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External returns to higher education in Mexico 2000-2010

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Abstract

This paper estimates the external returns to higher education in Mexico using cross-sectional micro data from the 2000 and 2010 censuses' samples. Results indicate that a one percentage point increase in the share of college graduates in Mexico increases the regression-adjusted average wages of a metropolitan area in more than six percent over a 10-year period. Analyzing whether these effects are mainly due to externalities or to supply movements along a downward sloping demand, it finds that part of the external returns to education is the result of externalities from direct or indirect interaction with these individuals.

JEL Classification**:** J0; R0; O0; O4.
Keywords**:** human capital, knowledge spillovers, education, wages, social returns to education.

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Resumen

Este artículo estima los retornos externos a la educación en México utilizando datos de la muestra de los Censos de Población de 2000 y 2010. Los resultados indican que el incremento de un punto porcentual de la participación de egresados universitarios en México, se traduce en un aumento de más de seis por ciento sobre los salarios promedio de las zonas metropolitanas, en un periodo de diez años. Analizando si estos efectos se deben a externalidades o a movimientos sobre la curva de demanda, se encuentra que parte de esos retornos, se deben a la interacción directa o indirecta de tales individuos.

***Clasificación JEL*:** J0; R0; O0; O4.
***Palabras Clave*:** capital humano, externalidades del conocimiento, educación, salarios, retornos sociales a la educación.

Introduction

Even though there is consensus regarding the magnitude of private returns to education (approximately 7% to 11% per extra year of schooling for the United States)[1], there is still no agreement on the existence, let alone the magnitude of social returns to higher education and the channels through which they operate (Moretti, 2004a). This paper analyzes the social returns for a developing country such as Mexico[2], to the best of our knowledge for the first time, and finds that they are significant.

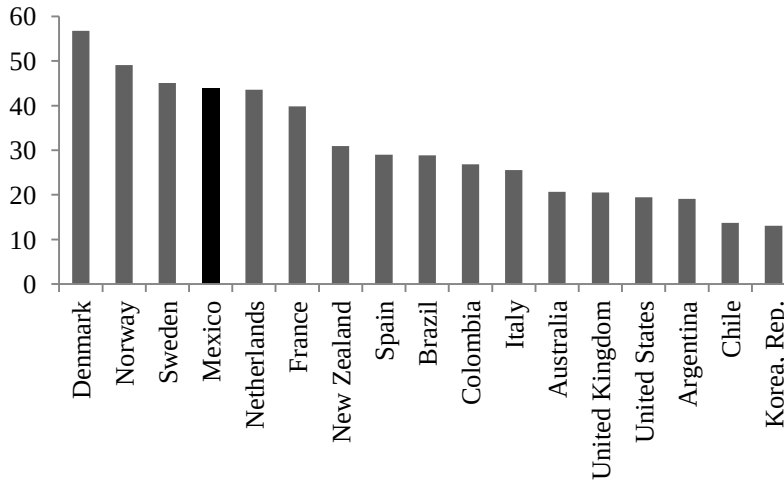
Social returns to education may arise either from direct interaction with more educated people, as we learn from working and talking to other individuals or, as will be explained later, indirectly through the effects that the presence of more educated people has on prices.

[1] Especially during the 90's a great deal of studies for the United States focused on the identification problems (unobserved ability) in the classical Mincerian regressions (Mincer, 1958, 1974). One of the most influential papers on this topic is Angrist and Krueger (1991) who use the quarter of birth as an instrumental variable (IV) for education; they argue that the effect of the IV on education is related to compulsory schooling laws. In general, the IV approach for private returns leads to higher returns than the OLS approach. See Card (1999) for a survey of the studies that use institutional factors as instruments to solve the endogeneity problem of education.

[2] In the case of Mexico, previous studies have found private returns to schooling in the range of 8-15%. See Morales-Ramos (2011) for a summary of the different results for Mexico.

The assumption of social returns to higher education and the externalities generated from direct or indirect interaction with more educated individuals is crucial for economic growth theory and education policy. Growth theorists like Lucas (1988) argue that, depending on their magnitude, human capital externalities can be considered a determinant of development. Furthermore, many economists such as Mankiw, Romer and Weil (1992) and Benabou (1996) consider that cross-country income and productivity disparities are the result of differences in the distribution of human capital. According to Goldin and Katz (2008) and Acemoglu and Autor (2012), investments in human capital can play an equalizing role in the context of skill-biased technological change. If technology is skilled biased, when technological change occurs (demand shifts), it benefits skilled workers increasing inequality between skilled and unskilled individuals. However, if the change is accompanied by steady increases in human capital (supply shifts), inequality can be reduced. Goldin and Katz (2008) regard these competing forces as a "race between education and technology".

Figure 1
Public investment in tertiary education per pupil as a percentage of GDP per capita 2009



Note: according to World Bank (2009) tertiary education refers to post-secondary including the education provided by a diversity of institutions that provide higher-order capacity such as Universities, technical institutes, community colleges, nursing schools, research laboratories, distance centers, among others.
Source: World Bank, 2009.

As Figure 1 shows, public investment per pupil in tertiary education in Mexico represents more than 40% of GDP per capita, a figure comparable

with that of developed countries such as Sweden and the Netherlands. Although these public investments in education are significant, there is no quantitative measure of their total return.

According to Moretti (2012), if such externalities really exist, they are not reflected in the wages of college graduates, who generate a social benefit for which they are not fully compensated, indicating a market failure. Accordingly, more people would probably earn a college degree if they were paid for the positive externalities they generate.

Recent studies, assessing the existence and magnitude of external returns to higher education, have focused on both the theoretical implications and the empirical problems that arise in estimating such returns. The empirical analyses conducted have found mixed results. Much of the lack of consensus emerges from the econometric difficulties of estimating social returns as well as human capital externalities. As Ciccone and Peri (2006) note, wages can change because of externalities, but could simply be responding to movement along a downward sloping demand curve for human capital: if the change is just a market response, there is no space for policy implications.

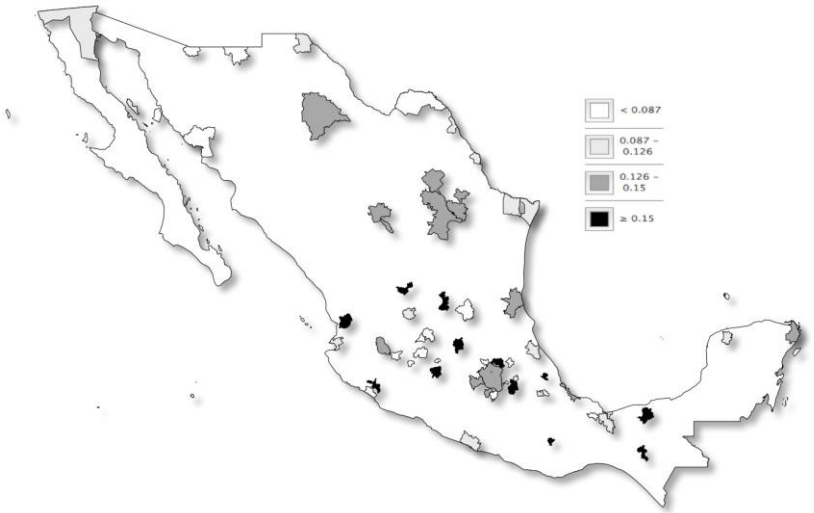
The question has thus inspired research on the identification of human capital externalities. Among the most influential papers are Rauch (1993), Acemoglu and Angrist (2001), Conley, Flyer and Tsiang (2003), Moretti (2004b, 2004c), Ciccone and Peri (2006) and Rosenthal and Strange (2008). Most of these papers have focused on developed countries, which have different educational characteristics and labor markets than developing countries. It is therefore important to analyze whether there are differences in human capital spillovers in developing countries.

According to census data, the average years of schooling for Metropolitan Areas (MA) and individuals aged 25 to 66 in Mexico increased from 8.7 in 2000 to 9.9 in 2010. In this same period the share of college graduates[3] rose from 13% to 16.5%. Indeed, as Figure 2 shows, most of the MAs have increased their share of college graduates, especially in the central and central-north region, where the proportion of college graduates is now greater than 15% in nearly all MAs. It is therefore of the utmost importance to assess the magnitude of these benefits and determine whether they are assimilated socially or merely privately.

