ISSN 2448-8402

Ensayos
Revista de Economía

Volumen XXXIV, número 1 mayo de 2015

UNIVERSIDAD AUTÓNOMA DE NUEVO LEÓN

Universidad Autónoma de Nuevo León

Facultad de Economía

Centro de Investigaciones Económicas

Ensayos Revista de Economía, Vol. 34, No. 1, enero-junio 2015. Es una publicación semestral, editada por la Universidad Autónoma de Nuevo León, a través de la Facultad de Economía con la colaboración del Centro de Investigaciones Económicas. Domicilio de la publicación: Av. Lázaro Cárdenas 4600 Ote., Fracc. Residencial Las Torres, Monterrey, N.L. C.P. 64930. Tel. +52 (81) 8329 4150 Ext. 2463 Fax. +52 (81) 8342 2897. Editor Responsable: Jorge Omar Moreno Treviño. Reserva de derechos al uso exclusivo No. 04-2009-061215024200-102, ISSN 1870-221X, ambos otorgados por el Instituto Nacional del Derecho de Autor. Licitud de Título y Contenido No. 14910, otorgado por la Comisión Calificadora de Publicaciones y Revistas Ilustradas de la Secretaría de Gobernación. Registro de marca ante el Instituto Mexicano de la Propiedad Industrial: 1182771. Impresa por: Serna Impresos, S.A. de C.V., Vallarta 345 Sur, Centro, C.P. 64000, Monterrey, Nuevo León, México. Fecha de terminación de impresión: 1 de mayo de 2015. Tiraje: 30 ejemplares. Distribuido por: Universidad Autónoma de Nuevo León, a través de la Facultad de Economía, Av. Lázaro Cárdenas 4600 Ote., Fracc. Residencial Las Torres, Monterrey, N.L. C.P. 64930.

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External returns to higher education in Mexico 2000-2010

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Fecha de recepción: 10 IV 2014 Fecha de aceptación: 24 XI 2014

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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ACKNOWLEDGEMENTS: We thank Raymundo Campos-Vázquez, Gerardo Esquivel, Laura Juárez, and Carlos Chiapa for their valuable comments and suggestions as well as Carolina Palacios for her support with bibliographic materials for this paper. We also thank all the participants in the seminars at El Colegio de México and the 1st Conference of the Economic Development Network, Instituto Politécnico Nacional, as well as the reviewers for their really valuable suggestions. All errors are naturally our own.

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.

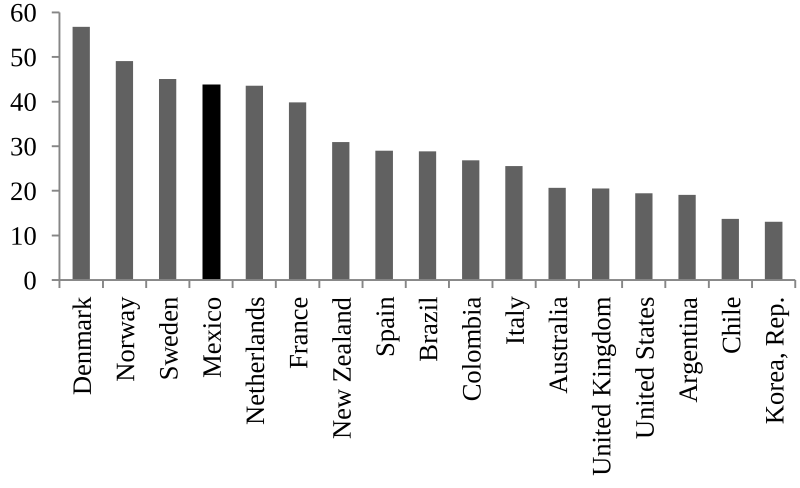
Social returns to education may arise either from direct interaction with more educated people, as we learn from working and talking to other individuals or, as will be explained later, indirectly through the effects that the presence of more educated people has on prices.

[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.

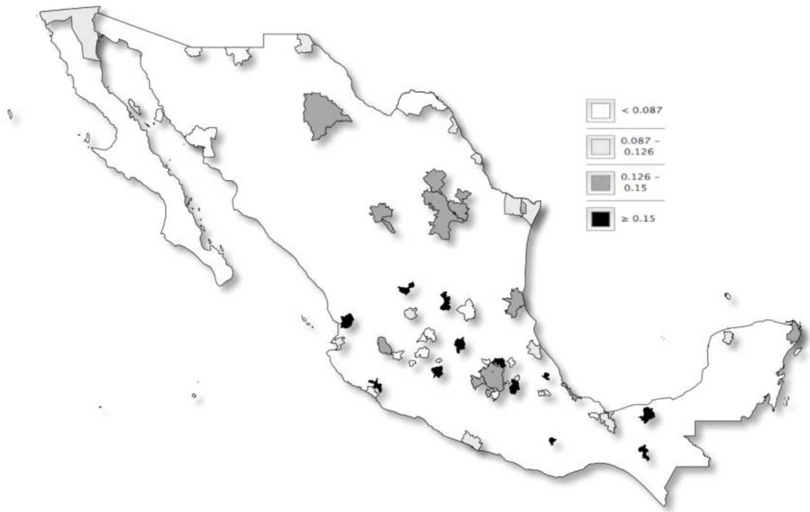
According to census data, the average years of schooling for Metropolitan Areas (MA) and individuals aged 25 to 66 in Mexico increased from 8.7 in 2000 to 9.9 in 2010. In this same period the share of college graduates[3] rose from 13% to 16.5%. Indeed, as Figure 2 shows, most of the MAs have increased 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.

