investigación económica, vol. LXXIII, no. 287, January-March 2014, pp. 85-114.

Skilled labor, specialization, and urban labor productivity on Mexico's northern border: A panel analysis of mixed effects

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Abstract

This article evaluates the impact of skilled labor on productivity and returns of labor at the level of industrial subsectors in the most populated urban settings of Mexico's northern region during 2001-2009. It was found that within the 53 subsectors considered in this study, the percentage of workers with a high level of schooling increased from 9.69% to 14.34%. The estimations of the fixed-panel, random, and mixed models suggest that the returns to scale increase as long as positive capital flows and foreign direct investment are occurring. At the city level, an important variability was detected in results, but this is mostly due to the characteristics of the economic activity rather than the geographic location of the cities.
Key words: productivity, wages, skilled labor, cities, northern border.
Classification JEL: C33, J24, O14, R11.

Introduction

In the past twenty years, Mexico's northern border has undergone important changes in its economic structure and dynamics as a result of growing economic integration between Mexico and the United States. As a result, significant economic and population growth has occurred in the border cities, leading to their urban expansion. Similarly, important economic sectors have developed, particularly in the manufacturing export and maquiladora sectors, leading to industrial agglomerations in the region. It is important, therefore, to estimate the effect of these changes on the urban labor market of the northern border, since it will allow us to understand if urbanization, economic specialization, and

Manuscript received August 2012; accepted March 2014.
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the labor force's educational levels have produced changes in productivity levels and in workers' wages in these urban areas.

It should be noted that incentives to specialization, as well as decisions to maintain a continuous flow of investment for physical infrastructure and technological improvement in economic activities, arise mainly from increasing returns derived from investment in human capital. The growth of an economic region, a city, a county, or a given industry, basically depends on maximizing the intensive use of the skills and knowledge acquired by the labor factor (Acemoglu, 2002; Henderson, 1974; Rosen, 1983). Further, it is noteworthy that the competence of the labor force in the local labor market also spurs learning (Schultz, 1972; Glaeser, 2011; OECD, 2012).

The appearance of economies of scale within industry is a complex process, not only because they may arise from any of the diverse divisions of labor that are part of modern economic activity (Henderson, 2003), but also because, at an aggregate level, they may be present without it being possible to attribute concretely from which activities they have derived. At an aggregate level, a spillover (the gains from an interaction within or outside companies among workers with distinct skills and varying access to technologies), can contribute to the growth of a particular company within the industrial sector to which it belongs.

Adjustment within the labor market, particularly having to do with nominal salaries, employment, and productivity, is complex and is not exclusively limited to a relationship such as the one depicted by the Phillips curve (Galindo and Catalán, 2010). Therefore, in the macroeconomic realm, it is difficult to estimate the effects of scale produced by spillovers of skills and knowledge. Further, the existence of economies of scale can be noted in reduced geographic areas, since, within these areas, the free exchange of knowledge among peers (workers) is facilitated due to their physical proximity (Barro and Sala-i-Martin, 2004). In this context, both cities and industries are a more adequate level of analysis to estimate the effects of scale that arise because of knowledge (Barro and Sala-i-Martin 2004: 219).

From an urban perspective, the potential for individuals and companies that participate in markets derives from acquiring skills and knowledge through which it is possible to apply production methods and techniques that will lead to the generation of economies of scale or, alternatively, will lessen the impact on economic growth that might result from an economic crisis due to shocks beyond the control of the city or its economic agents (Jacobs 1970; Glaeser and Redlick, 2008; Glaeser, 2011; OECD, 2012).

This paper endeavors to find evidence that, between 2001 and 2009 in northern Mexico's most densely populated urban areas, skilled labor (where "skilled" refers to schooling and specialization), showed greater returns to scale than low skilled labor, and that these returns were not only individual gains, but also point to the presence of both a human-capital and a pecuniary spillover effect at an industrial subsector and city level. Here we understand pecuniary to mean the monetary impacts of having knowledge, and non-pecuniary the effects observed on production itself. Further, we hope to estimate returns across time among economic sectors and cities. We ground our objectives on the assumption that workers are drawn to the city due to the incentives available there to exchange skills that complement those already acquired, to learn from others, and to gain personally from diversifying their abilities (Marshall, 1890; O'Flaherty, 2005).

Specifically, we analyze the ten largest urban areas in Mexico's northern region by focusing on the skills and knowledge of those who live there. After more than four decades of political and institutional changes that have restructured the country's northern region (Mendoza Cota, 2002; Urciaga García and Almendarez Hernández, 2008), we would hope to observe that the labor dynamic in cities, and in companies and individuals therein, has changed, and that having skills and knowledge is a decisive factor in differences in output and in labor wages.

The paper is structured as follows: in section two we briefly discuss empirical factors regarding labor conditions found in the economic activity of northern Mexico's ten most populated urban centers at two moments in time, *i.e.*, 1999 and 2009. Based on the aforementioned review, section three discusses the theoretical foundation of the study; in section four the methodology is considered, in section five we discuss the econometric results, and, finally, in section six we discuss the conclusions.

Particularities of northern Mexico's urban labor markets

In this section we describe the behavior of variables that characterize the labor market of the largest cities of Mexico's northern border. Graph 1 shows productivity (π)[1] and average wages (w) in logarithms by city for 1999 and 2009.

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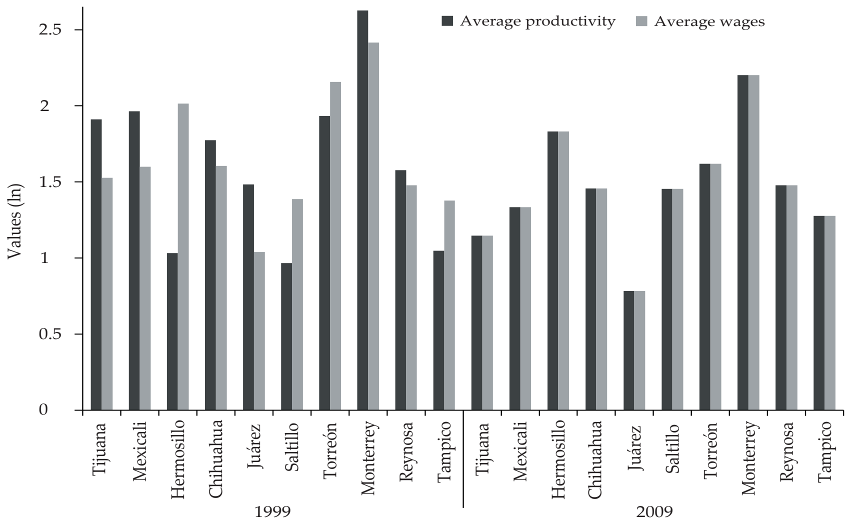
1 Labor productivity was obtained by dividing value added by employed personnel in the 53 subsectors of urban production.

In most cases both variables decreased during the two years considered. In Hermosillo, Torreón, Saltillo, and Tampico, wages exceed productivity. The opposite occurs in the other cities. The only case where π and w are almost equal is Juárez in 2009. Thus from the data we conclude that wages and productivity do not behave equally, suggesting that local factors in the urban centers are behind the difference in the behavior of the labor markets.