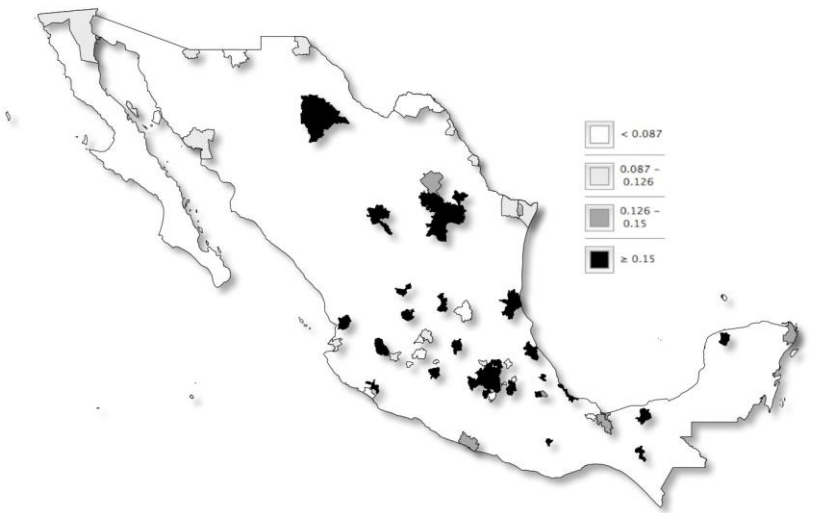
[3] The definition of college graduates used in this study is based on years of schooling and educational level. That is, it includes individuals with more than 16 years of schooling that report having undergraduate and/or graduate studies.

Figure 2
Percentage of college graduates 2000-2010

A) 2000



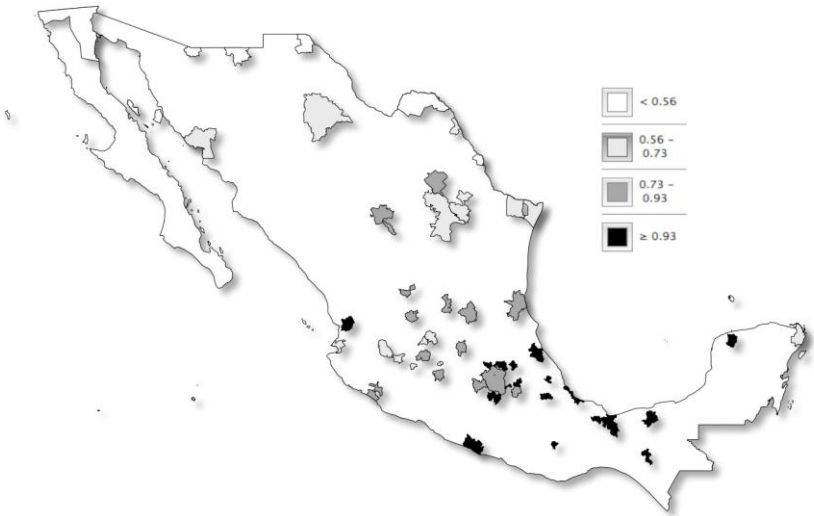
B) 2010



Source: authors' calculations using data from Mexico's 2000 and 2010 Population and Housing Censuses, INEGI.

In the north, it is mainly the border that exhibits less improvement in the share of college graduates. As can be seen in Figure 3, the same applies to the percentage change in average MA wages, controlling for individual characteristics, from 2000 to 2010. That is, there appears to be a direct relation between the change in the share of college graduates and the change in average regression-adjusted wages[4], which is consistent with external returns to higher education.

Figure 3
Change in regression-adjusted average log(wage) 2000-2010



Source: authors' calculations using data from Mexico's 2000 and 2010 Population and Housing Censuses, INEGI.

Even though these data suggest a clear improvement in terms of education, a static analysis of the figures shows that they are similar to those of the bottom MAs in the U.S, in which the percentage of college graduates ranges from 11% to 17% while in the top MAs it reaches more than 35% (Moretti, 2012). With such a different educational structure, as Table 1 shows for the whole population, Mexico is likely to have a different dynamic than the U.S.

[4] Average regression adjusted wages are obtained as the MA effect from a Mincerian regression including education, age, age squared, gender and marital status. Although the classical Mincerian equation includes potential experience, which is constructed as E*=age-6-years of schooling, age is used in this case in order to avoid problems with the calculation of this variable especially in the case of people with little education, for whom it is necessary to arbitrarily define an age of entry into the labor market.

Table 1
Mexico's educational structure vs. the United States'

	Mexico	**U.S.**
None	6.90%	0.30%
1st-6th grade	32.90%	2.26%
7th-8th grade	3.00%	1.53%
9th grade	21.30%	1.61%
Occupational degree	0.70%	10.10%
10th-12th grade	15.80%	34.90%
Some college or more	18.70%	49.27%

Note: U.S. Census Bureau, Current Population Survey, 2011 Annual Social and Economic Supplement.
Source: Mexico's 2010 Housing and Population Census, INEGI.

This paper analyzes whether, in the case of Mexico, some individuals benefit from the higher level of education (in this case university education) that other individuals receive; in other words, whether there are external returns to human capital. Furthermore, it examines whether these benefits arise or not from externalities.

In order to correctly identify these effects, the ideal experiment would compare the wages of individuals with similar educational level, gender, family background, and other relevant characteristics, in two cities that differ only in average level of education (in this case the proportion of college graduates).

The main contribution of this paper is to analyze the external returns to higher education in a developing country with a college educated population comparable to those of cities of lower educational level in developed countries. The case of Mexico is particularly relevant because it is still in a manufacturing stage with no clear link between college, engineering and innovation; therefore, different magnitudes of social returns and externalities are expected. The empirical strategy is to analyze both the external returns to higher education and the externalities generated by college graduates, using Moretti's (2004b) IV and Ciccone and Peri's (2006) constant composition approaches and comparing the results. This method clarifies the importance of externalities as opposed to market responses.

The paper is organized as follows: section 1 provides a literature review of the empirical studies on social returns to education. Section 2 presents the theoretical model that is used as a basis for empirical estimates. In section 3, the methodology and data are presented. Results are discussed in section 4 and conclusions in section 5.

1. Literature review

As the concepts are essential to understanding the policy implications of the findings presented here, we should start by examining what is meant by social and external returns to higher education. Social returns are the change in average wages due to an increase in the average level of education (in this case, the share of college graduates); external returns are social returns minus the private return. As will be explained later in more detail, external returns are observed if there are human capital externalities, but also in the case of imperfect substitution between skilled and unskilled workers.

According to human capital theory[5], education generates positive externalities either through technology or prices (pecuniary externalities). In the first case, human capital is included in the neoclassical aggregate production function as a determinant of technology[6]; that is, human capital increases productivity both directly and indirectly. Lucas (1988) argues that external effects are the result of interaction with others as "most of what we know we learn from other people". Following Jacobs (1969), this approach emphasizes the role of cities in the exchange of ideas and thus in economic growth.

In the second case, externalities arise from complementarities between physical and human capital; increased supply of human capital in a city creates incentives for firms to invest in additional physical capital, as there are more people capable of using it. However, since there are costs associated with job matching, unskilled workers end up using more physical capital and enjoying higher wages than similar workers in other cities (Acemoglu, 1996). The difference between these two kinds of externalities is that the first one builds upon the production function in a frictionless context, while the second is the result of microeconomic market interactions. Empirically, both theories lead to similar relationships.

Other positive social benefits of human capital considered in this literature and not directly related to productivity are the reduction of crime rates and improvements in voting behavior as well as more charitable society[7].

[5] It is assumed that human capital affects productivity (Becker, 1980) as opposed to being merely a signaling device. In the latter case, an increase in the average human capital in a city would yield negative externalities instead of the positive ones that are tested in the empirical models throughout this paper.

[6] Lucas (1988) includes a specific term for the external effect of human capital in the neoclassical production function and assumes that the technology level is constant.