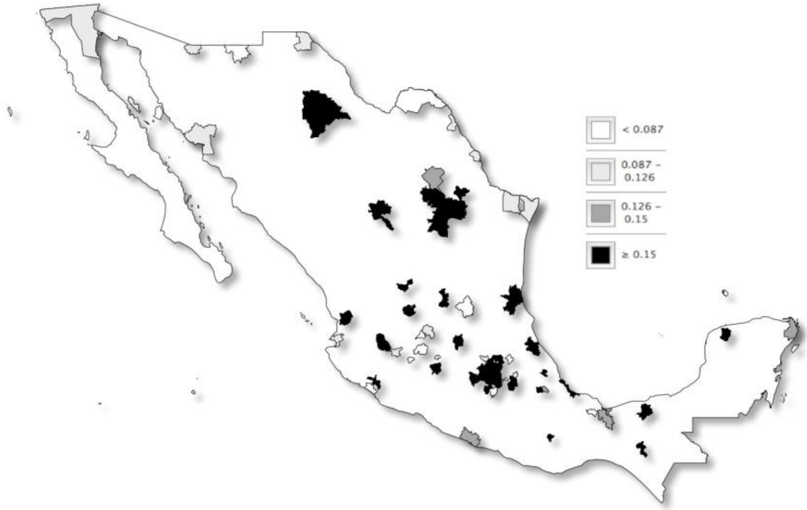
Figure 2

Percentage of college graduates 2000-2010

A) 2000



B) 2010

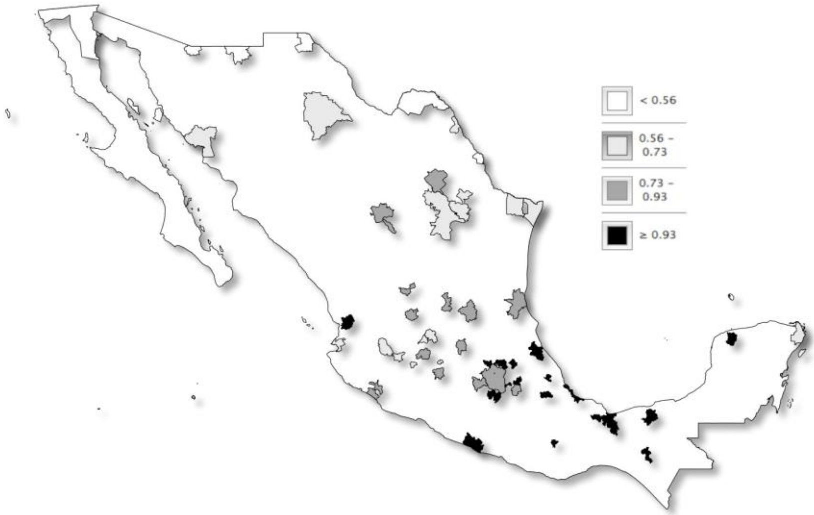


Source: authors' calculations using data from Mexico's 2000 and 2010 Population and Housing Censuses, INEGI.

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:

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

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):

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

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:

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

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).

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

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:

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

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:

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

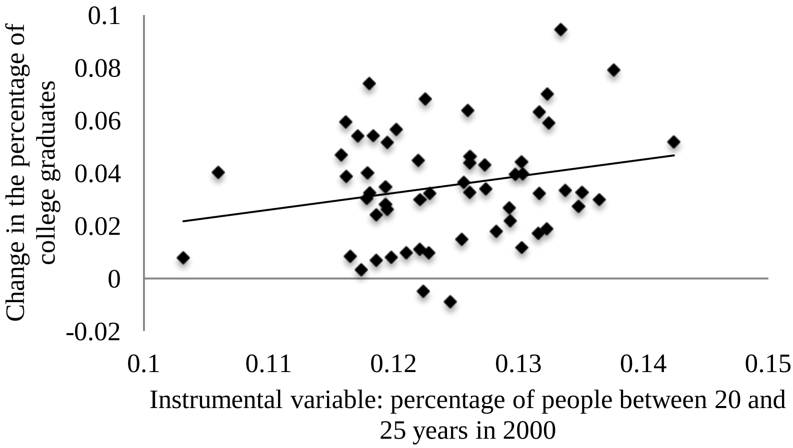
Where:

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]:

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

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:

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

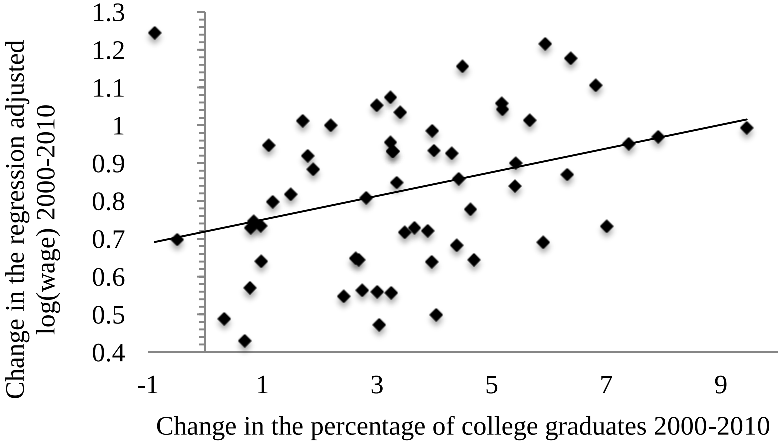
[12] Ciccone and Peri (2006) use potential experience (E*) instead of age. Potential experience is constructed as E*=age-6-years of schooling. However, due to the problems in calculating potential experience (especially in the case of people with little education, for whom it is necessary to arbitrarily 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
7th-9th 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
10th-12th 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:

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

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.

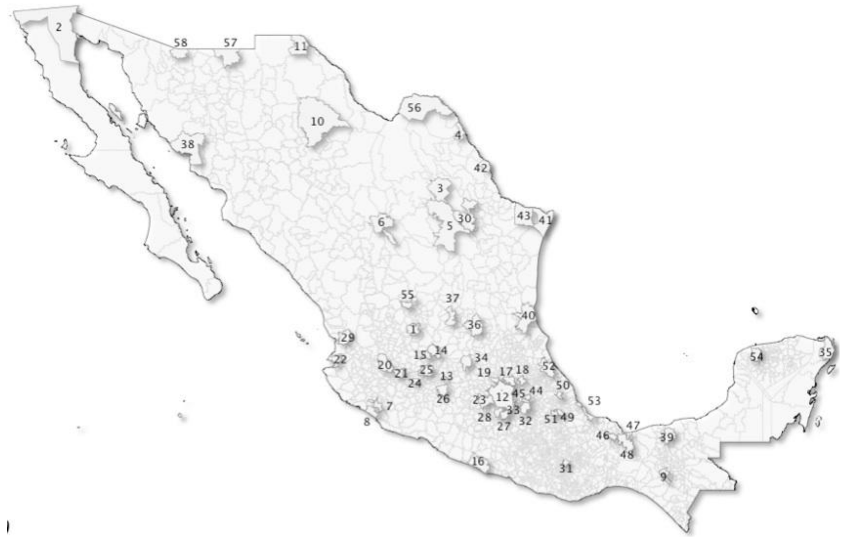
Finally, it is important to consider that these results are based on a one generation model: more highly educated individuals only affect people of the same generation. However, in a more comprehensive analysis based on development theory, the interaction with more educated individuals could have intergenerational 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.

Ensayos Revista de Economía–Volumen XXXIV, No.1, mayo 2015, pp. 35-74

Modelo de equilibrio general aplicado para México y análisis de impuestos a la extracción de hidrocarburos

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Fecha de recepción: 02 II 2014 Fecha de aceptación: 05 XI 2014

Resumen: Para una matriz de contabilidad social (MCS) de 2003, se presenta un modelo de equilibrio general aplicado parsimonioso, utilizable para analizar diversas problemáticas. Se emplea aquí para analizar los efectos de sustituir los altos impuestos del sector de la minería -que se presentan a causa de la excesiva carga sobre la paraestatal Petróleos Mexicanos (Pemex)- por un incremento en el impuesto sobre la renta. Incluimos la MCS que constituye un valioso resultado por sí misma, utilizable para aplicar una amplia gama de métodos de análisis para la economía mexicana. En el análisis de la simulación que elimina el exceso impositivo sobre la extracción de hidrocarburos, se muestra la magnitud y dirección de cambios para variables seleccionadas.

***Clasificación JEL*:** C68.
***Palabras Clave*:** matriz de contabilidad social, equilibrio general aplicado, economía mexicana, impuestos a hidrocarburos.