Graph 1
Logarithm of mean productivity and wages by city and year, 1999 and 2009



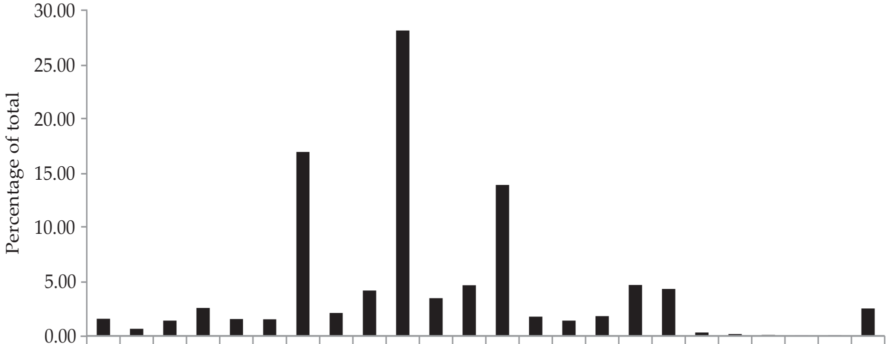
Source: compiled by authors based on data from *Censos Económicos 1999* and *2009,* INEGI.

Graph 2 shows the years of schooling of employed personnel in the 53 industrial subsectors[2] (following the North American Industrial Classification System, NAICS, published by Instituto Nacional de Estadística y Geografía, INEGI), for the ten

[2] 112 Animal breeding and production, 221 Electric power generation, transmission, and distribution, 311 Food industry, 312 Beverage and tobacco industries, 313 Textile inputs manufacturing and textiles finishing, 314 Textile products manufacturing, except apparel, 315 Apparel manufacturing, 321 Wood industry, 322 Paper industry, 323 Printing and related industries, 324 Petroleum and coal products manufacturing, 325 Chemical industry, 331 Basic metal industry, 332 Metal products manufacturing, 333 Machinery and equipment manufacturing, 334 Manufacturing of computer, communications, and measuring equipment, and other electronic equipment, components, and appliances manufacturing, 335 Electric appliances, accessories, and electric-power generation equipment manufacturing, 336 Transportation equipment manufacturing, 337 Furniture, mattresses, and blinds manufacturing, 339

most populated urban areas of six states in the north of Mexico in 2000. Taking the average schooling of the six states together, most employed personnel in the 53 subsectors have nine years of schooling, *i.e.*, 28.1% of all personnel.

Graph **2**
Schooling of employed personnel by industrial subsectors in northern Mexico's ten largest cities, 2000



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	99
%	1.5	0.6	1.4	2.5	1.5	1.5	16.	2.1	4.1	28.	3.4	4.6	13.	1.7	1.3	1.8	4.6	4.3	0.3	0.1	0.0	0.0	0.0	2.5

Years of schooling

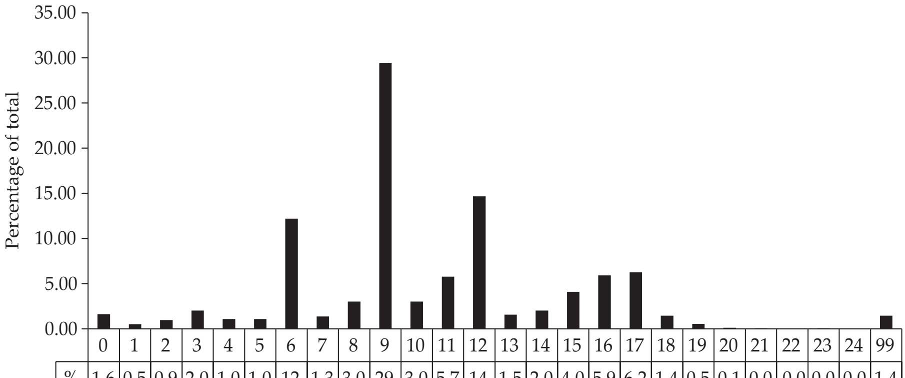
Source: compiled by the authors based on the *Censo de Población 2000*, inegi.

Other manufacturing industries, 432 Wholesale trade of textile products and footwear, 433 Wholesale trade of pharmaceutical and perfumery products, recreational goods, and small and major household appliances, 434 Wholesale trade of agricultural, forestry, and industrial raw materials, and waste materials, 435 Wholesale trade of agricultural, industrial, commercial, and services machinery, equipment, and furniture, and other general purpose machinery and equipment, 461 Retail trade of groceries, food, beverages, ice, and tobacco, 462 Retail trade in self-service shops and department stores, 463 Retail trade of textile products, costume jewelry, clothing accessories, and footwear, 464 Retail trade of health-care items, 465 Retail trade of stationery supplies, recreational, and other personal goods 466 Retail trade of household goods, computers, interior decorative articles, and used goods, 467 Retail trade of hardware and glass, 468 Retail trade of motor vehicles, parts, fuels, and lubricants, 469 Retail trade exclusively through Internet and printed catalogs, television, and similar media, 481 Air transportation, 484 Freight ruck transportation, 491 Postal service, 492 Courier and messenger services, 511 Newspaper, magazine, book, software, and other materials publishing, and integrated publishing and printing of these publications, 512 Film and video industry, and sound recording industry, 522 Credit and financial intermediation institutions, non-stock exchange, 523 Stock market, currency exchange, and financial investment activities, 531 Real estate services, 541 Professional, scientific, and technical services, 561 Business support services, 562 Waste management and remediation services, 621 Outpatient medical services and related services, 622 Hospitals, 623 Social assistance and health care residential facilities, 721 Temporary accommodation services, 722 Food and beverage preparation services, 811 Repair and maintenance services, 812 Personal services, 813 Associations and organizations.

The next two largest groups are: six years of schooling, encompassing 16.9% of employed personnel, and twelve years of schooling, with 13.9% of the total. Note that these three groups (6, 9, and 12 years of schooling) represent 58.9% of all employed personnel in those same subsectors during 2000. The latter figure, when added to the 14.43% of the remaining levels of schooling (between eight and eleven years), accounts for 73.33% of all employed personnel. In other words, 73 of every 100 employees have between six and twelve years of schooling. Further, personnel with an even higher level of schooling (16 years of schooling or more), make up 9.69% of all personnel in these same urban areas, while 9.29% have less than five years of schooling, meaning either unfinished primary school or no schooling at all.

Graph 3 shows years of schooling of employed personnel in the 53 economic subsectors in the ten largest urban areas in the six states of northern Mexico in 2010. At the end of the decade, 56.1% of workers had nine years of school, a drop of 2.8% compared to 2000. Similarly, the group with between six and twelve years of schooling that comprised a bit less than three-quarters of the total, in 2010 made up only 69.21% of the total, a drop of somewhat more than four percent.

Graph 3
Schooling of employed personnel by industrial subsectors in the ten largest cities in northern Mexico, 2010



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	99
%	1.6	0.5	0.9	2.0	1.0	1.0	12	1.3	3.0	29	3.0	5.7	14	1.5	2.0	4.0	5.9	6.2	1.4	0.5	0.1	0.0	0.0	0.0	0.0	1.4

Source: compiled by the authors based on data from *Censo de Población 2010,* inegi.