[7] See Psacharopoulos (2006) for other nonmarket and external benefits associated to education.

According to Lochner (2004) and Lochner and Moretti (2004) street crimes are reduced as a result of an increase in human capital in a city, while white collar crimes decline less as they can't be committed by uneducated individuals.

As Moretti (2004a) argues, there is still a great deal of research to do in this area, as empirical studies have found mixed results regarding the existence of external returns to higher education. Furthermore, Sand (2013) indicates that the results are highly sensitive to the geographical definition (when states are used rather than cities, lower estimates are observed) and that evidence is much stronger for the upper-side of the educational distribution (externalities generated by college graduates), while there is little evidence for the other side.

According to Moretti (2004a), there are three different empirical approaches in the analysis of human capital spillovers and social returns to education. The first and most commonly used is the Mincerian approach, which basically includes an aggregate measure of human capital in the widely used relationship between individual wages and education. The second approach consists of analyzing plant production functions and directly obtaining the effect of the plant-level stock of human capital on productivity. Finally, since land prices should fully reflect spillovers in a general equilibrium framework, a measure of the spillover could be obtained by comparing housing prices of cities with different levels of human capital, for housing with similar characteristics.

Rauch (1993) represents the first attempt to find quantitative measures of the social return to education under the Mincerian approach. Starting from the Roback (1982) model, he treats the city educational level as a public good, finding social returns for the U.S. of 3-5% in terms of average years of schooling. Acemoglu and Angrist (2001) extend this analysis by using panel data and compulsory schooling laws as an instrumental variable (IV) for average MA schooling and the quarter of birth as an IV for individual schooling in order to solve the problems resulting from unobserved heterogeneity and endogeneity of individual education[8]. They find evidence of modest returns for the U.S. in the range of 1-3%.

Following the previous results, Conley et al. (2003) and Rosenthal and Strange (2008) focus on the geographical scope of these spillovers. The first authors analyze human capital spillovers considering the economic distance between agents measured as travel times between locations and find results

[8] The use of quarter of birth is based on Angrist and Krueger (1991).

consistent with external returns for Malaysia. The other two authors analyze the attenuation of these effects considering concentric rings of influence based on distances and find that a 100,000 increase in the number of individuals with a college degree, generates an upward change in wages in the range of 5-7%.

One of the problems that arise in the estimation of human capital externalities or social returns to education is the difficulty of establishing whether the relation between wages and any measure of average human capital is causal. As Ciccone and Peri (2006) as well as Moretti (2004a, 2004b) explain, it is difficult to assess whether these externalities really exist or if the effects on wages are merely a movement along a downward sloping demand for skilled workers. This is important because policy implications are different depending on the case. If the effect is associated just to demand, everything is working through the market; however, if there are externalities, there is some space for public policy. Paraphrasing Moretti (2012), if people with a college degree could incorporate the social benefits they generate (externalities) into their wages, probably more would earn a college degree.

The downward slope of the demand curve is related to imperfect substitution (or complementarity) between skilled and unskilled workers (in a framework of two skill types). In this sense, Moretti (2004a, 2004b) argues that wages of unskilled workers will always benefit from an increase in the percentage of college graduates in a city as two reinforcing effects are at work: imperfect substitution that allows less skilled workers to use more capital in their work, as well as the positive externalities from direct or indirect interaction with more educated individuals. However, the effect for college graduates is ambiguous as there are two opposing forces: the increase in the supply of skilled people pushes their wages downward while the positive externalities of interacting with other college graduates exerts an upward influence on their wages.

Considering these differentiated effects, Moretti (2004b) extends the previous literature by controlling for possible demand shocks and using the MA demographic structure as an IV for the percentage of college graduates. He finds that a one-percentage point increase in the supply of college graduates has an average effect of 1.13% on regression-adjusted average wages for the U.S. By estimating the social return for different educational groups he concludes that part of the effect should be the result of externalities.

Ciccone and Peri (2006) argue that the Mincerian approach fails to identify the externalities generated by a higher supply of more educated people as it cannot separate the effects of externalities and the effects of a downward sloping demand curve for human capital. They propose the constant

composition approach, in which the skill composition in an MA is held constant, to identify the effects of these spillovers and find no externalities for the U.S.

Another empirical problem in the estimation of these returns is that it is difficult to establish whether there are unobservable characteristics in the cities that attract highly educated individuals, in which case, there would be inverse causality.

2. Theoretical framework

Following the model presented in Moretti (2004a, 2004b), it is assumed that cities are competitive economies that produce one output good *y* that is traded nationally. The production function is Cobb-Douglas, and uses skilled (S) and unskilled (U) workers, as well as physical capital (K), and includes productivity shifters:

$$y = (\theta_U N_U)^{\alpha_U} (\theta_S N_S)^{\alpha_S} K^{1-\alpha_U-\alpha_S} , \qquad (2.1)$$

Where:
N_U = Number of unskilled workers
N_S = Number of skilled workers
θ_j = Productivity shifters, *j=U,S*

Human capital spillovers are included by letting workers' productivity depend on the share of skilled people in the city, $s \equiv N_S/(N_S + N_U)$:

$$\ln(\theta_j) = \phi_j + \gamma \left(\frac{N_S}{N_S+N_U}\right) \qquad j = U, S \qquad (2.2)$$

ϕ_j is group-specific and captures the direct effect of own human capital on productivity. Therefore, $\phi_S > \phi_U$.

If spillovers are observed, γ must be different from zero. At equilibrium, considering productivity shifters as given, the effects of an increase in the share of skilled people (*s*) on wages for the two skill groups are:

$$\frac{\mathrm{dln}(\mathrm{w}_S)}{\mathrm{ds}} = \left(\frac{\alpha_S - 1}{s}\right) - \left(\frac{\alpha_U}{1-s}\right) + (\alpha_U + \alpha_S)\gamma \qquad (2.3)$$
$$\frac{\mathrm{dln}(\mathrm{w}_u)}{\mathrm{ds}} = \left(\frac{1-\alpha_U}{1-s}\right) + \left(\frac{\alpha_U}{s}\right) + (\alpha_U + \alpha_S)\gamma$$

where the last term in both equations is the effect of the spillover. As can be seen, in the case of skilled people *(S)*, the first two terms are negative, consistent with a downward sloping demand curve. However, due to imperfect substitution between skilled and unskilled workers, the first two terms in the equation for unskilled people *(U)* are positive. That is, unskilled people always benefit regardless of the channel, while the effect on wages of skilled people is ambiguous. Therefore, if positive effects are found for skilled people they indicate the presence of externalities.

In this sense, the external return is defined as the derivative of average wages with respect to the share of college graduates less the private return β (the difference in wages between skilled and unskilled):

$$\frac{\mathrm{dln}(\bar{w})}{\mathrm{ds}} - \beta = s\frac{d\beta}{ds} + \frac{dln(w_U)}{ds} + (\alpha_U + \alpha_S)\gamma \qquad (2.4)$$

This equation clearly shows that, on average, external returns can be observed even in the absence of externalities ($\boldsymbol{\gamma = 0}$), as the second term, which represents imperfect substitution, is positive.

3. Empirical strategy

Two kinds of estimates are used in order to establish the existence of external returns to higher education and determine whether they are due to externalities or are merely supply movements along a downward sloping demand. In this sense, both the Mincerian and constant composition approaches are used.

First, following Moretti (2004b), and due to the cross-section characteristics of the census data, social returns to education are estimated in two stages. In the first, Mincerian equations with city effects are estimated separately for each census:

$$lnw_{ict} = \alpha_{ct} + x_{ict}\beta_t + u_{ict} \qquad t = 2000, 2010 \qquad (3.1)$$

Where:
lnw_{ict} = logarithm of nominal hourly wage of individual i in city c and time t.
α_{ct} = Regression-adjusted average city ln(wages).
x_{ict} =Vector of individual characteristics such as education, gender, marital status, age and a quadratic term for age.

Nominal wages are used as a dependent variable because, in a general equilibrium framework such as Roback (1982), prices in general should be reflected in land prices. That is, in a city with greater amenities, wages will be higher, but these amenities will also increase the cost of living. The regression-adjusted city wages are then the estimated average city wages obtained after controlling for individual characteristics[9].