Abstract: For a Social Accounting Matrix (SAM) of 2003, we present a parsimonious Applied General Equilibrium Model (AGEM), useful to analyze several problems; it is used here to analyze the effects of substituting high taxes on Mining -given by the excessive burden on Pemex (the Mexican public petroleum company)-, by an increase on income taxes. We include the SAM, a valuable result by itself -usable with the methods of the structural analysis, among others. We analyze the simulation that eliminates the excessive tax on hydrocarbons extraction, and report magnitude and direction of changes for selected variables.

***JEL Classification*:** C68.
***Keywords*:** Social Accounting Matrix, Applied General Equilibrium, Mexican Economy, Hydrocarbons taxes.

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Introducción

Uno de los requerimientos científicos más importantes, en un trabajo de investigación, es el de la reproducción y validación de resultados por parte de otros investigadores. Por tal razón, en este artículo uno de los principales objetivos es el de hacer transparente el diseño del modelo utilizado, así como la conformación de la base de datos que lo sustenta, de manera que tanto el procesamiento de los datos como los supuestos del modelo puedan ser analizados, y los resultados reproducidos, a fin de cumplir con el requerimiento antes dicho: que el trabajo sea susceptible de validación o, en su caso, corrección o mejoramiento, para lo cual incluimos la matriz de contabilidad social (MCS) en que se basa el modelo.

Uno de los criterios que han guiado el trabajo, en esta parte, es el del diseño de un modelo parsimonioso, de sencillo seguimiento e interpretación, aunque para ello se han tenido que adoptar supuestos simplificadores. Estos supuestos pueden ser sustituidos y emplearse otros que se consideren más adecuados, en trabajos posteriores.

El siguiente criterio que se considera también relevante, es el de utilizar un modelo como el modelo de equilibrio general aplicado para México para el año 2003, y al cual llamamos MEGA-Mx03, a fin de analizar la eliminación de la excesiva carga impositiva sobre el sector minería -causada por la política de gravar cuantiosamente a Pemex[1]-, compensando la disminución en la recaudación con un incremento en el impuesto sobre la renta (ISR) que recaude el mismo monto; de modo que la recaudación total es constante y, por lo tanto, el gasto público se mantiene. Este análisis es importante tanto si se privatiza al sector energético, como si no, pues contribuye a aportar elementos de juicio necesarios para cuantificar el impacto de los cambios derivados de la disminución de los impuestos sobre la extracción de petróleo y gas.

Además en los últimos años, el aporte fiscal de Pemex ha rondado el billón de pesos anuales, lo que representa cerca del 33% del presupuesto del gobierno federal; por lo cual, considerando el peso que la educación pública y los servicios públicos de salud tienen en dicho presupuesto, las implicaciones para el bienestar social son amplias y profundas[2].

[1]Petróleos Mexicanos (Pemex) ha sido la empresa paraestatal encargada de la extracción y procesamiento de los hidrocarburos del país. Con la llamada reforma energética, realizada por la administración de Enrique Peña Nieto, Pemex deja de ser una empresa paraestatal para convertirse en “empresa productiva del Estado” (Diario Excelsior, 21 de julio de 2014).
[2]Diario La Jornada, 12 de enero de 2013.

El artículo se organiza como sigue: En la primera sección, se presenta la construcción de la MCS; en la segunda, se detalla el modelo matemático MEGA-Mx03; en la tercera, se realizan dos simulaciones que eliminan los impuestos excesivos sobre el sector minería compensando con un incremento al ISR, y se analizan los resultados. La cuarta sección corresponde a los comentarios finales.

1. Matriz de contabilidad social MCS-Mx03

En México, el trabajo para construir matrices ha sido discontinuo y disperso, sin que se haya logrado consolidar hasta ahora una metodología consistente y continua, que permita construir matrices periódicamente para la economía del país. Núñez (2004) construyó una MCS para México para el año 1996, con el fin de llevar a cabo un análisis estructural y de equilibrio general de la economía mexicana; en la página 46 de su trabajo, se halla una breve revisión de las matrices hechas para México.

Más recientemente, Barbosa-Carrasco, Vázquez-Alvarado y Matus-Gardea (2009), construyeron una matriz para México en 2004, utilizando un enfoque de entropía cruzada e información de las cuentas nacionales. Aunque la revisión del trabajo y de las matrices que se han hecho para México no es exhaustiva, abarca la mayor parte y presenta una descripción realista de la situación actual en el país, por lo que cito a continuación:

> "A pesar de su importancia no hay una SAM oficial para México y cada investigador construye la suya: 1) Una SAM, en 1975, para analizar la función del sector público en la economía del país (Pleskovic y Treviño 1985); 2) una, con datos de 1989, para calibrar el modelo para evaluar el impacto de la apertura comercial de México (Levy y Van Wijnbergen, 1992); 3) una, base 1985, para calibrar los modelos de equilibrio general computable para analizar las consecuencias del TLC de América del Norte y políticas fiscales (Sobarzo, 1992 y 1994); 4) una SAM con datos de 1996 (Harris y Robinson, 2003) y el Global Trade Analysis Project (GTAP) tiene en su base de datos una SAM para México con cifras de 1997 y 2001 (McDonald y Thierfelder, 2004). De esas matrices sólo se publicaron las de Pleskovic y Treviño (1975), de Harris y Robinson (2003) y una SAM del GTAP con datos de 1997, (Trejos *et al*., 2004). Debido a que no hay una SAM reciente y disponible para México, se efectuó el presente trabajo con el objetivo de construir una para 2004".

Entre otros factores, el hecho de que el INEGI no generara durante cerca de 30 años matrices de insumo-producto, contribuyó a que esta área de investigación no se desarrollara en México, y se diera el fuerte atraso que actualmente se observa.

En este trabajo se utiliza la matriz insumo-producto (MIP) simétrica doméstica para la economía total de 2003 (INEGI, 2008), para elaborar una macro-MCS y a partir de esta, las desagregaciones para obtener la micro-MCS de interés; se sigue principalmente la metodología desarrollada por Núñez (2004, 2008), para el caso de México.

Aunque la MCS puede verse como una extensión de la MIP, tiene dos implicaciones conceptuales fundamentalmente distintas: la MIP se centra en los sectores productivos -especificando insumos y destino de la producción-, mientras que la MCS refleja el flujo circular de la economía en su totalidad y especifica el equilibrio de todas las cuentas de la economía, centrándose en las instituciones de la misma (hogares, gobierno y empresas, por lo cual se denomina MCS). En consecuencia, la MCS contiene necesariamente más información que la MIP y, de acuerdo con el formato estándar convencional, cada cuenta tiene una fila con los ingresos (recursos) y una columna con los gastos (usos), en donde el total por fila es exactamente igual al total por columna (Defourney y Thorbecke, 1984). Así, la diferencia entre una MCS y una MIP es tanto conceptual como informativa, y no una cuestión de formato, por lo que no es posible poner una MIP en formato de MCS.

En lo que sigue, se recurre a los datos del Sistema de cuentas nacionales de México (SCNM), para elaborar una macro-MCS balanceada; a partir de la cual, se construye la micro-MCS. En el proceso, se introducen nuevas cuentas a fin de presentar adecuadamente los datos de la economía.