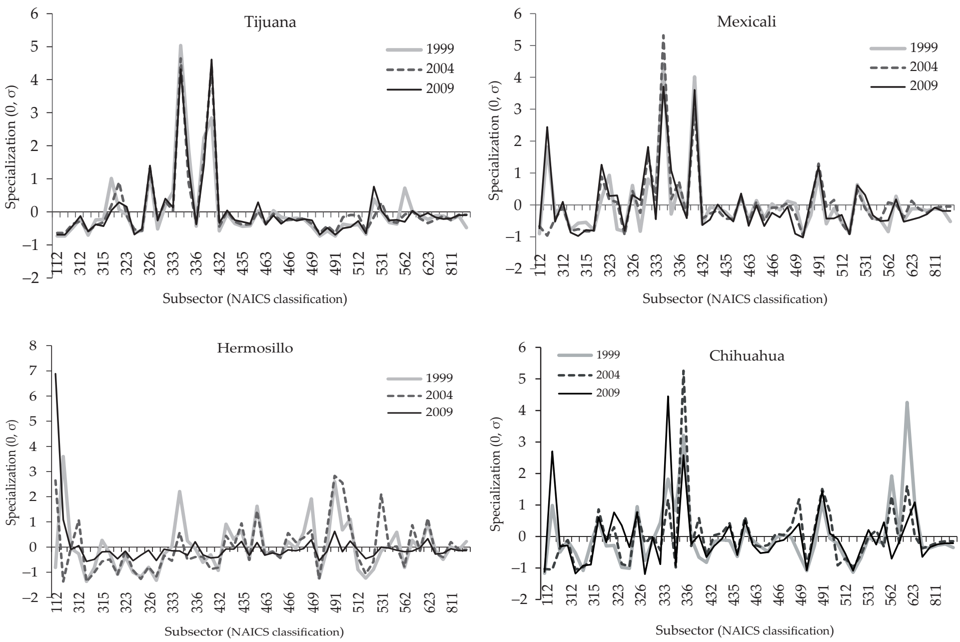
The percentage of personnel with incomplete primary schooling (from 0 to 5 years) also decreased: in 2010 it was 8.3% of the total, 1.01% less than in 2000. The overall drop in all sectors might indicate a fall in general employment, given the worldwide recession during the decade; still, the group with 16 or more years of schooling grew, from 9.69% in 2000 to 14.34% in 2010.

Note that in both Graph 2 and 3 there are small variations in schooling. Yet we suggest that the differences between 2000 and 2010 in the make-up of the strata with most schooling are considerable over this period.

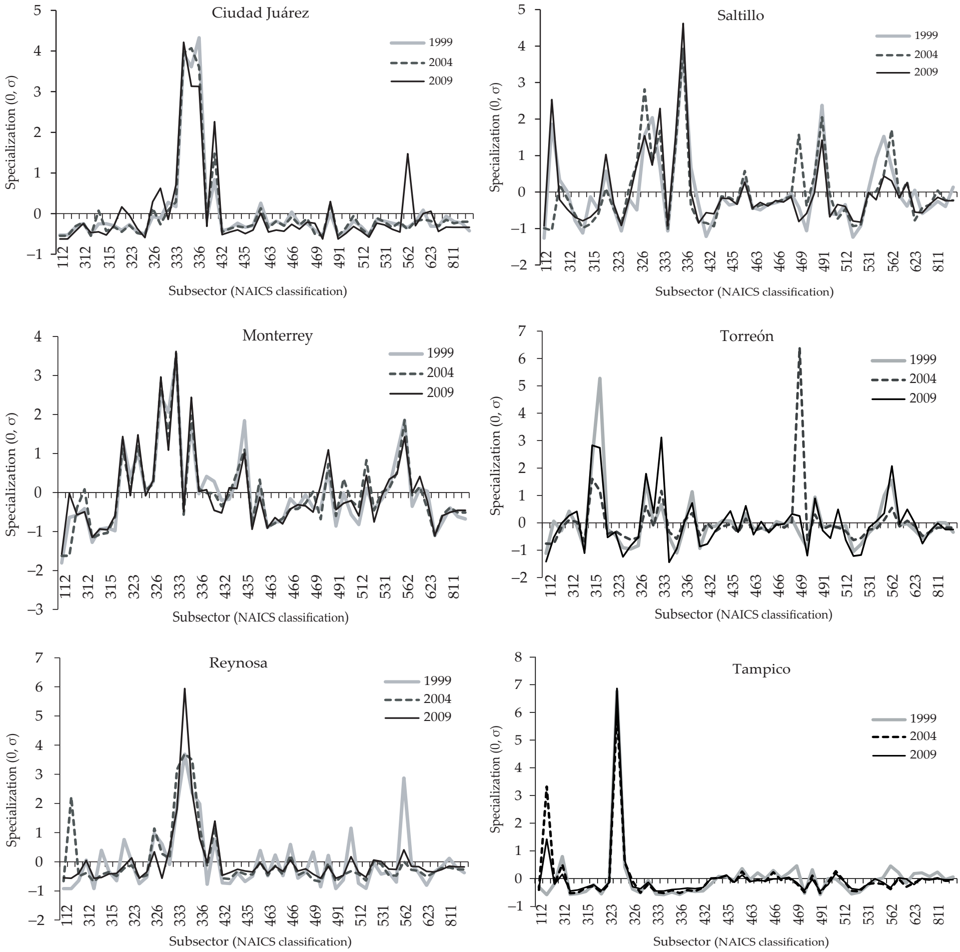
Insofar as labor specialization is considered, Graph 4 shows the coefficient of specialization constructed for each city in the sample in the three moments of time under study. The constructed coefficient was normalized (*i.e.*, zero mean and constant deviation by year), in order to have a point of comparison in the distribution by year of labor use in the 53 subsectors in each urban area. In this graph we opted to include the year 2004 so as to observe the transition in activities within the cities studied over the course of the decade.

Graph **4**

Labor specialization: activities by city that have the largest number of employed personnel, 1999, 2004, and 2009



Graph 4, continuation…



Source: compiled by the authors based on data from the *Censos Económicos 1999, 2004,* and *2009* from inegi.

It is noteworthy that the manufacturing of computer, communications, and measuring equipment subsector (334) posted increases above the national average, which is the subsector that constantly has a higher index in several of the cities studied, with the exception of Tijuana and Mexicali, in which spikes had already occurred in 2004 and 1999. In fact, in 2004 and 2009, in Mexicali there is a drop in the intensity of use of employed personnel in this subsector.

Two cases which could have been expected were the spikes in Tampico (221: Electric power generation, transmission, and distribution; and 324: Petroleum and coal products manufacturing), and Hermosillo (112: Animal breeding and production), during the three years, but more so in 2009). Noteworthy is the fall in subsector 221 that occurred in Tampico during 2004-2009, a city in which there is petroleum industry activity, which is an exception in the ten urban areas. Given the strong influence of primary activities in the state of Sonora, it is logical that Hermosillo would specialize in one subsector thereof, although it is unusual that the growing specialization would occur in the three time periods.

In addition to subsector 334, the presence of 333: Machinery and equipment manufacturing; of 335: Electric appliances, accessories, and electric-power generation equipment manufacturing; of 336: Transportation equipment manufacturing; and 339: Other manufacturing industries, underscore the importance of the assembly industry in Mexico's northern region. Nonetheless, the panorama and the relevance across time in each particular case differ: in Tijuana, for example, specialization in subsector 339 grew, as it did in Juárez. Yet, in Chihuahua and Juárez specialization in subsector 336 fell over the decade, while in Saltillo it grew.

Graph 5, as in Graph 1, shows changes among the independent variables: h (percentage of workers with a high level of schooling, l (workers with a low level of schooling), and s (labor specialization).[3] In most cases, h is greater than l both in 1999 and 2009; the exceptions are Monterrey, in 1999, and Reynosa, in 2009. From 1999 to 2009, the drop in the three variables is apparent, and is most evident in labor specialization in almost all cases.