In the second stage, the estimated city effects $\hat{\alpha}_{ct}$ are used as a dependent variable in a regression analysis against the percentage of college graduates in the city (P_{ct}), a vector of city-time characteristics such as unemployment or demand shocks (Z_{ct}), as well as city (d_c) and year effects (d_t).

$$\hat{\alpha}_{ct} = \pi P_{ct} + Z_{ct}\gamma + d_c + d_t + \varepsilon_{ct} \tag{3.2}$$

The parameter of interest in this equation is π, as it represents the return (in terms of wages) of having more educated people in a city.

As mentioned before, social returns to education share most of the econometric problems of private returns, including inverse causality, meaning that high wages attract college graduates instead of wages increasing due to a raise in the percentage of more highly educated individuals. In order to correct for this, following Moretti (2004b) and Ciccone and Peri (2006), the demographic structure is used as an instrumental variable. Additionally, an index of demand shifts proposed by Katz and Murphy (1992) is used in an effort to control for changes in the industrial mix of the cities that could confound the relation between the share of college graduates and nominal wages. This index is defined as:

$$shock_{jc} = \sum_{s=1}^{S} \eta_{sc} \Delta E_{js} \tag{3.3}$$

[9] In this sense, the regression-adjusted average city wages indicate average wages in a city for single males between 25 and 66 years old.

Where:
$shock_{jc}$ = Predicted employment change of workers from educational group j in city c
η_{sc} = Share of hours worked in sector s in city c in 2000
ΔE_{js} = Change in the ln(hours) worked by group j in industry s nationally

The second-stage equation is estimated in first differences, so the time-constant city specific effects are taken into account implicitly.

3.1. Instrumental variables

Endogeneity of the percentage of college graduates poses a challenge in the identification of externalities generated by the share of college graduates in a city. Thus, following Acemoglu and Angrist (2001), Moretti (2004b) and Ciccone and Peri (2006), an IV approach is used.

Three variables, based on the demographic structure of the MAs, were tested as instruments. The first one is based on Moretti (2004b) and consists of the 1990 demographic structure, which should be exogenous. This IV builds upon the fact that younger cohorts are more educated, so MAs with a higher proportion of young people in 1990 should have experienced a greater increase in their share of college graduates[10]. It is important to note that this variable is based on the assumption that there is variability in the demographic structure among MAs. However, for Mexico this is not the case. Therefore, it is not possible to use the IV approach introduced by Moretti (2004b), as the age structures of the 58 MAs used in this paper are very similar.

The second IV is OLD, and it is calculated as the percentage of people aged 60-65 in an MA, who leave the sample in 2010. Considering that older cohorts received less education, it was expected that this variable would show correlation with the share of college graduates. However, the hypothesis that it was a weak instrument could not be rejected.

[10] The IV is constructed as follows:

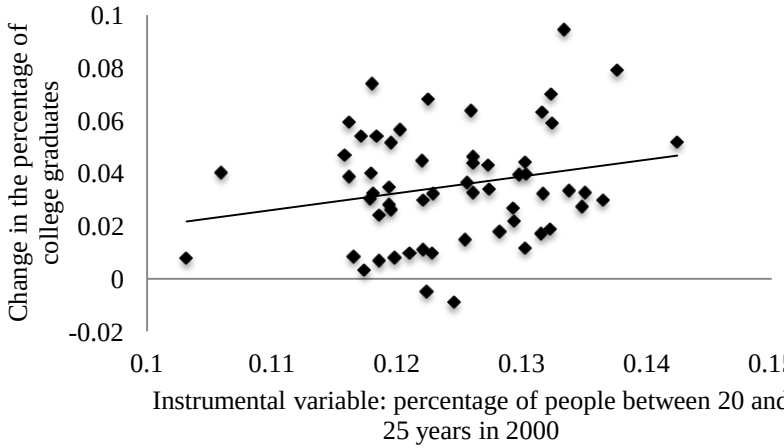
$$IV_c = \sum_{m=1}^{M} w_{mc} \Delta P_m$$

Where:
ω_{mc} = Weights in 1990 of the age-gender group m
ΔP_m = National change in the college share for group m 2000 - 2010

In this case, 40 age-gender groups were created from the sample using the 1990 demographic structure as weights. Data from the whole labor force were used.

Finally, the IV YOUNG is calculated as the percentage of people aged 20-25 in an MA in 2000. This is the cohort entering the sample in 2010 and, as depicted in Figure 4, there is a direct relation between this variable and the share of college graduates in an MA. Accordingly, all tests indicate that this is not a weak instrument.

Figure 4
Relation between the change in the percentage of college graduates and the instrumental variable



Source: authors' calculations using data from Mexico's 2000 and 2010 Population and Housing Censuses, INEGI.

3.2. Constant-composition Approach

As mentioned before, one of the problems regarding human capital externalities is that they can easily be confounded with neoclassical supply-demand movements that need no government intervention. The approach used by Moretti (2004b) merely allows the identification of such externalities but can say nothing about their magnitude. In order to address this problem, Ciccone and Peri (2006) introduced the constant-composition approach, which also has the advantage of avoiding the need to find instruments for individual schooling[11].

[11] Following Angrist and Krueger (1991) an IV approach is necessary in order to estimate private returns to education in the classic Mincerian equation.

Under their approach, the effects of externalities are estimated in two steps. In the first, regression-adjusted average wages are estimated for each age-education group in an MA[12]:

$$\boldsymbol{lnw_{ict} = lnw_{ct}(s,a) + x_{ict}\beta + v_{ict}} \tag{3.4}$$

Where:
w_{ict} = hourly wage of individual i in city c at time t
$lnw_{ct}(s,a)$ = log average hourly wage of individuals with schooling s and age a in city c at time t
x_{ict} = vector of controls for marital status and gender

In the second stage, the constant composition logarithms of wages are calculated using the same age-education weights for both 2000 and 2010 ($l_{c,2000}(s,a)$). By doing this, the skill composition of the MAs is held constant and the effects related to a downward sloping demand are eliminated:

$$\begin{aligned} l\widehat{w}^{2000}_{c,2010} &= \sum_{s,a} \widehat{lw}_{c,2010}\,(s,a) l_{c,2000}(s,a) \\ l\widehat{w}^{2000}_{c,2000} &= \sum_{s,a} \widehat{lw}_{c,2000}\,(s,a) l_{c,2000}(s,a) \end{aligned} \tag{3.5}$$

Finally, a regression analysis is performed of the difference of wage logarithms against the percentage of college graduates (for which YOUNG is used as an IV), as well as other city characteristics, an analysis similar to equation 3.2:

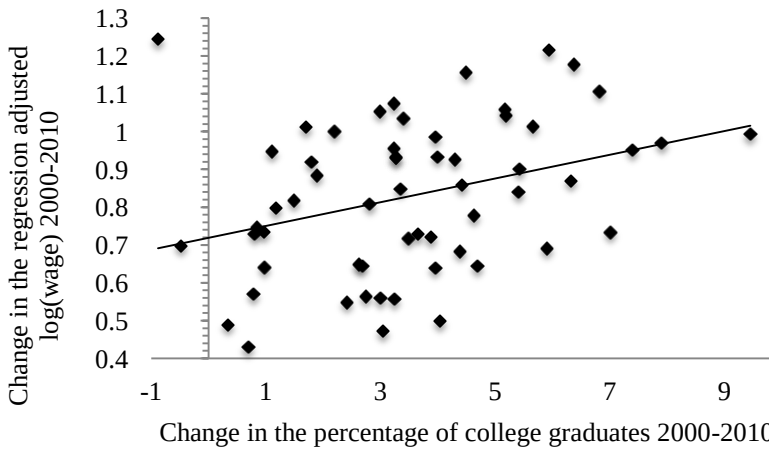
$$l\widehat{w}^{2000}_{c,2010} - l\widehat{w}^{2000}_{c,2000} = \pi \Delta P_{c,2010} + \Delta Z_{c,2010}\gamma + \Delta\varepsilon_{c,2010} \tag{3.6}$$

[12] Ciccone and Peri (2006) use potential experience (E*) instead of age. Potential experience is constructed as E*=age-6-years of schooling. However, due to the problems in calculating potential experience (especially in the case of people with little education, for whom it is necessary to arbitrarily define an age of entry into the labor market), education-age groups are used.