Comenzando por los hogares, se introducen tres cuentas: la de capital y la de trabajo, para desagregar el valor agregado y la de sociedades, para aprovechar los datos de las cuentas por sectores institucionales (CSI, INEGI 2010b). Según el cuadro 3 de las cuentas de bienes y servicios (CByS, INEGI 2010a), la remuneración de asalariados (incluyendo las contribuciones sociales) asciende a 2,370,474 (en lo que sigue, todas las cifras están en millones de pesos de 2003, a menos que se indique lo contrario), el excedente bruto de operación (EBO) a 4,487,421 y sumando ambos, tenemos 6,857,895, cuya diferencia con respecto al valor agregado bruto de la economía total reportado por la MIP nos da 310,631, que son los otros impuestos a la producción, pagados por los sectores productivos (actividades) al sector público (gobierno), además de los impuestos netos sobre los productos. El EBO va a la cuenta de capital que lo transfiere a las sociedades. La remuneración de asalariados va a la cuenta de trabajo, menos las contribuciones sociales pagadas al gobierno, pues de acuerdo con las CSI las contribuciones sociales netas percibidas por el gobierno son de 147,621, por lo que el resto 2,222,853, corresponde necesariamente a los hogares.

Por otra parte, según las CSI, las transferencias sociales (prestaciones sociales distintas a las transferencias en especie) son de 117,510, de las que se restan las otras transferencias sociales (netas) 4,269, para obtener las transferencias totales que el gobierno hace a los hogares: 113,241.

También de acuerdo con las CSI, las otras transferencias corrientes (netas) del resto del mundo (RdM) son de 167,223 (que son las remesas que reciben los hogares) y el pago del resto del mundo al factor trabajo es de 16,353, con lo cual se completan los ingresos de los hogares, faltando solamente lo que reciben por renta de capital.

Para obtener el EBO que reciben los hogares, se calcularon sus demás gastos, a fin de obtenerlo como un saldo. Según las CSI, el ahorro bruto de las sociedades es de 779,607, el del gobierno de 116,046, el de los hogares más el de las instituciones sin fines de lucro que sirven a los hogares de 757,902, y el del resto del mundo de 76,071. Finalmente, de acuerdo con las CSI, el ISR que pagan los hogares es de 226,509 (además de los impuestos al consumo que ya vimos). (El ISR pagado por las sociedades es de 170,107). Como ya está el gasto total de los hogares y todos los elementos de su ingreso, se calcula el EBO que obtienen como la diferencia dada por el saldo: 3,513,249, con lo cual queda balanceada la cuenta de los hogares.

Sigue la cuenta de las sociedades, para la que prácticamente ya se calcularon todos los elementos, y solo resta un saldo de 24,458 que corresponde a la renta de la propiedad que pagan al resto del mundo, lo cual es consistente con los datos de las CSI. Con esto queda también balanceada la cuenta de las sociedades.

En este punto, se puede constatar que todas las cuentas están ya balanceadas, excepto la del gobierno, que presenta un desequilibrio de 124,766, correspondiente al pago de la renta de la propiedad del gobierno al resto del mundo. Valga notar que este pago, más el pago hecho por las sociedades, que antes obtuvimos, suman 149,224, monto exactamente igual a la renta de la propiedad (neta) del resto del mundo reportada por las CSI. Con esto queda balanceada la macro-MCS, que se presenta en el cuadro 1.

Cuadro 1

Macro matriz de contabilidad social para México, 2003 (millones de pesos, 2003)

	Hogares	Sociedades	Gobierno	Inversión	Capital	Trabajo	Actividades	RdM	Total
Hogares		3,513,249	113,241			2,239,206		167,223	6,032,919
Sociedades					4,487,421				4,487,421
Gobierno	578,149	170,107		4,617			495,025		1,247,897
Ahorro	757,902	779,607	116,046					76,071	1,729,627
Capital							4,487,421		4,487,421
Trabajo							2,222,853	16,353	2,239,206
Actividades	4,476,438		892,322	1,436,114			3,806,997	1,813,205	12,425,075
RdM	220,430	24,458	126,289	288,896			1,412,780	102,560	2,175,412
Total	6,032,919	4,487,421	1,247,897	1,729,627	4,487,421	2,239,206	12,425,075	2,175,412	

Fuente: elaboración propia.

1.1. Desagregación de las actividades

La desagregación de las actividades es directa: se restablecen los datos de la MIP agregados para elaborar la macro-MCS, y luego con la información de las CByS se desagregan los datos restantes.

Previamente, se introducen cuatro cuentas para separar los impuestos (ISR, contribuciones sociales, impuestos sobre productos y otros impuestos a la producción). Luego, se abren las 20 cuentas necesarias para desagregar las actividades, en donde se copian inmediatamente los datos de la MIP: submatriz de intercambios interindustriales, y columnas de consumo privado, consumo de gobierno, formación bruta de capital fijo más variación de existencias y exportaciones. Con esto queda completamente desagregado el destino de todos los bienes y servicios aportados por la oferta total de las actividades.

También de forma inmediata se desagregan las filas importaciones e impuestos sobre productos, copiando los datos de la MIP a la MCS, con lo cual se agota la información de la MIP aprovechable para construir la MCS, y se comienzan a utilizar los datos de las CByS.

Los cuadros 55, 58, y 59 de las CByS, contienen las cifras, por sector productivo de la remuneración de asalariados, de los otros impuestos a la producción, y del EBO. Como en esos cuadros los sectores 48 y 49 están agregados, considerando que el sector 49 es relativamente pequeño, y para mantener la transparencia de los datos, fueron agregados también en la MCS estos dos sectores.

Los tres rubros mencionados conforman el valor agregado bruto (VAB) pero, a diferencia de la MIP, el EBO reportado en las CByS incluye los Servicios de intermediación financiera medidos indirectamente, que no están desagregados. Así que para calcular el EBO por actividad, primero se sumaron las remuneraciones, los otros impuestos y el EBO de las CByS para obtener un VAB que incluye los servicios financieros, y luego se restó el VAB de la MIP para obtener los servicios financieros por sector, los que a su vez fueron restados del EBO de las CByS para obtener el EBO por actividad neto de servicios financieros.

Los otros impuestos a la producción del cuadro 58 de las CByS son los impuestos netos (304,878), que difieren de los que se calcularon para la macro-MCS (310,631), esta diferencia inexplicada es relativamente pequeña (1.85%), y para distribuirla se parte del supuesto de que se reparte proporcionalmente.

Por otro lado, se tienen que separar las contribuciones sociales de las remuneraciones, para lo cual también se supone que el pago de contribuciones sociales es proporcional a las remuneraciones pagadas por cada sector.

Una vez incluidos los otros impuestos a la producción, las remuneraciones y las contribuciones sociales por sector en la MCS, el saldo corresponde necesariamente al EBO. Para evaluar la exactitud del saldo, con respecto al EBO por sector que se obtuvo de las CByS, se elabora el cuadro 2.

Cuadro 2

Comparación de la desagregación del EBO (millones de pesos, 2003)

Actividad	EBO MCS	EBO CByS	Diferencia	Diferencia %
1	209,815	209,549	266	0.13
2	134,895	139,540	-4,645	-3.33
3	56,135	56,075	60	0.11
4	280,858	280,531	327	0.12
5	825,868	824,998	870	0.11
6	812,116	811,283	832	0.1
7-8	356,640	356,191	449	0.13
9	139,864	139,709	155	0.11
10	119,624	119,551	72	0.06
11	787,251	786,389	862	0.11
12	207,590	207,342	248	0.12
13	5,444	5,513	-68	-1.24
14	65,871	65,806	65	0.1
15	87,608	87,515	93	0.11
16	94,318	94,209	109	0.12
17	20,673	20,653	21	0.1
18	144,914	144,750	164	0.11
19	163,187	136,024	162	0.12
20	1,749	1,791	-42	-2.37

Fuente: elaboración propia.