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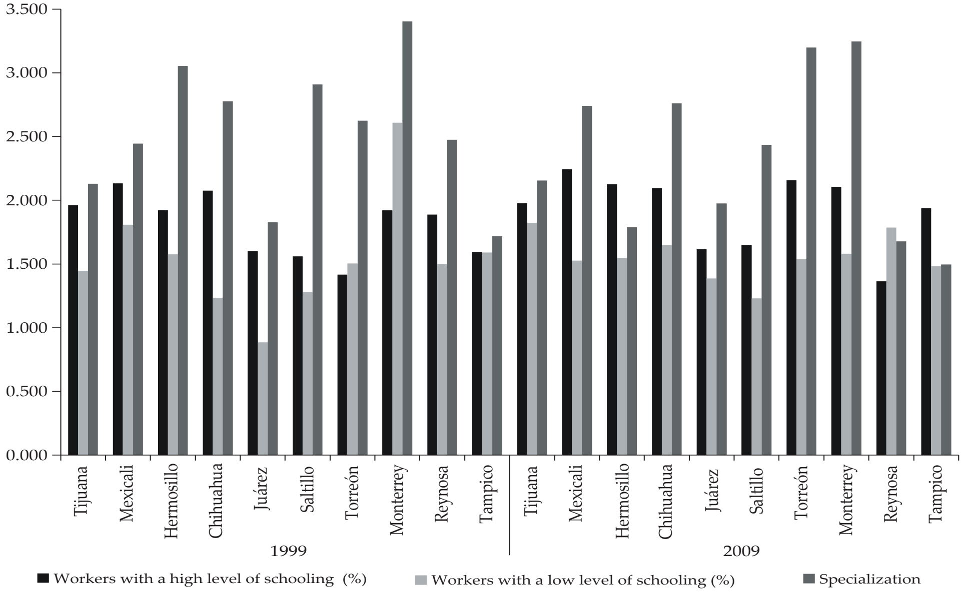
[3] The variable that reflects labor specialization is calculated by dividing total employed personnel (by subsector, by city, and by year) by total employed personnel (by subsector and year at a national level). Formally:

$$s = \frac{employed\ personnel_{ict} / employed\ personnel_{ct}}{employed\ personnel_{int} / employed\ personnel_{nt}} \qquad [1]$$

where i is the economic subsector; c, the city; t, the year; j, schooling level, and n, the country (Mexico).

Graph 5
Percentage of workers with a high and low level of schooling, and labor specialization, by city and year, 1999 and 2009



Source: compiled by the authors based on data from *Censos Económicos 1999* and *2009* and *Censos de Población 2000* and *2010,* inegi.

In conclusion, the phenomenon we are observing is perhaps the restructuring of the labor force in light of the changes in the labor market brought about by the recession over the course of the decade considered here. Companies come and go, and the work force adapts to the situation. Further, from Graph 5 we conclude that it is possible to undertake an econometric analysis to determine the time-linked effects of specialization. In terms of schooling at work, disparities are perhaps more noticeable among cities than among periods, but with the graph is it possible to show that they do in fact exist.

Theoretical perspective regarding the urban-labor market analysis

This paper's theoretical perspective is founded on two established currents: the theory of human capital and economic theories of city systems. Given that positions affiliated with one or the other are not mutually exclusive, we seek to integrate the two perspectives. This we do by synthesizing theoretical compilations, in order to have theoretical-conceptual elements that lend perspective to the econometric estimations on the effect skilled labor has on labor productivity in the urban areas of Mexico's northern border.

Theory of human capital

Human capital is an economic category that considers highly-skilled labor as an intangible factor of production, able to create wealth both for the skilled individual and for society as a whole. Further, it becomes a distinctive feature of the person who has skills since, when configured as knowledge and technical ability, both the worker and the capitalist have a stock that can be used (Schultz, 1972: 5-6). Thus investing in education is a profitable endeavor (Becker, 1993: 17), or, stated differently, its use leads to rewards stemming from yields that in turn derive from applying capital in the production process. Thus, both schooling as well as job training or learning-by-doing are important to the worker (Lucas, 1988). Regardless of the way knowledge and job-related skills has been acquired (formally or informally), these factors raise profits and productivity (Becker, 1993: 20-1).

If it is conceptually possible to break down human capital by where it was acquired (school or work), in technical terms it is also possible to define it as a rival or non-rival good. Human capital is a rival good if it is knowledge whose practical application in production cannot be conceived of without the physical presence of the individual, and as a non-rival good if it is thought of as a stock, which, although produced by individuals, remains and can be applied both by its creator as well as by others (Romer, 1990).

For several authors (Romer, 1990; Lucas, 2008; Moretti, 2004), it is in the non-rival aspect of human capital where its spillovers should be sought. We understand spillovers to mean the influence of human capital over and above the individual output that a single person could earn by possessing it (Moretti, 2004). In other words, we should assume that the factors of production work under increasing returns to scale and that, with time, the process will mature enough so that we can suppose that the creation of knowledge, as an externality, has occurred and has benefitted productivity (Barro and Sala-i-Martin, 2004).

Yet the literature in this regard is unclear what this non-rivalry is about and where it originates. It is possible that it derives from research and development (Romer, 1990) undertaken by a company or industry to improve its production process. It may also come from the interaction among individuals whose level of human capital is average for the economy or from an aggregate level of human capital (Lucas, 1988; Barro and Sala-i-Martin, 2004; Moretti, 2004).

We use the following equation herein:

$$\log\theta_j = \varphi_j + \gamma(S)$$

where $\log\theta_j$ is a parameter that expresses productivity, φ_j represents the individual's contribution, and $\gamma(S)$ is the combined contribution of all workers.

Further, we hold that $Y = AK^{\alpha} + L^{\beta}$, where K is capital and L is labor, assuming that $\alpha + \beta = 1$ (Barro and Sala-i-Martin, 2004). Thus, in imitating economies such as Mexico's, the contribution of physical capital is not the total contribution, but rather behaves as the aggregate of what is available ($Y = AL^{\beta}\sum_{c=1}^{N} X^{\alpha}$). Assuming that A (changes in productivity) depends on the total schooling of workers in a city, then $A = \gamma(S)$, while L is a function of the schooling or marginal contribution of education, *i.e.*, $L = \varphi_j$.

Thus we obtain $Y = \gamma(S)\varphi_j K$, whose logarithmic transformation generates the equation: $\ln Y = \ln\gamma(S) + \ln\varphi_j + \ln K$. Returning to our initial equation, the model becomes: $\log\theta_j = \varphi_j + \gamma(S)$, where θ is a change in productivity (*productivity shifters*), φ_j are effects of group (j) that account for individual variations of human capital and S is the stock of total human capital (Acemoglu and Autor, 2011: 47-50; Moretti; 2004: 2271).

Economic theory in city systems

Economies of scale can occur at different levels of economic activity, but whether they occur or not, they are invariably linked to the city's characteristics and the people who live there. In many ways, the city is the smallest observable geographic unit, where the interaction of economic agents can be seen as an interconnected system governed by the heterogeneity of individuals that determines the individual contribution to wealth generated therein (Hesham M. and Anas, 2004).

Skills and knowledge are largely essential to understanding the "why" of this heterogeneity among agents and, thus, are an important element for explaining the presence of economies of scale. In many other affairs, the heterogeneity of the urban labor force and its capacity for specialization or differentiation defines the pattern of economic life within the city and, ultimately, its development or decay (Glaeser, 2011; Jacobs, 1970).

Marshall is attributed with the first discussions regarding economic agglomeration. In his *chef d'oeuvre*, Marshall dedicates significant space to examining the locality and, specifically, how the patterns of agglomeration of economic activity vary among different cities and towns, leading to skills and expertise (Marshall, 1890). From that point, research branched into two significant currents on dissemination of knowledge within cities: the search for returns from agglomeration that generate economies of scale as posited by Marshall, Arrow, and Romer (Henderson, 2003; Glaeser, 1999), and the returns through differentiation of economic activities or the economies of scale referred to by Jacobs (Jacobs, 1970; Glaeser, 1999).

Note that theories on city systems generally focus on analyzing the rise of human agglomerations, as well as on the existence or fall of cities (Hesham M. and Anas, 2004; Glaeser and Redlick, 2008). Among their discussions, a key concept is paramount for this paper: labor specialization. Both industrial agglomeration and pollination of new activities arise initially from the assimilation of knowledge, not individual knowledge, but rather from the mass of workers themselves. (Glaeser *et al.*, 1992; Henderson, 2003). The concept disrupts what has already been discussed in the theory of human capital regarding on-the-job training. Yet the authors mentioned previously discuss it as something inherent to the city, as a human phenomenon with a geographic pattern (Bacolod, Blum and Strange, 2009), which reflects an abundance of skilled labor trained in a specific activity within the locality (Glaeser, 1999; Henderson, 1994).