3.3. Data and descriptive statistics

The data used in this paper come from microdata of Mexico's 2000 and 2010 Housing and Population Censuses' samples, INEGI. The sample includes employed individuals aged 25-66 who live in any of 58 MAs considered[13]. MAs are chosen as units of analysis, as they are the areas in which an individual lives and works, so knowledge spillovers are more likely to be observed in these geographical units. As Conley et al. (2003) argue, the definition of the geographical area is important, due to the difficulty of characterizing the human capital of the set of agents that interact with each individual.

Figure 5
Change in the regression adjusted average ln(wage) vs. change in the percentage of college graduates 2000-2010



Note: the regression-adjusted wage is obtained through two separate regressions for 2000 and 2010 including as regressors years of schooling, age and age squared, controlling for marital status and gender. The sample selected includes individuals with ages ranging from 25 to 65.
Source: authors' calculations using data from Mexico's 2000 and 2010 Population and Housing Censuses, INEGI.

As can be seen in Figure 5, there is a direct relation between the change in the percentage of college graduates in an MA and the regression-adjusted

[13] The 58 MA are constructed using CONAPO and INEGI's definition. Three additional MAs are included because of the importance of the *maquila* industry and the industrial growth of these areas. See Appendix I for the construction of the MAs.

average wages growth[14]. The same pattern is observed for the different educational groups, although the relation appears to be stronger for college graduates, which is an unexpected result. In the theoretical model the effects of human capital externalities and the supply effects of an increase in college graduates have different signs. A possible explanation for this result could be that human capital externalities are stronger for this group.

Table 2 shows the descriptive statistics for the data used in the first-stage estimates[15]. There is a significant increase in the average hourly nominal wage as well as the average years of schooling.

Table 2
Sample descriptive statistics

	Mean	Std. Deviaton	Min	Max
2000				
Hourly wage	21.81	23.33	2.40	176.74
ln(hourly wage)	2.71	0.82	0.88	5.17
Years of schooling	9.47	4.68	0.00	22.00
Marital status1	0.74	0.44	0.00	1.00
Age	38.13	9.83	25.00	66.00
Gender (1=women)	0.33	0.47	0.00	1.00
N		974,303		
2010				
Hourly wage	37.91	36.39	3.86	263.94
ln(hourly wage)	3.32	0.76	1.35	5.58
Years of schooling	10.42	4.52	0.00	24.00
Marital status1	0.70	0.46	0.00	1.00
Age	40.12	10.23	25.00	66.00
Gender (1=women)	0.38	0.49	0.00	1.00
N		803,508		

Source: authors' calculations using data from Mexico's 2000 and 2010 Population and Housing Censuses, INEGI.

[14] As can be seen in Figure 5, there is an outlier. This point exhibits little change in the share of college graduates, while its average wage shows a substantial increase.
[15] These figures differ from the ones discussed in the introduction because in Table 2, only people who receive a wage are included, rather than the whole population.

4. Results

Table 3 presents the results under the Mincerian approach using YOUNG as an instrument for the share of college graduates in an MA. In column (1) no other controls are included, column (2) controls for the change in unemployment in the city and column (3) uses the index of Katz and Murphy (1992) to control for demand shifts. Finally, column (4) includes both unemployment and the Katz and Murphy index.

As can be seen in the first panel, the estimates indicate that a one percentage point increase in the share of college graduates in an MA results in more than a six percent increase in wages over a period of ten years. That is, whatever the cause (externalities or a downward sloping demand), there is an effect from an increase in the supply of college graduates. The magnitude of these results is almost six times that found by Moretti (2004b) for the U.S.

However, transforming the results in order to compare them with that of Rosenthal and Strange (2008) it is found that an increase of 100,000 individuals with a college degree generates changes in average wages[16] of 3%.

According to the theoretical model, less educated individuals should benefit both from externalities and from supply movements along a downward sloping demand. On the other hand, the effect is ambiguous for more educated people, as the increase in the supply of college graduates puts a downard pressure on their wages while externalities generate an upward pressure. Therefore, if most of the effect is due to externalities, the coefficient for more educated people should be positive and significant.

In this case, analyzing the coefficients by educational groups, the results show that there are effects for all the different groups and that the coefficients for college graduates are higher than the others, an unexpected result that could indicate that externalities work differently depending on the educational group. Another possibility is that movements along a downward sloping demand, which under this approach are still considered, are heterogeneous between these groups. In this sense, externalities appear to be present, at least qualitatively.

[16] The sample of individuals aged 25-66 who live in MAs consists of 22,616,641 people and has a weighted mean share of people with college of 16% for 2000. Thus, the number of individuals with college in the sample for that year is of 3.7 million. Hence, a change of one percentage point is equivalent to 227,562 individuals. Considering the estimates from Table 3, a change of 100,000 individuals with a college degree generates an average increase in regression-adjusted wages of approximately 3%.

Table 3

Estimates of the effect of the percentage of college graduates on the regression-adjusted MA wages using the demographic structure as IV

Dependent variable: log difference of the regression-adjusted MA wages	**1**	**2**	**3**	**4**
Whole sample				
Change in the percentage of college	7.74*	6.44	7.52**	7.35*
	-4.08	-5.02	-3.01	-4.42
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.04	0.16	0.21	0.22
Prob>F	0	0.001	0	0
Less than high school				
Change in the percentage of college	4.18*	1.46	4.47***	2.66
	-2.34	-2.14	-1.7	-2.07
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.26	0.47	0.46	0.57
Prob>F	0.07	0	0	0
High school and occupational				
Change in the percentage of college	4.40**	2.7	4.36***	3.34*
	-2.16	-2.22	-1.53	-1.9
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.1	0.39	0.34	0.47
Prob>F	0.04	0	0	0
Some college				
Change in the percentage of college	4.16*	4.58	4.09*	4.84
	-2.43	-3.35	-2.32	-3.49
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.14	0.15	0.15	0.16
Prob>F	0	0.01	0.01	0.02
College graduates				
Change in the percentage of college	7.33***	7.65**	6.90***	7.57**
	-2.5	-3.49	-2.1	-3.15
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	-	-	0.07	-
Prob>F	0	0.01	0.01	0.21

Note: standard errors are in parenthesis, * significant at the 10 percent level, ** significant at the 5 percent level and *** significant at the 1 percent level.

Source: authors' calculations using data from the Mexican Population and Household Censuses for 2000 and 2010.

Using the constant composition approach and the variable YOUNG as an instrument for the share of college graduates in order to isolate the effect of knowledge spillovers or externalities, and under the four different specifications of the equation, the change in the percentage of college graduates is positive and significant. However, against the result of Table 3, the coefficients reduce to approximately 5% for the whole sample, as can be seen in Table 4. This means that externalities are observed in Mexico and their effects are not the modest ones found in other studies, such as Acemoglu and Angrist (2001) for the U.S.

Table 4

Estimates of the effect of the percentage of college graduates on the constant composition regression-adjusted MA wages using the demographic structure as IV

Dependent variable: log difference of the regression-adjusted MA wages- Whole sample	**1**	**2**	**3**	**4**
Change in the percentage of college college graduates	5.64***	4.34*	5.44***	4.59**
	(2.1)	(2.29)	(1.65)	(2.13)
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks	No	No	Yes	Yes
N	58	58	58	58
R^2	0.11	0.36	0.3	0.43
Prob>F	0.010	0.000	0.000	0.000

Note: * significant at the 10 percent level, ** significant at the 5 percent level and *** significant at the 1 percent level.

Source: authors' calculations using data from the Mexican Population and Household Censuses for 2000 and 2010.

In order to compare the results presented in Table 3 using educational groups with the ones using the constant-composition approach, results are presented in Table 5 for five educational groups, holding the age composition constant for each in all the MAs. Results are consistent with the Mincerian approach and, once again, the coefficients are higher for individuals with college education.