Así, resulta una inconsistencia en la desagregación del EBO con respecto a las cifras de la MIP, empero este error es transparente y no significativo, ya que en el mayor de los casos solo asciende al 3.3% (actividad 2, minería), y puede ser inmediatamente corregido con los datos necesarios.

1.2. Desagregación de los hogares

Sigue ahora la desagregación de la cuenta de los hogares. El cuadro 3 muestra su ingreso trimestral total según la ENIGH-2004 (INEGI, 2005), ordenados en deciles de menor a mayor ingreso. Es inmediatamente notable la diferencia de ingresos: El decil de mayor ingreso, percibe 24 veces más que el decil más pobre, y más del doble que el siguiente decil de mayor ingreso, este indicador, aunque sencillo, da cuenta ya de la profunda brecha distributiva que existe en el país.

Para llevar a cabo la desagregación de la cuenta de los hogares, en los 10 deciles clasificados según el ingreso de acuerdo con el cuadro 3, se recurre a la estructura porcentual (participación de cada decil en el gasto total del rubro que se trate), implicada por los datos de la ENIGH 2004, para los conceptos que más se asemejan a los que deseamos desagregar.

Cuadro 3

Ingreso trimestral total de los hogares, por decil según ingreso

Decil según Ingreso*	Número de hogares	Ingreso trimestral total (miles de pesos corrientes, 2004)
I	2,584,508	11,856,865
II	2,584,508	21,519,019
III	2,584,508	29,244,218
IV	2,584,508	36,685,057
V	2,584,508	44,655,144
VI	2,584,508	54,580,609
VII	2,584,508	68,129,751
VIII	2,584,508	87,593,131
IX	2,584,508	122,119,283
X	2,584,509	284,747,905
Total	25,845,081	761,130,982

Fuente: Encuesta Nacional de Ingresos y Gastos de los Hogares (INEGI, 2005).

En el cuadro 4, se muestran los cálculos para desagregar el consumo privado y los impuestos sobre los bienes, suponiendo que los hogares pagan dichos impuestos sobre los bienes y servicios que consumen. Para llevar a cabo la desagregación, se utiliza la estructura de la participación en el gasto corriente total de cada uno de los hogares, de acuerdo con los datos del cuadro 9.4 de la ENIGH-2004.

Cuadro 4

Desagregación de consumo privado e impuestos sobre productos (millones de pesos, 2003)

Decil	Gasto corriente total ENIGH-2004	Estructura de la participación	Consumo privado MCS	Impuestos sobre productos
I	17,245,519	0.026	113,953,979	8,951,495
II	25,904,317	0.038	171,169,102	13,445,949
III	32,646,033	0.048	215,716,638	16,945,318
IV	38,882,266	0.057	256,924,071	20,182,310
V	44,715,511	0.066	295,468,662	23,210,127
VI	52,699,390	0.078	348,224,092	27,354,256
VII	63,211,739	0.093	417,687,006	32,810,818
VIII	76,457,836	0.113	505,213,828	39,686,365
IX	105,960,082	0.156	700,157,125	54,999,862
X	219,730,563	0.324	1,451,923,369	114,053,807
Total	677,453,256	1.000	4,476,437,873	351,640,307

Fuente: elaboración propia con base en el cuadro 9.4 de la ENIGH-2004 (INEGI, 2005).

Sigue el cálculo del ISR que paga cada decil. En el cuadro 5 se muestran los porcentajes aplicados a los ingresos mensuales de las personas físicas como ISR, de acuerdo con el Art. 113 de la Ley del Impuesto Sobre la Renta (SAT 2003, p. 574).

Cuadro 5

ISR sobre el ingreso mensual de las personas físicas, 2003

Límite inferior Pesos	**Límite superior** Pesos	**Cuota fija** Pesos	**Tasa para aplicarse sobre el excedente del límite inferior** Porcentajes
0	429	0	3
429	3,645	13	10
3,645	6,406	334	17
6,406	7,446	804	25
7,446	En adelante	1,064	32

Fuente: Servicio de Administración Tributaria (SAT 2003).

En el cuadro 6, se presentan los cálculos para la desagregación del ISR que pagan los hogares en cada decil, de acuerdo con las cuotas y límites del cuadro anterior.

Cuadro 6

Desagregación del ISR (millones de pesos, 2003)

	Total	I	II	III	IV	V	VI	VII	VIII	IX	X
Hogares	25,845,081	2,584,508	2,584,508	2,584,508	2,584,508	2,584,508	2,584,508	2,584,508	2,584,508	2,584,508	2,584,509
Ingreso total trimestral (miles $)	761,130,982	11,856,865	21,519,019	29,244,218	36,685,057	44,655,144	54,580,609	68,129,751	87,593,131	122,119,283	284,747,905
Ingreso trimestral por hogar (miles $)	29	5	8	11	14	17	21	26	34	47	110
Ingreso mensual por hogar ($)	9,817	1,529	2,775	3,772	4,731	5,759	7,039	8,787	11,297	15,750	36,725
Límite inferior		429	429	3,645	3,645	3,645	6,406	7,446	7,446	7,446	7,446
Cuota fija		12.9	12.9	334.4	334.4	334.4	803.8	1,063.90	1,063.90	1,063.90	1,063.90
Excedente		1,100	2,346	127	1,086	2,114	634	1,341	3,851	8,304	29,279
Tasa sobre excedente		0.1	0.1	0.17	0.17	0.17	0.25	0.32	0.32	0.32	0.32
ISR sobre excedente		110	235	22	185	359	158	429	1,232	2,657	9,369
ISR total pagado	20,845	123	247	356	519	694	962	1,493	2,296	3,721	10,433
Participación	1	0.006	0.012	0.017	0.025	0.033	0.046	0.072	0.11	0.179	0.501
ISR MCS	226,508,972	1,335,016	2,689,145	3,868,252	5,641,042	7,539,925	10,455,749	16,222,711	24,951,512	40,435,560	113,370,061

Fuente: elaboración propia con base en el cuadro 9.4 de la ENIGH-2004 (INEGI 2005).

Se continúa con la desagregación del ahorro, cuyos cálculos se muestran en el cuadro 7. Para hacer la desagregación, se utiliza la estructura de la participación en los depósitos en cuentas de ahorro, tandas, cajas de ahorro, etc., de cada hogar, de acuerdo con los datos del cuadro 9.4 de la ENIGH 2004.