Finally, another theoretical element presented in the analytic focus on labor is specialization, which arises from the time used for a particular activity. As a starting point we again take up Duranton and Puga's equation (2004) obtaining: $x(h) = \beta[l(h)]^{1+\theta}$, where x is output, β is productivity, h is the time that worker l spends on producing x, and θ is the intensity of the individual return from specialization. If we assume that physical capital is given at the aggregate level, this implies that $Y = \beta L^{1+\theta}$, *i.e.*, that specialization generates increasing returns to labor.

Theories on changes in productivity and its measurement

Studies of productivity are often carried out from a perspective of convergence or divergence between regions at an aggregate level. Evidence exists of significant convergence in the industrialized world during the past century: countries with low labor productivity at the end of the 19th century experienced a higher rate of convergence growth throughout the 20th century (Baumol, 1986). The surroundings have also been studied as an element that affects labor productivity (Sveikauskas, 1975), as do economic cycles (Jorgenson and Griliches, 1967).

The sources of shocks to productivity produce alterations in production possibilities, such as technology and changes in the cost of factor utilization, among which is the labor factor. The impact of knowledge in production is a shock to productivity, since it strengthens the production possibilities of a plant, an industry, or a region (Bernanke, 1981). The theories previously mentioned (human capital and city systems theories) explore these shocks and their relation to the acquisition of knowledge. Note that measuring productivity shocks as spillovers of knowledge implies dividing them into pecuniary and non-pecuniary (Acemoglu and Autor, 2011). For this reason, the model discussed in the previous section, $\log\theta_j = \varphi_j + \gamma(S)$, allows us to get a good approximation when measuring θ_j, by either productivity itself (Y/L or π), or by the monetary income of labor for its contribution to production, given that in competitive equilibrium $max_{L,\bar{K}}\ f(K,L) = \frac{\partial Y}{\partial L} L = wL$, which in theory means that salary or remuneration is a good proxy for measuring productivity.

Formalizing the applied model

In order to reconcile the theoretical positions that make up the framework, the application and the practicality of the applied empirical model, we begin with the regional unit of analysis at the level of cities, in turn linked to the national environment. With this focus, we assume the Mexican economy to be that of a country that imitates technology, formalized as: $Y = AL^{\beta}\sum_{c=1}^{N} X^{\alpha}$, with X as available intermediate goods (Barro and Sala-i-Martin, 2004: 352), or physical capital K. Note that the only difference between an imitating country and a technology-creating one resides in differences between A and L. Particularly, the differences in A (taken either as a parameter of productivity or as the aggregate level of human capital) can be attributed to institutional differences among countries, such as access to schooling and the productive environment in which companies work (Acemoglu and Dell, 2010: 4). For Mexico, and specifically, on-the-ground production in northern Mexico, two significant changes are the

Import Substitution Industrialization model (ISI) from the mid-20th century, and the National Border Industrialization Program, from the second half of the 20th century (Bataillon, 1988: 39-40), that led to the so-called maquiladora export industry.

The purpose of this paper is to analyze the details of the effects of both changes in the patterns of economic growth. Thus, the paper is grounded in the assumption that those changes have occurred, in other words, that the cities under study went through different stages and now have certain conditions that, hopefully, will show human capital and specialization to be key factors in productivity and wages.

Formally, following Acemoglu and Autor (2011: 47-8), the production function for the urban areas of northern Mexico would be defined as:

$$Y = AL^{\beta} \sum_{c=1}^{N} X^{\alpha} \qquad [2]$$

where $L^{\beta} = h^{\beta 1} s^{\beta 2} l^{\beta 3}$, h is a worker's marginal contribution in industry i with a high level of schooling and l is that of a workers with little schooling, X represents the intermediate goods or available physical capital and s is the local labor specialization, understood as:

$$s = L^{1+\theta} = \frac{\left(\delta L_{ic} / L_c\right)}{\left(\delta L_{in} / L_n\right)}$$

or labor ratio (δ) in industry i in city c with respect to industry i at a national level (n).

In an imitating economy there is a cost of imitating foreign innovations (Barro and Sala-i-Martin, 2004: 353-5). In the model to be applied, prices are not included, nor are we interested in the market effects of imitation. In other words, we are not seeking to determine an explicit cost within the formalization; on the contrary, we assume the cost to be implicit when dividing labor's share (β) into various elements. Labor, then, does not have similar returns to those found in an innovating economy, unless all the required elements exist (skilled labor, labor specialization).

Likewise, technological change arising from investments in physical capital, K, happens if the labor force has the necessary skills (Acemoglu, 2002). Under the assumptions used to build the model, however, change due to investments in K is internalized: the labor force already has a given amount of schooling and specialization. In an imitating country, capital flows are internal, external, and divisible, given that records of foreign direct investment (FDI) flows exist, and their impact is significant, particularly in areas of northern Mexico (Gallagher and Zarsky, 2007; Feenstra and Hanson, 1995).

It is possible that K (or intermediate inputs $\sum_{c=1}^{N} X^{\alpha}$, as also mentioned previously) can be read as a fixed flow. If at time t we have $K_t = 1$, then at t+1 we would have $K = 0$ if:

$$\frac{\partial K_{t+1}}{\partial K_t} < 0$$

and at t+2 if:

$$\frac{\partial K_{t+2}}{\partial K_{t+1}} < 0$$

In other words, if N is the sum of activities in the economy (or available intermediate goods), then:

$$\sum_{c=1}^{N} \left[\frac{\partial K}{\partial t}\right]^{\alpha} = \sum_{c=1}^{N} \left[\frac{\partial X}{\partial t}\right]^{\alpha}$$

would be as physical capital is formally assumed to be, whose values are only 0 and 1. Also $FDI = 1$ if subsector i, in city c at year t receives foreign direct investment flows, and is 0 in other circumstances.

Methodology of estimation

Based on the theoretical concepts previously presented involving equation [1] and revisiting the assumptions discussed in the previous section, we developed an empirical model to measure the variables transformed into logarithms. The model covers the individual effects of human capital on productivity φ_j and the overall effects $\gamma(S)$, or total human capital, and is one in which we would hope to observe spillovers of human capital thusly:

$$\log\theta = [\beta_1 \log(h) + \beta_2 \log(l) + \beta_3 \log(s)] + \gamma \log(A) + \alpha \log(\partial K/\partial t) + FDI \quad [3]$$

This is an equation in which:

1. $\log\theta$ is the parameter that measures labor productivity. In this paper, $\log\theta = \log\pi = \log w$, where π is productivity measured in terms of output volume (value added) and w is the wages earned.
2. $\varphi_j = [\beta_1 \log(h) + \beta_2 \log(l) + \beta_3 \log(s)]$corresponds to individual effects with h as labor with a high level of schooling, l is labor with little schooling, and s is a specialization index.
3. $\gamma(S) = \gamma \log(A)$ is total schooling in the city, a sum of all schooling of all working personnel in the urban sector, or the overall effects, which is where we would hope to see spillovers. In order to keep lower-case notation for variables, we note that $\gamma \log(A) = a$, which is not the same as the coefficient α for physical capital.
4. $\alpha \log(\partial K/\partial t) + FDI$ is the portion of physical capital, both the existing flow as well as the contribution of foreign capital. Both are fictitious variables (values of zero and one).