Table 5

Estimates of the effect of the percentage of college graduates on the constant composition regression-adjusted MA wages using the demographic structure as IV by educational levels

Dependent variable: log difference of the regression-adjusted MA wages	**1**	**2**	**3**	**4**
No education				
Change in the percentage of college duates	5.48**	3.27	5.66***	3.94
	(2.55)	(2.73)	(2.18)	(2.89)
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.21	0.43	0.28	0.43
Prob>F	0.030	0.000	0.020	0.000
Primary school				
Change in the percentage of college	4.93**	2.54	5.04***	3.45
	(2.25)	(2.13)	(1.73)	(2.12)
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.25	0.48	0.44	0.56
Prob>F	0.030	0.000	0.000	0.000
7^{th}-9^{th} grade				
Change in the percentage of college	4.83*	2.75	4.85***	3.76
	(2.76)	(2.91)	(1.85)	(2.40)
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	.	0.32	0.28	0.41
Prob>F	0.080	0.000	0.000	0.000
10^{th}-12^{th} grade				
Change in the percentage of college	4.90***	4.18*	4.62***	4.24**
	(1.83)	(2.20)	(1.42)	(1.83)
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.10	0.25	0.30	0.36
Prob>F	0.010	0.000	0.000	0.000
College or more				
Change in the percentage of college	6.31***	6.61**	6.05***	6.75**
	-2.11	-3	-1.81	-2.79
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.0	.	0.2	.
Prob>F	0.000	0.000	0.000	0.000

Note: * significant at the 10 percent level, ** significant at the 5 percent level and *** significant at the 1 percent level.

Source: authors' calculations using data from the Mexican Population and Household Censuses for 2000 and 2010.

4.1. Robustness checks

As a robustness test, the same equations were estimated for women and the results (not shown here) were very similar to the ones presented in Tables 3 and 4. Additionally, estimations were made excluding Acayucan which, as can be seen in Figure 5, is an outlier that exhibits a low change in the percentage of college graduates while its regression-adjusted average wage shows a high growth rate; the results did not change significantly. Finally, a similar IV to YOUNG, was constructed using data from the 1990 census for people with ages between 10-15 (the same people that would be 20-25 in 2000) and the results did not change much.

In order to test the robustness of the results regarding demand shifts, the constant composition approach was extended in order to account for the possible demand shifts directly in the dependent variable. Instead of equation 3.4 we estimate:

$$lnw_{ict} = lnw_{ct}(s,a,k) + x_{ict}\beta + v_{ict} \tag{4.1}$$

Where

$lnw_{ct}(s,a,k)$
$=$ log average hourly wage of individuals with schooling s and age a working in sector k in city c at time t .

In the second stage, the logarithms of wages are calculated as a weighted mean, using as weights the share of each schooling-age-sector group for each city:

$$\widehat{lw}^{2000}_{c,2010} = \sum_{s,a,k} \widehat{lw}_{c,2010}\,(s,a,k)\, l_{c,2000}(s,a,k)$$

Therefore, the change in wages was calculated holding the age-education-sectoral composition constant. As Table 6 shows, results are similar to the conventional constant composition approach (Table 4). Thus, the original model is controlling well for demand shifts.

Table 6

Estimates of the effect of the percentage of college graduates on the constant composition regression-adjusted MA wages using the demographic structure as IV (sectoral constant composition)

Dependent variable: constant composition log difference of the regression-adjusted MA wages- Whole sample wages	**1**	**2**
Change in the percentage of college graduates	5.78***	4.08*
	(2.12)	(2.28)
Change in unemployment	No	Yes
N	58	58
R^2	0.07	0.39
Prob>F	0.010	0.000

Note: * significant at the 10 percent level, ** significant at the 5 percent level and *** significant at the 1 percent level.
Source: authors' calculations using data from the Mexican Population and Household Censuses for 2000 and 2010.

Even though the literature uses nominal wages, in order to test the robustness of our results we estimated the general model using real wages (using city prices in order to adjust wages for changes in prices). As Table 7 shows, the result are slightly lower than the ones from the first panel of Table 3.

Table 7

Estimates of the effect of the percentage of college graduates on the regression-adjusted real MA wages using the demographic structure as IV

Dependent variable: log difference of the regression-adjusted real MA wages -Whole sample	**1**	**2**	**3**	**4**
Change in the percentage of college graduates	5.03*	3.44	5.13**	4.32*
	(2.17)	(2.22)	(1.59)	(1.97)
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.2	0.45	0.39	0.5
Prob>F	0.000	0.001	0.000	0.000

Note: standard errors are in parenthesis, * Significant at the 10 percent level, ** Significant at the 5 percent level and *** Significant at the 1 percent level.
Source: authors' calculations using data from the Mexican Population and Household Censuses for 2000 and 2010.

Considering that the results observed could be driven by the small size of our sample, we estimated the same equation including 1990 in order to duplicate the number of observations. Although the inclusion of 1990 has the advantage of increasing the sample, it has the disadvantage of the change in economic classifications (which we use to construct the Katz & Murphy control variables). Thus, these variables are not included in this specification. As Table 8 shows, the estimates reduce a little against our baseline estimate (first panel of Table 3).

Table 8

Estimates of the effect of the percentage of college graduates on the regression-adjusted MA wages using the demographic structure as IV 1990-2010

Dependent variable: log difference of the regression-adjusted MA wages- Whole sample	**1**	**2**
Change in the percentage of college graduates	5.15**	3.88**
	(1.71)	(1.82)
Change in unemployment	No	Yes
N	116	116
R^2	0.88	0.89
Prob>F	0.000	0.000

Note: standard errors are in parenthesis,* significant at the 10 percent level, ** significant at the 5 percent level and *** significant at the 1 percent level.
Source: authors' calculations using data from the Mexican Population and Household Censuses for 1990, 2000 and 2010.

Finally, recent literature has focused on the analysis of the wage distribution as well as job polarization and has found that changes in this distribution under technological change are not only related to skills but also to the tasks contents of different occupations. (Acemoglu and Autor, 2011; Autor, Levy and Murnane, 2003; Autor and Dorn, 2013) Therefore, we analyze whether the occupations distribution affects our estimates of the external returns to higher education. Table 9 shows the results controlling for the occupations distribution. As can be seen in the table, the coefficient associated to the share of college graduates reduces to less than half against the estimates shown in Table 3 once we take into account the occupational structure. Analyzing the coefficient for each occupation we observe that having a larger share of managers results in a higher wage increase in an MA, while MAs with a higher share of agricultural workers have lower wage increases or even reductions.

Table 9

Estimates of the effect of the percentage of college graduates on the regression-adjusted MA wages using the demographic structure as IV controlling for occupation

Dependent variable: log difference of the regression-adjusted MA wages- Whole sample	**1**	**2**	**3**	**4**
Change in the percentage of	2.93*	2.51	3.10**	2.97
	(1.518)	(2.635)	(1.448)	(2.406)
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks	No	No	Yes	Yes
Occupations				
Managers	2.94***	3.13***	3.4***	3.46***
Professionals & technicians	-1.65*	-1.52	-0.78*	-0.74*
Sales	1.28***	1.35***	1.35***	1.38***
Personal care & protective	0.31***	0.37***	0.45***	0.48***
Agricultural	-1.27**	-1.35*	-1.12**	-1.14**
Craftsmen	1.30***	1.19**	1.77***	1.744***
Operators/Laborers	1.91***	1.97***	2.82***	2.84***
Support activities	-	-	-	-7.61***
N	58	58	58	58
R^2	0.784	0.788	0.785	0.787
Prob>F	0.000	0.001	0.000	0.000

Note: standard errors are in parenthesis,* significant at the 10 percent level, ** significant at the 5 percent level and *** significant at the 1 percent level.
Source: authors' calculations using data from the Mexican Population and Household Censuses for 2000 and 2010.

4.2. Sectoral results

Table 10 shows the sectoral breakdown of external returns. In this case the methodology proposed by Moretti is used, as holding the skill composition constant for each sector is too restrictive.