Cuadro 7

Desagregación del ahorro de los hogares (millones de pesos, 2003)

Decil	**Depósitos en cuentas de ahorro, etc. ENIGH-2004**	**Estructura de la participación**	**Ahorro privado MCS**
I	237,527	0.005	3,641,739
II	407,406	0.008	6,246,306
III	527,907	0.011	8,093,815
IV	975,818	0.020	14,961,139
V	1,075,477	0.022	16,489,101
VI	1,836,727	0.037	28,160,506
VII	2,743,924	0.056	42,069,556
VIII	4,656,751	0.094	71,396,819
IX	7,173,919	0.145	109,989,776
X	29,797,591	0.603	456,853,548
Total	49,433,047	1.000	757,902,305

Fuente: elaboración propia con base en el cuadro 9.4 de la ENIGH-2004 (INEGI 2005).

Cuadro 8

Desagregación de las importaciones de los hogares (millones de pesos, 2003)

Decil	**Otros gastos diversos y transferencias**	**Estructura de la participación**	**Importaciones de hogares MCS**
I	260,184	0.008	1,842,747
II	453,994	0.015	3,215,401
III	685,868	0.022	4,857,643
IV	904,610	0.029	6,406,878
V	1,303,163	0.042	9,229,620
VI	1,296,846	0.042	9,184,880
VII	1,972,635	0.063	13,971,139
VIII	3,066,204	0.099	21,716,314
IX	5,418,153	0.174	38,373,935
X	15,761,612	0.506	111,631,227
Total	31,123,269	1.000	220,429,783

Fuente: elaboración propia con base en el cuadro 5.5 de la ENIGH-2004 (INEGI 2005).

Finalmente, el cuadro 8 muestra la desagregación de las importaciones de los hogares, utilizando la estructura de los otros gastos diversos y transferencias, de acuerdo con el cuadro 5.5 de la ENIGH-2004.

Una vez desagregados todos los elementos del gasto, procedemos a desagregar los elementos del ingreso de los hogares. El cuadro 9 contiene la desagregación de las remuneraciones al trabajo, para lo que se utiliza la estructura proporcional implícita en el cuadro 8.4 de la ENIGH-2004 para las remuneraciones al trabajo.

Cuadro 9

Desagregación del ingreso por trabajo (millones de pesos, 2003)

Decil	**Remuneraciones al trabajo**	**Participación**	**Trabajo MCS**
I	3,536,812	0.01	20,293,113
II	9,493,540	0.02	54,470,940
III	14,932,382	0.04	85,677,302
IV	20,038,470	0.05	114,974,425
V	25,229,110	0.06	144,756,682
VI	28,617,917	0.07	164,200,588
VII	38,513,215	0.10	220,976,689
VIII	49,013,088	0.13	281,221,651
IX	69,963,150	0.18	401,426,504
X	130,925,364	0.34	751,208,474
Total	390,263,048	1.00	2,239,206,369

Fuente: elaboración propia con base en el cuadro 8.4 de la ENIGH-2004 (INEGI 2005).

Sigue la desagregación de las transferencias del gobierno a los hogares. El cuadro 10 contiene los cálculos, para los que utilizamos la estructura proporcional implícita en el cuadro 8.4 de la ENIGH para las becas y donativos provenientes del gobierno y ong's, que de acuerdo con las notas de dicho cuadro, “... incluye el beneficio del Progresa u Oportunidades y Procampo”.

Cuadro 10
Desagregación de las transferencias del gobierno
(millones de pesos, 2003)

Decil	Becas y donativos provenientes del gobierno y ong's.	Estructura de la participación	Transferencias del gobierno MCS
I	1,068,016	0.12	14,008,481
II	928,522	0.11	12,178,828
III	863,644	0.10	11,327,864
IV	712,467	0.08	9,344,973
V	835,565	0.10	10,959,570
VI	1,026,756	0.12	13,467,300
VII	568,561	0.07	7,457,450
VIII	856,577	0.10	11,235,171
IX	845,863	0.10	11,094,642
X	927,589	0.11	12,166,590
Total	8,633,560	1.00	113,240,869

Fuente: elaboración propia con base en el cuadro 8.4 de la ENIGH-2004 (INEGI 2005).

Por último, en el cuadro 11, se desagregan las transferencias del resto del mundo, para lo que se utilizó la estructura proporcional implícita en el cuadro 8.4 de la ENIGH-2004 para los Ingresos provenientes de otros países, que principalmente se refieren a las remesas enviadas desde EEUU.

Cuadro 11
Desagregación de las transferencias del resto del mundo
(millones de pesos, 2003)

Decil	Ingresos provenientes de otros países	Estructura de la participación	Transferencias del RdM MCS
I	213,510	0.02	3,010,782
II	552,108	0.05	7,785,476
III	837,441	0.07	11,809,060
IV	923,079	0.08	13,016,673
V	942,856	0.08	13,295,556
VI	1,396,322	0.12	19,690,045
VII	1,138,749	0.10	16,057,914
VIII	2,151,614	0.18	30,340,692
IX	1,347,951	0.11	19,007,948
X	2,355,005	0.20	33,208,783
Total	11,858,635	1.00	167,222,929

Fuente: elaboración propia con base en el cuadro 8.4 de la ENIGH-2004 (INEGI 2005).

Finalmente, los ingresos por capital quedan dados por el saldo restante. La matriz obtenida con el procedimiento hasta aquí descrito se presenta en el Apéndice B.

2. El modelo matemático MEGA-Mx03

En México, la primera aplicación del enfoque de Equilibrio General Aplicado (EGA) se remonta al trabajo de Sidaoui y Sines (1979), que está dirigido al análisis de distorsiones en los mercados de factores. En ese mismo año, Serra-Puche (1979) presentó en su disertación doctoral un MEGA para analizar la reforma fiscal mexicana, que luego constituyó la base del MEGAMEX -un modelo auspiciado por el Banco de México-, y de varios artículos: Kehoe y Serra-Puche [1983a, 1983b], Kehoe, Serra-Puche y Solís [1984], y Serra-Puche [1984]. La panorámica de Decaluwé y Martens [1988] incluye, además, un modelo de Levy (1987), que introduce restricciones cuantitativas en el comercio, y un modelo de Gibson, Lustig y Taylor (1986) de enfoque marxista.

También se han elaborado otros modelos para el comercio internacional: Hierro (1983), Sobarzo (1998, 1992), Guerrero (1989), Pérez (1989), Francois y Shiells (1994); y para el sector rural: Adelman, Taylor, y Vogel (1988), Robinson, Burfisher, Hinojosa-Ojeda y Thierfelder (1993), Taylor, Yúnez-Naude, y Hampton (1999).

Con respecto al sistema impositivo mexicano, otros modelos que se han elaborado incluyen el de Ayala (1985), Estrada (1987), Robles (1987), Ibarra (1988), Apolonio (1982) y Núñez (2004); sin embargo, hasta donde es conocido, no se han desarrollado modelos para el estudio de los impuestos sobre la extracción de hidrocarburos.

En esta sección se detalla el modelo matemático. Aunque el origen de los actuales modelos se remonta a la década de los 50's con el trabajo de Johansen (1960), no es sino hasta años recientes que se alcanza cierto grado de estandarización y consenso en la especificación de los sistemas de ecuaciones. La más importante referencia actual está contenida en el manual editado por Dixon y Jorgenson (2013).

Se inicia por los parámetros calibrados a partir de los datos de la economía, contenidos en la MCS. El cuadro 12 presenta los parámetros y su descripción. En el cuadro 13, se enumeran y describen todas las variables utilizadas, y luego se describen las variables endógenas del modelo y las ecuaciones del sistema.