This model allows us to estimate the impact of the determinants of labor productivity in the largest cities in northern Mexico, using several variables that impinge on the skills and qualifications of the labor force. First, the variable in point 2 expresses the marginal effects of workers in each of the industries being considered. These effects are linked to workers' diverse schooling levels and the degree of labor specialization that they possess (φ_j). Further, we constructed a variable that includes the total effect of schooling and the possibility that this generates spillover effects or dissemination of labor skills to the agglomeration of workers in the industries and cities considered [$\gamma(S)$]. Finally, we included a variable that represents physical capital with values from zero to one, in order to control the effects of capital in labor productivity.

Panel model with mixed effects

As originally constructed, the model's structure implies that the data present a multi-tiered three-dimensional structure: city, subsector, and time. Thus the model in matrix array should have the following form:

$$y_{ict} = x'_{ict}\beta + u_{ict}$$

where i is the economic subsector, c the city, t time, and x is a vector of K explanatory variables (Hsiao, 2003: 302), as defined in the previous section.

According to Baltagi (2001: 175), the term of shocks also has a structure with embedded errors as follows:

$$u_{ict} = \mu_c + v_{ic} + \varepsilon_{ict}$$

an expression in which μ_c represents the error corresponding to the city and v_{ic} the error corresponding to the industry.

Therefore the embedded error components become estimators of the magnitude conferred to the total variance of activities in subsector i, in city c and in the set of levels ict. We assume that they are normally distributed with a zero mean and $\sigma_\mu^2, \sigma_v^2, \sigma_\varepsilon^2$, respectively. The model foresees a breakdown of the matrix of error variances and covariances so that we can undertake an ordinary least squares regression (OLS) of the transformed data. Doing so, however, is similar to a generalized least squares (GLS) regression of the original regression with weights based on the variability between and by groups (Hsiao, 2003: 303). For this reason we also estimated a panel model with mixed effects that allows us to transform the error variance, thus controlling for the hierarchy of error order (Stata Press, 2011; Rabe-Hesketh and Skrondal, 2008). Particularly, to the extent that the β of the panel model are considered as means among groups, we can estimate the variance among groups in the models being considered.

So, given the nature of the data base in use, it is impossible to consider the variance as a typical panel model that has y years and x observations in territory u, another category subject to grouping. For this reason, the term "panel" is used here to describe an econometric estimation technique and not because the data on hand behave like a panel itself. It is for this reason that we ran the fixed and random effects regressions with data based on two variables from different groups: by city c and by subsector i. This can have two consequences: the coefficients of variables at level 1 (subsector) and level 2 (city) become inflated, or turn out to be not significant, or show signs of multicollinearity among variables.

Table 1 shows the results of the estimated panel models. In those where productivity is a dependent variable and random effects are assumed, it is possible to register effects by city. The total coefficients of determination hover between 0.42 and 0.52, which, for panel data, is estimated to be adequate. These models take on a structure of a heteroscedastic panel, in order for any result that shows considerable variability to be immediately detected. This was not the case, at least, in variables related to labor and level of schooling.

Table 1

Results of panel models: fixed, random, and GLS effects by city and subsector

Productivity													
Parameters		*Group variable: c (city)*						*Group variable: i (subsector)*					
		RE		FE		MCG		RE		FE		MCG	
Ratio of educated workers (<12)by subsector with respect to the mean by city	*h*	0.362***	0.0277	0.377***	0.026	0.362***	0.0274	0.338***	0.0314	0.329***	0.033	0.354***	0.0247
Average ratio of educated workers (<12) by city	*h*	–0.856***	0.162	0	(.)	–0.868***	0.166	–0.829***	0.14	–0.818***	0.14	–0.610***	0.131
Average stock of human capital by subsector	*a*	0.0876**	0.033	0.0684*	0.0309	0.0791*	0.0324	0.154*	0.0699	0	(.)	0.0793**	0.0272
Ratio of non-educated workers (>5) by subsector with respect to the mean by city	*l*	0.194***	0.0269	0.197***	0.0251	0.199***	0.0266	0.152***	0.0282	0.143***	0.0292	0.174***	0.0247
Average ratio of non-educated workers (>5) by city	*l*	1.838***	0.136	0	(.)	1.814***	0.134	1.864***	0.117	1.874***	0.117	1.622***	0.11
Labor specialization in differences with respect to time	*s*	–0.594***	0.0509	–0.833***	0.0534	–0.584***	0.051	–0.570***	0.0448	–0.562***	0.0449	–0.535***	0.0423
Capital flows	*k*	0.398***	0.0602	0.426***	0.0566	0.389***	0.0587	0.370***	0.0535	0.367***	0.0536	0.321***	0.0486
Foreign direct investment flows	*fdi*	0.416***	0.0651	0.387***	0.061	0.429***	0.0637	0.184*	0.0844	0.0896	0.0928	0.390***	0.0624
Intercept		–0.814*	0.34	0.528*	0.207	–0.688*	0.324	–1.255*	0.518	–0.242	0.226	–0.896**	0.274
R^2 Within		0.5125		0.5212				0.3763		0.3771			
R^2 Among		0.6084		0.0003				0.6799		0.684			
R^2 Total		0.5219		0.4292				0.5137		0.4977			
Tests													
Breusch and Pagan LM test for random effects		632.66						604.01					
Probability > Chi-squared		0.0000						0.0000					
Hausman test		-		217.34				-		11.38			
Probability > Chi-squared		-		0.0000				-		0.1229			

Notes: RE: random effects; FE: fixed effects; GLS: generalized least squares. *h* and *l* (at the city level) omitted due to collinearity. *a* (at the subsector level) omitted due to collinearity. The matrix of variances-covariances used in the Hausman test (V_b-V_B) is not defined as positive.

Table 1, continuation…

Parameters		Wages											
		Group variable: c (city)						*Group variable: I (subsector)*					
		RE		FE		MCG		RE		FE		MCG	
Ratio of educated workers (<12) by subsector with respect to the mean by city	*h*	0.416***	0.0238	0.421***	0.0229	0.405***	0.0233	0.406***	0.029	0.387***	0.031	0.467***	0.0209
Average ratio of educated workers (<12) by city	*h*	–0.186	0.13	0	(.)	–0.263*	0.129	–0.138	0.0968	–0.13	0.0961	–0.103	0.104
Ratio of educated workers (<12) in differences with respect to time	*h*	–0.384***	0.0364	–0.438***	0.0359	–0.366***	0.0355	–0.410***	0.0304	–0.407***	0.0305	–0.409***	0.0328
Ratio of non-educated workers (>5) by subsector with respect to the mean by city	*l*	0.187***	0.0203	0.181***	0.0195	0.183***	0.0198	0.115***	0.0206	0.100***	0.0213	0.178***	0.0179
Average ratio of non-educated workers (>5) by city	*l*	0.750***	0.111	0	(.)	0.820***	0.104	0.772***	0.0826	0.778***	0.082	0.752***	0.0891
Labor specialization by subsector with respect to the mean by city	*s*	0.226***	0.0294	0.229***	0.0283	0.238***	0.0289	0.264***	0.0303	0.283***	0.0317	0.151***	0.0241
Mean labor specialization by city	*s*	0.446***	0.0516	0	(.)	0.440***	0.0494	0.460***	0.0385	0.462***	0.0382	0.407***	0.0416
Capital flows	*k*	0.135**	0.0468	0.127**	0.0449	0.139**	0.0449	0.0773*	0.0363	0.0701	0.0362	0.103**	0.0378
Foreign direct investment flows	*fdi*	0.369***	0.0507	0.384***	0.0488	0.360***	0.0492	0.0127	0.0594	–0.0581	0.0622	0.319***	0.0443
Intercept		–0.519*	0.204	1.389***	0.0396	–0.503**	0.189	–0.533**	0.165	–0.536***	0.151	–0.578***	0.165
R^2 Within		0.6565		0.6573				0.5939		0.5948			
R^2 Among		0.7106		0.0209				0.6882		0.6697			
R^2 Total		0.6611		0.5872				0.6392		0.6271			
Tests													
Breusch and Pagan LM test for random effects		293.54						1 717.47					
Probability > Chi-squared		0.0000						0.0000					
Hausman test				–99.64				-		18.09			
Probability > Chi-squared				!				-		0.0342			

Notes: *h*, *l*, and *a* (at a city level) omitted due to collinearity. The matrix of variances-covariances used in the Hausman test (V_b-V_B) is not defined as positive. The fitted model with these data does not fulfill the necessary asymptotic conditions for the Hausman test.