Table 10

Estimates of the effect of the percentage of college graduates on the regression-adjusted MA wages using the demographic structure as IV (Sectoral breakdown)

Dependent variable: log difference of the regression-adjusted MA wages	**1**	**2**	**3**	**4**
Agriculture and mining				
Change in the percentage of college	3.16	1.62	3.34*	2.36
	(2.36)	(3.09)	(1.93)	(2.90)
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.26	0.27	0.34	0.33
Prob>F	0.180	0.040	0.020	0.000
Manufacturing				
Change in the percentage of college	5.77**	3.78	5.94***	5.08**
	(2.55)	(2.60)	(1.61)	(2.03)
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.12	0.4	0.36	0.46
Prob>F	0.020	0.000	0.000	0.000
Trade (wholesale & retail)				
Change in the percentage of college	4.65**	2.36	4.62***	2.85
	(2.30)	(2.33)	(1.78)	(2.17)
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.24	0.49	0.42	0.55
Prob>F	0.040	0.000	0.000	0.000
Finance & insurance				
Change in the percentage of college	6.14*	5.69	5.86**	6.23
	(3.40)	(4.71)	(2.60)	(3.84)
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	.	.	.	.
Prob>F	0.070	0.010	0.010	0.010
Other services				
Change in the percentage of college	5.32**	4.08*	5.43***	4.91**
	(2.17)	(2.28)	(1.72)	(2.15)
Change in unemployment	No	Yes	No	Yes
Katz & Murphy demand shocks variables	No	No	Yes	Yes
N	58	58	58	58
R^2	0.16	0.39	0.31	0.39
Prob>F	0.010	0.000	0.000	0.000

Note: * significant at the 10 percent level, ** significant at the 5 percent level and *** significant at the 1 percent level.

Source: authors' calculations using data from the Mexican Population and Household Censuses for 2000 and 2010.

In the case of agriculture and mining the change in the share of college graduates in an MA is only significant in one out of the four specifications. That is, wages of workers in this sector are not affected by their interaction with more educated individuals. A possible explanation for this result is that tasks performed in this kind of activity are routine-based and may not be subject to productivity improvements as a result of an increase in the share of college graduates in a city.

Other sectors, mainly manufacturing and services have coefficients close to the ones presented for the whole sample (between 4.5 and 6%).

4.3. Externalities and regional inequality

In order to assess the regional equalizing role of external returns (i.e. important changes in the skill mix of individuals in a city), the change in the share of college (keeping control variables at their real levels) that cities with regression-adjusted average wages below the median would have required in order to reach the median in 2010 was calculated.

Table 11

Change in the share of college graduates 2000-2010 required to reach the median regression-adjusted average wage vs. real change

Metropolitan Area	Required change	Real change	Metropolitan Area	Required change	Real change
Orizaba	17.23	6.38	Merida	14.18	5.17
Poza Rica	17.05	5.94	Tuxtla	14.02	5.19
Cordoba	16.30	4.49	Acapulco	13.97	3.24
Apizaco	16.08	2.99	Tula	13.84	3.23
Tlaxcala	15.81	3.40	Cuautla	13.66	1.11
Tulancingo	14.92	1.70	Puebla-Tlaxcala	13.30	4.03
San Martin Texmelucan	14.90	2.20	Pachuca	13.21	3.96
Minatitlan	14.61	5.66	Oaxaca	12.63	7.90
Xalapa	14.60	6.82	Tampico	12.31	5.42
Acayucan	14.36	-0.88	Veracruz	12.19	4.00

Source: authors' calculations using data from the Mexican Population and Household Censuses for 2000 and 2010.

Results indicate that the MA with the lowest wage level (controlling for individual charactersitics) needed an increase of 17 percentage points in its share of college graduates in order to reach the median MA wage level (see Table 11). Comparing this figure with the highest change in the percentage of college graduates registered by an MA (9.2 percentage points), such a change does not appear to be plausible. As the table shows, the MAs did not

even reach 50% of the change required, holding other variables constant, in order to achieve the median regression adjusted wage for MAs.

5. Discussion

Even though external returns to higher education are crucial for growth theory and public investment on education, there is still little agreement regarding their existence and even less on their precise nature. That is, it is not clear whether they are due to market conditions or to externalities generated by direct or indirect interaction with more educated individuals.

Most of the literature has focused on developed countries, which have an entirely different educational structure from developing economies, with mixed results[17]. Thus, it is important to analyze whether similar results are obtained for developing countries, as well as to determine the nature of these returns, in order to consider the different policy implications.

This paper addressed these issues by using the Mincerian and constant composition approaches, instrumenting in both cases for the share of college graduates in an MA with its demographic structure. The results indicate that external returns to education are found in all the different specifications used in the analysis. A one percentage point increase in the share of college graduates in an MA results in more than a six percent increase in regression-adjusted average wages. This magnitude is much higher than that of Moretti's (2004) finding for the U.S. (1.13%) but highly consistent with the results of Rosenthal and Strange (2008).

An unexpected outcome of this analysis is that the coefficients are higher for college graduates, while according to the theoretical model, the effects should be ambiguous for this kind of workers. A possible explanation is that externalities have different effects depending on the educational level. Another alternative that could lead to these results, and that should be further analyzed, is the case of a segregated distribution of skills in which individuals with very different educational background do not interact much. Theoretically, we could consider a continuum of agents located along an interval of the real line where skilled and unskilled individuals could either locate uniformly along the inverval or divide into segments of skilled and unskilled people.[18] In this kind of framework the relevant variable for each

[17] Conley et al. (2003) calculate social returns for Malaysia, which is a developing country, but as can be seen in their descriptive statistics, the average share of college graduates in that country is much higher than the one observed in Mexico.
[18] See Mookherjee, Napel, and Ray (2010) for an example of segregated settings.

individual in the productivity shifter (equation 2.2) would no longer be the share of college graduates in the city but a function $\rho(c)$, that indicates the proportion of skilled people that individual c works with. Thus, for unskilled individuals, the proportion of college graduates in a city would be much higher than the one he really observes[19]. In this context, the equalizing role of human capital is not clear.

Contrary to what Ciccone and Peri (2006) find for the U.S., in the case of Mexico, human capital externalities are significant. In this sense, there appears to be space for public policies aimed at enhancing these positive externalities (incentives for college studies), which are consistent with the standard public finance analysis.

Further analysis is required in order to identify the sources of these externalities. For example, Mexico, unlike the U.S., is not involved in a process in which clusters of college graduates are drivers of the whole country's productivity. Therefore, it is important to assess the effects of different kinds of occupations, which pose the challenge of finding appropriate instruments.

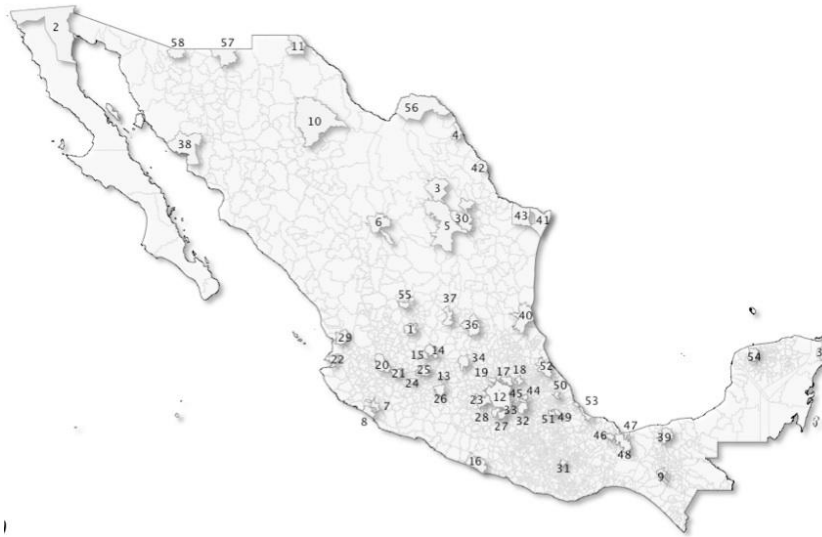
From the geographical perspective, this paper assumes that MAs are the best units for the analysis of knowledge spillovers, that is, that individuals live and work in an MA, and all the interactions that could generate positive human capital externalities take place in this area. Thus, it is important to test whether these results hold under alternative geographical definitions, as well as to allow for the possibility of commuting between locations.