Cuadro 12
Parámetros del Mega-Mx03. Parte 1

Parámetro	Descripción	Parámetro	Descripción
Factores		**Inversión**	
Captotecon	Capital total en la economía	*Deprec*	Depreciación (ahorro de empresas)
Trabtotoecon	Trabajo total en la economía	τ_{DEPREC}	Tasa de depreciación
		$\alpha_{INVIMPORT}$	Parte de importación de capital en inversión total
Hogares			
$\tau_{CAPHOGh}$	Parte de hogares en *captotecon*	α_{INVINT}	Parte de inversión interna en inversión total
$\tau_{TRABHOGh}$	Parte de hogares en *trabtotecon*	β_{INVi}	Parte de cada bien en inversión interna
$\beta_{TRANSFSOCh}$	Parte de hogares en transferencias sociales		
		Producción	
$\beta_{OTRTRANSFh}$	Parte de hogares en remesas del resto del mundo	α_{CAPi}	Parte del capital en el valor agregado
PMA_h	Propensión marginal al ahorro de los hogares	α_{TRABi}	Parte del trabajo en el valor agregado
$\tau_{AHRHOGh}$	Parte de hogares en ahorro privado	$aescva_i$	Parámetro de escala para el valor agregado
$\alpha_{CONSCPh}$	Parte del bien agregado en el consumo	$ruii_{i1,i}$	Requerimiento unitario de insumos
$\alpha_{IMPORTHOGh}$	Parte de lo importado en el consumo	$ruva_i$	Requerimiento unitario de valor agregado

Nota: el cuadro 12 consta de 2 partes.

Cuadro 12

Parámetros del Mega-Mx03. Parte 2

Parámetro	Descripción	Parámetro	Descripción
Gobierno		**Producción**	
τ_{ISRh}	Tasa del ISR de los hogares	α_{PIi}	Parte de producción interna en oferta total
VARISRHOG	Suma de las tasas del ISR de los hogares	α_{Mi}	Parte de importaciones en oferta total
$partisrhog_h$	Parte de cada hogar en *VARISRHOG*	$aescot_i$	Parámetro de escala para la oferta total
τ_{ISRCAP}	Tasa del ISR de las empresas	$rucp_i$	Requerimientos unitarios para el bien final
τ_{IPHh}	Tasa de impuesto sobre consumo privado	**Resto del mundo**	
τ_{IPi}	Tasa del impuesto sobre la producción	*dotcaprdm*	Dotación de capital del resto del mundo
τ_{IMPINV}	Tasa del impuesto sobre la importación de bienes de capital	τ_{CAPRDM}	Parte del resto del mundo en captotecon
τ_{TRABi}	Tasa de las contribuciones sociales	$\alpha_{TRABRDM}$	Parte del trabajo en el gasto del resto del mundo
$\alpha_{TRANSFSOC}$	Parte de transferencias sociales en gasto público	$\alpha_{TRRDMHOG}$	Parte de las remesas en el gasto del resto del mundo
α_{AHRGOB}	Parte del ahorro en gasto público	α_{AHRRDM}	Participación del ahorro del resto del mundo en el gasto del resto del mundo
$\alpha_{IMPORTGOB}$	Parte de importaciones en gasto público	α_{EXPORT}	Participación de las exportaciones en el gasto del resto del mundo
$\alpha_{CONSPUB}$	Parte de consumo en gasto público	$\beta_{EXPORTi}$	Parte de cada bien en las exportaciones
$\beta_{CONSPUBb}$	Parte de cada bien en gasto público		

Nota: el cuadro 12 consta de 2 partes.
Fuente: elaboración propia.

Cuadro 13

Variables endógenas del Mega-Mx03. Parte 1

Actividad		**Total**	**50**
	Variables reales		
Consumo privado por hogar	*CONSPRIVh*		10
Importaciones por hogar	*IMPORTHOGh*		10
	Variables nominales		
Ingreso disponible por hogar	*INGDISPh*		10
Ahorro de cada hogar	*AHRHOGh*		10
Propensión marginal al ahorro	*PMAHOGh*		10
Gobierno		**Total**	**29**
	Variables reales		
Importaciones del gobierno	*IMPORTGOB*		1
Consumo del gobierno	*CONSPUBi*		19
	Variables nominales		
Recaudación por ISR	*RECISR*		1
Recaudación por impuestos a productos	*RECIMPPRODS*		1
Recaudación por contribuciones sociales	*RECIMPTRAB*		1
Recaudación por importación de capital	*RECIMPINV*		1
Ingresos del gobierno	*INGGOB*		1
Transferencias sociales	*TRANSFSOC*		1
Ahorro público	*AHRGOB*		1
Superávit público	*SPVTGOB*		1
Variable para el ISR de los hogares	*VARISRHOG*		1
Ahorro-inversión		**Total**	**21**
	Variables reales		
Inversión en capital importado	*INVIMPORT*		1
Inversión en capital nacional	*INVi*		19
	Variables nominales		
Ahorro total de la economía	*AHRTOT*		1

Nota: el cuadro 13 consta de 2 partes.

Cuadro 13

Variables endógenas del Mega-Mx03. Parte 2.

Producción	**Total**	**536**
	Variables reales	
Demanda de capital por actividad	*DEMCAPi*	19
Demanda de trabajo por actividad	*DEMTRABi*	19
Valor agregado por actividad	*VAi*	19
Demanda de insumos por actividad	*DEMINSi1,i*	361
Producto interno por actividad	*PRODNINTi*	19
Demanda de importaciones por actividad	*DEMIMPORTi*	19
Oferta total por actividad	*OFTOTi*	19
Consumo privado total	CONSPRIVTOT	1
	Precios	
Precio del capital	*PCAP*	1
Precio del trabajo	*PTRAB*	1
Precio del valor agregado	*PVAi*	19
Precio de la producción interna	*PPIi*	19
Precio de la oferta total	*POTi*	19
Precio del bien de consumo privado	*PCP*	1
Resto del mundo	**Total**	**25**
	Variables reales	
Trabajo contratado por el resto del mundo	*TRABRDM*	1
Exportaciones por actividad	*EXPORTi*	19
	Variables nominales	
Ingresos del resto del mundo	*INGRDM*	1
Transferencias del resto del mundo	*TRRDMHOG*	1
Ahorro del resto del mundo	*AHRRDM*	1
	Precios	
Tipo de cambio	*TC*	1
Precio índice del resto del mundo	*PRDMIND*	1
	Gran total	**661**

Nota: el cuadro 13 consta de 2 partes.

Fuente: elaboración propia.

El modelo consiste en un sistema de 649 ecuaciones individuales, cuando se fija la tasa de ahorro (*savings-driven*), de modo que la inversión varía cuando hay cambios en el ahorro; en este caso, las propensiones marginales al ahorro de los hogares quedan fijas como parámetros, también quedan fijas dos variables más en este macro-cierre que se llama básico: la tasa impositiva para el impuesto sobre la renta y el tipo de cambio con el resto del mundo.