Note: in all GLS models, heteroscedastic panels are assumed with no autocorrelation among them. Standard errors in italics. Significance of parameters: (*) $p < 0.05$, (**) $p < 0.01$ and (***) $p < 0.001$.
Source: compiled by the authors based on data from *Censos Económicos 1999* and *2009* and *Censos de Población 2000* and *2010*, INEGI.

Data

Data were obtained from Mexico's official census published by INEGI. Specifically, we used the *Censos Económicos* from 1999 and 2009, and the *Censos de Población y Vivienda* from 2000 and 2010. The former contains data on economic activity during 1998 and 2008. In line with the *Censos* style, we maintain the years that it uses in our analysis of the variable, so that, when 1999 is mentioned, the information really pertains to 1998, and the same holds true for 2009.

Four variables are taken from the *Censos Económicos*: gross census value added, total wages, employed personnel, gross fixed capital formation. From the *Censos de Población* we obtain information on the microdata, specifically on the accumulated schooling of the employed personnel in local economic activities from the ten cities under consideration. Lastly, all data were fitted in order to appear as numerical indexes, where the smallest value among subsectors, by city, would be 1, and the highest 100. All variables considered herein were handled in this way. Formally, we can say that each variable X becomes:

$$I_X = 1 + \left[(100-1) * \frac{X_{ict} - X_{MIN,ct}}{X_{MAX,ct} - X_{MIN,ct}} \right]$$

All natural logarithms obtained are derived from the transformed variables by this process.

Results of panel and GLS models

In the models of Table 1, results of the fixed, random, and GLS-effects panel models are shown by city and by subsector. In models where wages is the dependent variable, grouping together by subsector is more convincing, given the individual and joint tests. The total coefficients of determination obtained (total R squared) vary between 0.58 and 0.66, which for panel data is considered good. The LM tests of Breusch-Pagan indicate that it is worthwhile to keep the random effects models. The Hausman test for data grouped by city does not confirm this, since a similar situation occurs in models with productivity as a dependent variable.

Insofar as the Hausman test results are concerned, we know that the structure of the data is not that of a normal panel and that its behavior might or might not fit that of a traditional panel. For this reason, we cannot be entirely surprised that tests such as the Hausman test provide results that are not entirely clear. The reason lies in the type of test itself, since we would hope that, given an infinite number of data, the result would always be a positive value and the variance-covariance matrix (VCE) would be defined as positive. Yet in finite data bases, this is not always the case. So, while in the first estimated Hausman test we find that the compound variance-covariance matrix for the test is not defined as positive, in the second test the result was completely negative. In this regard, recent theoretical evidence exists (Schreiber, 2008) indicating that, in the case of a negative statistic, it is possible to take the absolute value of the indicator, even though the variance-covariance matrix, constructed from the parameters, is not defined as positive. This is independent of whether the indicator obtained is positive or negative.

It is important to note the characteristics of the multilevel model with mixed effects. This model is a maximum likelihood regression model with mixed effects: fixed and random. The estimated fixed effects are the same as those that would be obtained by running a maximum likelihood regression in panel. The random effects are not parameters in and of themselves; rather they are the effect that that variable has on the total variance of the model (Stata Press, 2011). We should recall that we are assuming that $y_{ict} = x_{ict}^{'}\beta + u_{ict}$, where $u_{ict} = \mu_c + v_{ic} + \varepsilon_{ict}$. In other words, the result obtained for random effects consists of the components of the u_{ict} error term (Gutiérrez, 2008).

Table 2 is constructed in the following way: there are three models whose dependent variable is productivity and three models with wages as the dependent variable. The only difference between them is the construction of the random effects: in model 1 we consider variables regarding the ordering of data (city and subsectors), and in model 2 we assume random effects in some relevant variables by subsector, while in model 3 this is done city by city.

Results of the mixed models: productivity

In the first model, where the dependent variable is productivity, total variance is 0.832. Notably, around 14% is attributable to differences in the city of origin of the activity undertaken, while 22.3% is due to differences in the activity undertaken itself (calculation obtained from the coefficients in Table 2). In

TABLE **2**

Mixed-effect models (embedded data), productivity and wages

Productivity							
Parameters		*Model 1*		*Model 2*		*Model 3*	
Fixed effects							
Ratio of educated workers (<12) by subsector with respect to the mean by city	*h*	0.349***	0.0271	0.353***	0.0277	0.360***	0.0297
Average ratio of educated workers (<12) by city	*h*	–0.789	0.643	–0.74	0.634	–0.697	0.625
Average stock of human capital by subsector	*a*	0.110**	0.0342	0.111**	0.0341	0.109**	0.0342
Ratio of non-educated workers (>5) by subsector with respect to the mean of the city	*l*	0.166***	0.0251	0.161***	0.0251	0.162***	0.025
Average ratio of non-educated workers (>5) by city	*l*	1.803***	0.538	1.779***	0.53	1.752***	0.522
Labor specialization in differences with respect to time	*s*	–0.812***	0.05	–0.826***	0.0555	–0.842***	0.0715
Capital flows	*k*	0.460***	0.0521	0.461***	0.0519	0.441***	0.0525
Foreign direct investment flows	*fdi*	0.346***	0.0647	0.333***	0.0649	0.338***	0.0646
Intercept		–1.077	1.056	–1.132	1.041	–1.128	1.027
Random effects							
City	μ	0.114***	0.0551	0.110***	0.0536	0.106***	0.0519
Ratio of educated workers (<12) by subsector with respect to the mean by city	*h*					0.00135**	0.00345
Labor specialization in differences with respect to time	*s*					0.0205***	0.0173
Subsector	ν	0.186***	0.0359	0.0223	0.102	0.188***	0.0361
Ratio of educated workers (<12) by subsector with respect to the mean by city	*h*			0.0166***	0.0151		
Labor specialization in differences with respect to time	*s*			0.0831***	0.0557		
Average stock of human capital by subsector	*a*			0.00331***	0.00241		
Residual	ε	0.532***	0.0345	0.495***	0.0363	0.522***	0.0341
Akaike information criterion (AIC)		2 670.577		2 668.21		2 669.696	
Bayesian information criterion (BIC)		2 730.169		2 742.7		2 739.22	
Likelihood-ratio test				8.37		4.88	
Probability > Chi-squared				0.039		0.0871	

