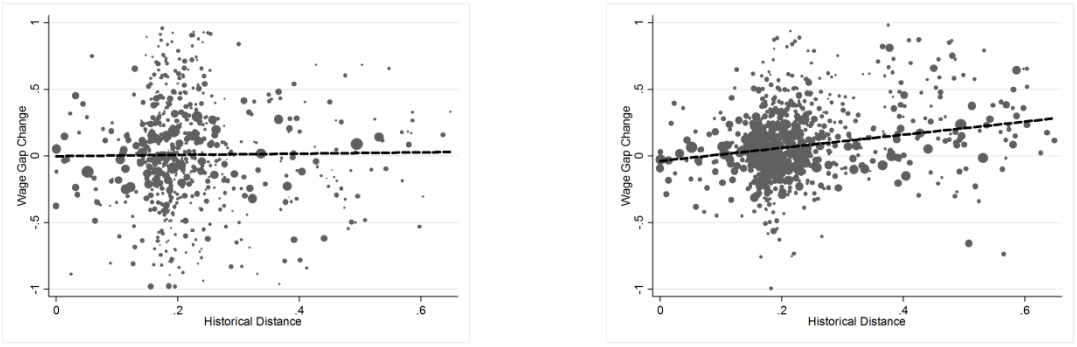
*a. Historical distance and log relative supply change*

a.1 Skilled | a.2 Unskilled




*b. Historical distance and gender wage gap change.*

b.1. Skilled b.2. Unskilled




Notes: Historical distance represent thousands of kilometers. Linear fit weighted by total labor force. Skilled represent population with 16 or more years of education, unskilled with less than 16 years of education.