Finally, it is important to consider that these results are based on a one generation model: more highly educated individuals only affect people of the same generation. However, in a more comprehensive analysis based on development theory, the interaction with more educated individuals could have intergenerational effects through changes in aspirations regarding future generations. The exchange of ideas could broaden what Ray (2006) regards as the aspiration window, allowing parents to expect more from their children, which in turn will generate wage benefits for the next generation.

[19] Additionally, in this case the conclusion that pecuniary externalities and technology externalities lead to similar empirical results does not longer hold. As pecuniary externalities work mainly through prices, they would still have the same effects even though less skilled individuals do not interact much with skilled people.

Appendix 1. MAs considered in the analysis

Figure 6
MAs structure



1 Aguascalientes	16 Acapulco	31 Oaxaca	46 Acayucan
2 Tijuana	17 Pachuca	32 Puebla-Tlaxcala	47 Coatzacoalcos
3 Monclova-Frontera	18 Tulancingo	33 San Martin Texmelucan	48 Minatitlan
4 Piedras Negras	19 Tula	34 Queretaro	49 Cordoba
5 Saltillo	20 Guadalajara	35 Cancun	50 Xalapa
6 Laguna	21 Ocotlan	36 Rioverde-Ciudad Fernandez	51 Orizaba
7 Colima- Villa de Alvarez	22 Puerto Vallarta	37 San Luis Potosi-Soledad Graciano Sanchez	52 Poza Rica
8 Tecoman	23 Toluca	38 Guaymas	53 Veracruz
9 Tuxtla Gutierrez	24 Zamora-Jacona	39 Villahermosa	54 Merida
10 Chihuahua	25 La Piedad	40 Tampico	55 Zacatecas-Guadalupe
11 Juarez	26 Morelia	41 Matamoros	56 Acuña
12 Valle de Mexico	27 Cuautla	42 Nuevo Laredo	57 Agua Prieta
13 Moroleon-Uriangato	28 Cuernavaca	43 Reynosa-Rio Bravo	58 Nogales
14 Leon	29 Tepic	44 Apizaco	
15 San Francisco del Rincon	30 Monterrey	45 Tlaxcala	

Source: authors' elaboration with information from INEGI/CONAPO SEDESOL.

References

Acemoglu, D. (1996). "A microfoundation for social increasing returns in human capital accumulation". *The Quarterly Journal Of Economics*, 111(3), 779-804.

Acemoglu, D., and Angrist, J. (2001). "How Large are Human-Capital Externalities? Evidence from Compulsory Schooling Laws". In B. S. Bernanke, and K. Rogoff (Eds.), *NBER Macroeconomics Annual 2000* (Vol. 15, 9-74). Cambridge, MA: MIT Press.

Acemoglu, D., and Autor, D. (2011). "Skills, tasks and technologies: Implications for employment and earnings." *Handbook of labor economics*, *4*, 1043-1171.

Acemoglu, D., and Autor, D. (2012). "What Does Human Capital Do? A Review of Goldin and Katz's The Race between Education and Technology". *NBER Working Papers No. 17820*.

Angrist, J., and Krueger, A.B. (1991). "Does Compulsory School Attendance Affect Schooling and Earnings". *Quarterly Journal of Economics*, 106, 979-1014.

Autor, D., and Dorn, D. (2013)."The growth of low-skill service jobs and the polarization of the US labor market." *The American Economic Review*, *103*(5), 1553-1597.

Autor, D., Levy, F., and Murnane, R. J. (2003). "The Skill Content of Recent Technological Change: An Empirical Exploration." *Quarterly Journal of Economics*, *118*(4).

Becker, G. (1980). *Human capital: a theoretical and empirical analysis, with special reference to education*. Chicago, IL, USA: University of Chicago Press.

Benabou, R. (1996). "Equity and efficiency in human capital investment: the local connection". *The Review of Economic Studies*, *63*(2), 237-264.

Card, D. (1999). "Estimating the Return to Schooling: Progress on some persistent econometric problems". *Econometrica*, 69(5), 1127-1160.

Ciccone, A., and Peri, G. (2006). "Identifying Human-Capital Externalities: Theory with Applications". *Review of Economic Studies*, 73, 381-412.

Conley, T. G., Flyer, F., and Tsiang, G. R. (2003). "Spillovers from Local Market Human Capital and the Spatial Distribution of Productivity in Malaysia". *Advances in Economic Analysis & Policy*, 3(1).

Goldin, C., and Katz, L. F. (2008). *The race between education and technology*. Cambridge, MA, USA: Belknap Press of Harvard University Press.

INEGI (1990). 1990 Population and Housing Census. Retrieved from www.inegi.org.mx

INEGI (2000). 2000 Population and Housing Census. Retrieved from www.inegi.org.mx

INEGI (2010). 2010 Population and Housing Census. Retrieved from www.inegi.org.mx

Jacobs, J. (1969). *The Economy of Cities.* New York, NY, USA: Random House.

Katz, L.F., and Murphy, K.M. (1992). "Changes in relative wages, 1963-1987: supply and demand factors". *The Quarterly Journal of Economics*, 107, 35–78.

Lochner, L. (2004). "Education, Work, and Crime: A Human Capital Approach". *International Economic Review*, 45(3), 811-43.

Lochner, L., and Moretti, E. (2004). "The Effect of Education on Crime: Evidence from Prison Inmates, Arrests, and Self-Reports". *American Economic Review*, 94(1), 155-189.

Lucas, R. E. Jr. (1988). "On the Mechanics of Economic Development". *Journal of Monetary Economics*, 22, 3-42.

Mankiw, N. G., Romer, D., and Weil, D. N. (1992). "A contribution to the empirics of economic growth". *The Quarterly journal of economics*, *107*(2), 407-437.

Mookherjee, D., Napel, S. and Ray, D. (2010). "Aspirations, Segregation, and Occupational Choice". *Journal of the European Economic Association*, MIT Press, 8(1), 139-168.

Mincer, J. (1958). Investment in human capital and personal income distribution. *The Journal of political economy*, 281-302.

Mincer, J. (1974). Schooling, Experience, and Earnings. Human Behavior & Social Institutions No. 2.

Morales-Ramos, E. (2011). "Los Rendimientos de la Educación en México". Working paper 2011-7, Banco de México.

Moretti, E. (2004a). "Human capital externalities in cities". *Handbook of regional and urban economics*, *4*, 2243-2291.

Moretti, E. (2004b). "Estimating the social return to higher education: evidence from longitudinal and repeated cross-sectional data". *Journal of Econometrics*, 121, 175-212.

Moretti, E. (2004c). "Workers' Education, Spillovers, and Productivity: Evidence from Plant-Level Production Functions". *The American Economic Review*, 94(3), 656-690.

Moretti, E. (2012). *The New Geography of Jobs*. New York, NY: HMH.

Psacharopoulos, G. (2006). The value of investment in education: Theory, evidence, and policy. *Journal of Education Finance*, 113-136.

Rauch, J. E. (1993). "Productivity Gains from Geographic Concentration of Human Capital: Evidence from Cities". *Journal of Urban Economics*, 34, 380-400.

Ray, D. (2006). Aspirations, poverty, and economic change. In Banerjee, A. V., Benabou, R., & Mookherjee, D. (Eds.). *Understanding poverty* (pp. 409-421). New York, NY, USA: Oxford University Press.

Roback, J. (1982). "Wages, rents, and the quality of life". *The Journal of Political Economy*, 1257-1278.

Rosenthal, S., and Strange, W., (2008). "The attenuation of human capital spillovers". *Journal of Urban Economics*, 64(2), 373-389.

Sand, B. M. (2013). A re-examination of the social returns to education: Evidence from US cities. *Labour Economics, 24*, 97-106.

U.S. Census Bureau. (2011). Current Population Survey, 2011 Annual Social and Economic Supplement.

World Bank. (2009). Public investment in tertiary education per pupil as a percentage of GDP per capita 2009. Data retrieved August, 2012, from World DataBank database.