Table 2, continuation…

Wages							
Parameters		*Model 1*		*Model 2*		*Model 3*	
Fixed effects							
Ratio of educated workers (<12) by subsector with respect to the mean by city	*h*	0.615***	*0.0271*	0.587***	*0.0256*	0.614***	*0.0271*
Average ratio of educated workers (<12) by city	*h*	–0.121	*0.429*	–0.103	*0.455*	–0.189	*0.452*
Ratio of educated workers (<12) in differences with respect to time	*h*	–0.702***	*0.0312*	–0.744***	*0.0374*	–0.715***	*0.0518*
Radio of non-educated workers (>5) by subsector with respect to the mean by city	*l*	0.0315*	*0.0141*	0.0346*	*0.0138*	0.0185	*0.0137*
Average radio of non-educated workers (>5) by city	*l*	0.726*	*0.367*	0.696	*0.389*	0.736	*0.386*
Labor specialization by subsector with respect to the mean by city	*s*	–0.0121	*0.0232*	0.0328	*0.0239*	0.0314	*0.0436*
Mean labor specialization by city	*s*	0.483**	*0.17*	0.509**	*0.181*	0.515**	*0.18*
Capital flows	*k*	0.182***	*0.0235*	0.176***	*0.0215*	0.162***	*0.0232*
Foreign direct investment flows	*fdi*	0.119**	*0.0434*	0.177***	*0.0417*	0.122**	*0.0419*
_cons		–0.633	*0.672*	–0.689	*0.712*	–0.573	*0.707*
Random effects							
City	μ	0.0415***	*0.023*	0.0489***	*0.0259*	0.0473***	*0.0256*
Ratio of educated workers (<12) by subsector with respect to the mean by city	*h*					2.67E-15	*5.64E-12*
Ratio of educated workers (<12) in differences with respect to time	*h*					0.0166***	*0.0094*
Labor specialization by subsector with respect to the mean by city	*s*					0.0123***	*0.00964*
Subsector	ν	0.484***	*0.0363*	0.427***	*0.0341*	0.476***	*0.0354*
Ratio of educated workers (<12) by subsector with respect to the mean by city	*h*			2.60e-08***	*4.43E-08*		
Ratio of educated workers (<12) in differences with respect to time	*h*			0.122***	*0.0268*		
Labor specialization by subsector with respect to the mean by city	*s*			0.0158***	*0.0096*		
Residual	ε	0.0870***	*0.00583*	0.0512***	*0.00516*	0.0784***	*0.00532*
AIC		1 784.748		1 721.155		1 754.544	
BIC		1 849.306		1 800.611		1 834	
Likelihood-ratio test				69.59		36.2	
Probability > Chi-squared				0.0000		0.0000	

Note: standard errors in italics. Significance of parameters: (*) $p < 0.05$, (**) $p < 0.01$ and (***) $p < 0.001$.
Source: compiled by authors based on data from *Censos Económicos 1999* and *2009* and *Censos de Población 2000* and *2010*, INEGI.

models two and three, in which productivity is a dependent variable, labor with a high level of schooling h impacts the random terms as an effect, due more to difference among subsectors, or activity undertaken, than due to differences among the different cities.

Labor specialization, s, or concentration of the labor force, becomes significant and considerable (11.38% of the variability of model 2), if we assume it to be a change across time (variation in the indicator from 1999 to 2009), whose impact is by subsectors. In other words, there are considerable changes in labor concentration, which suggests a restructuring in the distribution of the labor force at a local level in the different cities; the effect, however, cannot be considered significantly distinct for each city. Rather, we should assume it occurred in general in the ten urban areas under study, or in certain subsectors regardless of the city.

A very interesting variable is the stock of human capital by subsector, included only in model 2 and only when productivity is considered a dependent variable. The elasticity of productivity to human capital is inelastic and the coefficient obtained in small, which indicates that the reserve of knowledge and skills is not a determinant of output. Nonetheless, it is worth noting that a positive coefficient is obtained from the stock of human capital in terms of productivity. Changes in human capital stock by subsector only explain 0.45% of the model's variance.

According to Moretti (2004), it is this variable where emphasis should be placed in terms of compelling evidence of human capital spillovers. We conclude, then, in line with results from the mixed models of productivity, that (very small) non-pecuniary spillovers do exist, and are limited to the industry that has them, not in the remaining activities. Given the high significance of FDI in the models, all evidence points to the effects being magnified in companies whose subsector is receiving foreign investment flows.

Results for wages

In the first model, in which wages are the dependent variable (lower half of Table 2), the differences between cities explain only 6.77% of the total variance, while the disparities among subsectors explain 79.02%. Thus most of the variability is related to the differences among subsectors, as opposed to the models with productivity as the dependent variable. Wages earned by employed personnel correspond to the labor category, and the differences derived from being located in the cities in which employees work is a very small percent.

In models 2 and 3, labor with a high level of schooling was inserted as a variation across time and as a difference among subsectors. Both in the random effect in the cities as well as the effect of the subsector, the difference across time in the percentages of personnel with a high level of schooling is more relevant; in model 2, for example, it explains 18.3% of the total variance. In other words, from 1999 to 2009, the wages received varied in the range of ±18%, and given that the sign of the fixed coefficient in model 2 of the same variable is negative, we think it is reasonable to assume that there was a decrease.

Labor specialization is inserted as a random effect in differences across time. As opposed to the models of productivity, in wages, specialization does not significantly explain why there is variability among subsectors.

Likelihood ratio and the AIC and BIC criteria

In mixed effects models, we are unable to carry out the Hausman test (which implies comparing two separate models), as in the conventional panel models. In these cases it is customary to undertake LR (likelihood ratio) tests between one model and another in order to establish the appropriateness of including random variables (Rabe-Hesketh and Skrondal, 2008). The LR tests shown in Table 2 indicate that, for productivity, model 2 is best (with random effects by subsector). For wages, both model 2 and 3 are better than model 1, yet 2 generates a higher chi-squared parameter, and it is deemed the better model for this reason too. The AIC and BIC criteria corroborate the same conclusion, given that these measures evaluate the advantages of the model's goodness of fit with respect to its level of complexity, thereby allowing us to select the model. Therefore, we can conclude that both the maximum likelihood test as well as the criteria utilized support the goodness of fit of the estimations, where labor productivity is the dependent variable.

Conclusions

Results show that the labor market underwent changes as a result of the growth in the labor factor's qualification and urbanization. Thus we see that most of the employed population of the largest cities in the north of Mexico has between

6 and 12 years of accumulated schooling. Further, between 1999 and 2009, the percentage of personnel with a high level of schooling employed in the 53 subsectors considered herein grew from 9.69% to 14.34%. Data tendencies indicate that wages earned in the subsectors with the greatest share of labor with a high level of schooling grew as compared to the subsectors with a less-schooled workforce; nonetheless, the tendency of productivity was just the opposite. These results suggest that a labor force with more schooling could have relocated to sectors with low productivity.

Results obtained from econometric estimations of the mixed-effects models show heterogeneity. The coefficients corresponding to the percentage of workers with more schooling and the coefficients of foreign direct investment were positive in all models. Yet the coefficient of specialization only showed positive impacts in wages at the city level. Therefore, notwithstanding the characteristics of the period being analyzed, returns to scale increase as long as there is a positive flow of capital and foreign direct investment in the cities. These results suggest that enclaves continue to be present and perhaps their repercussion has already transcended a single firm but has not permeated beyond the confines of the subsector or company concerned. These results coincide with the work of Jordaan (2008) whose econometric estimations suggest that FDI generates negative externalities within industries, but positive externalities through backward linkages.

Another finding of this study is that estimates show that differences among subsectors are the origin of a good deal of variability, both in productivity as well as in wages. Thus we can see that the fixed-effects model makes clear that in models where wages are the dependent variable, the differences between cities account for less than the changes in total variance. Most of the variability derives from the changes among subsectors. This means that the geographic location does not account for much variability; rather, activity at the level of subsectors is the most relevant determinant. Finally, if the effects across time are included, the growth of labor specialization in the cities and economic subsectors turns out to be positive in the dynamic of growth of labor productivity and wages.

The findings in this study suggest the existence of some favorable aspects for growth and labor employment in the manufacturing sector of northern Mexico's urban areas. What stands out in particular are the positive effects in the growth of schooling of the labor force, but also in labor specialization, particularly at the subsector level. Therefore, implementing policies that favor development of industrial agglomerations at the level of subsectors could be a potential factor for the growth of manufacturing productivity and wages. Thus, the possibility of attracting investments that will allow agglomerations to grow at a higher level of disaggregation, leading to external economies, is an area that should be considered within a possible industrial policy. The foregoing could have a decisive role in the expansion of productivity of Mexico's manufacturing sector.

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