Cuando se implementa el cierre al que se denomina alternativo (*investment-driven*), la tasa de ahorro de los hogares es variable y la inversión fija, y quedan como variables la tasa del ISR para los hogares y el tipo de cambio, de modo que se puede fijar el ingreso del gobierno y del resto del mundo o de cualquier componente del gasto, por ejemplo, el ahorro público o el externo.

Actividad

Siguiendo el orden de la MCS, se inicia por los hogares que tienen 4 bloques de ecuaciones. El ingreso disponible de cada hogar es igual a sus rentas por capital y trabajo, sobre las que pagan el ISR (se supone que el trabajo contratado por el resto del mundo no paga ISR), más las transferencias que reciben del gobierno y del resto del mundo:

$$\begin{aligned} INGDISP_h = {} & [\tau_{CAPHOGh} * captotecon * P_{CAP} \\ & + \tau_{TRABHOGh}(trabtotecon - TRABRdM)P_{TRAB}] \\ & (1 - partisrhog_h)VARISRHOG \\ & + \beta_{TRANSFSOCh} * TRANSFSOC \\ & + \beta_{OTRTRANSFh} * TRRdMHOG * TC \\ & + \tau_{TRABHOGh} * TRABRdM * P_{RdMIND} * TC \end{aligned} \qquad (3H.1)$$

De su ingreso disponible, los hogares dedican una proporción fija al ahorro:

$$AHRHOG_h = PMAHOG_h * INGDISP_h, \quad h=1,2, \dots, 10 \qquad (3H.2)$$

Y el resto lo dedican a importar y comprar bienes para consumo final. Los hogares tienen preferencias Cobb-Douglas (de proporciones fijas) sobre importaciones y un bien agregado de consumo privado. El bien agregado de consumo privado paga el impuesto sobre los productos:

$$CONSPRIV_h = \frac{\alpha_{CONSCPh}[INGDISP_h - AHRHOG_h]}{P_{CP}(1+\tau_h^{IPH})} \qquad (3H.3)$$

$$IMPORTHOG_h = \frac{\alpha_{CONSMh}[INGDISP_h - AHRHOG_h]}{P_{RDMIND}TC} \tag{3H.4}$$

Gobierno

Para el gobierno se definen cinco variables de ingreso y cuatro de gasto. El ingreso público total es la suma de las recaudaciones por ISR (actividad y capital), impuestos sobre productos (actividad y actividades), contribuciones sociales e impuestos a la importación de bienes de capital:

$$INGGOB = RECISR + RECIMPPRODS + RECIMPTRAB + RECIMPINV \tag{3G.1}$$

La recaudación por ISR es igual al ISR que pagan los hogares más el que paga el capital:

$$RECISR = \sum[\tau_{CAPHOGh} captotecon P_{CAP} + \tau_{TRABHOGh}(trabtotecon - TRABRDM)P_{TRAB}] \; partisrhog_h VARISRHOG + \tau_{ISRCAP} captotecon P_{CAP} \tag{3G.2}$$

La recaudación por impuestos sobre productos es la suma de los impuestos pagados por los hogares, más los impuestos sobre productos y otros impuestos sobre la producción pagados por las actividades:

$$RECIMPPRODS = \sum_{h1}[CONSPRIV_{h1} P_{CP}]\, \tau_{h1}^{IPH} + \sum_{i1}[PRODNINT_{i1} PPI_{i1}]\, \tau_{IPi1} \tag{3G.3}$$

La recaudación por el impuesto sobre el trabajo:

$$RECIMPTRAB = \sum_i \tau_{IMPTRABi} DEMTRAB_i P_{TRAB} \tag{3G.4}$$

Y la recaudación por la importación de bienes de capital:

$$RECIMPINV = (INVIMPORTPRDMINDTC)\tau^{IMPINV} \tag{3G.5}$$

Para el gasto del gobierno, se supone que la política es destinar una proporción fija de la recaudación total, a cada elemento del gasto público:

$$TRANSFSOC=\alpha_{TRANSFSOC}INGGOB \qquad (3G.7)$$

$$CONSPUB_i = \frac{\beta_{CONSPUBi}\alpha_{CONSPUB}INGGOB}{P_{OFTOTi}} \qquad (3G.8)$$

$$IMPORTGOB=\frac{[\alpha_{IMPORTGOB}INGGOB]}{[P_{RDMIND}TC]} \qquad (3G.9)$$

$$SPVT=INGGOB - TRANSFSOC - AHRGOB - \sum_i CONSPUB_i\, P_{OFTOTi} - IMPORTGOBP_{RDMIND}TC \qquad (3G.10)$$

Ahorro-inversión

El ahorro total de la economía es igual a la suma de todos los ahorros:

$$AHRTOT=\sum_h AHRHOG_h + AHRGOB + deprecP_{CAP} + AHRRDMTC \qquad (3AI.1)$$

La economía dedica una fracción fija del ahorro total a la importación de bienes de capital, el precio de la inversión importada incluye el impuesto:

$$INVIMPORT=\frac{\alpha_{INVIMPORT}AHRTOT}{P_{RDMIND}TC(1+\tau_{IMPINV})} \qquad (3AI.2)$$

Las otras 19 ecuaciones están dadas por el bloque del macro-cierre ahorro-inversión, que iguala el ahorro total -menos lo invertido en importaciones- con la inversión interna. Este bloque lo ponemos al final, en la sección de cierres macroeconómicos (condiciones de equilibrio general).

Producción Cobb-Douglas de valor agregado

Se considera como primer anidamiento la generación del valor agregado (VA), en donde hay dos bloques de variables para las demandas de factores y un bloque de precios para el valor agregado generado por cada actividad.

Suponiendo una función de producción Cobb-Douglas con rendimientos constantes a escala, y minimización de costos, obtenemos las demandas óptimas:

$$DEMCAP_i = \frac{VA_i}{aescva_i}\left[\frac{P_{TRAB}(1+\tau_{IMPTRABi})}{P_{CAP}}\frac{\alpha_{CAPi}}{\alpha_{TRABi}}\right]^{\alpha_{TRABi}} \quad (3V.1)$$

$$DEMTRAB_i = \frac{VA_i}{aescva_i}\left[\frac{P_{CAP}}{P_{TRAB}(1+\tau_{IMPTRABi})}\frac{\alpha_{TRABi}}{\alpha_{CAPi}}\right]^{\alpha_{CAPi}} \quad (3V.2)$$

Del supuesto de competencia perfecta -precio igual a costo medio-, obtenemos:

$$PVA_i VA_i = DEMCAP_i P_{CAP} + DEMTRAB_i P_{TRAB}(1+\tau_{IMPTRABi}) \quad (3V.3)$$

Producción interna

Del mismo modo, para la producción interna hay tres bloques de variables, uno para la demanda de valor agregado, otro para insumos, y el tercero para precios. Con una agregación Leontief, las demandas óptimas son:

$$DEMINS_{i1,i} = PRODNINT_i ruii_{i1,i} \quad (3PI.1)$$

$$VA_i = PRODNINT_i ruva_i \quad (3PI.2)$$

Y del supuesto de competencia perfecta:

$$P_{PIi} PRODNINT_i = P_{VAi} VA_i + \sum_i DEMINS_{i1,i} P_{OTi} \quad (3PI.3)$$

Producción de la oferta total

Igualmente, para la producción de la oferta total tenemos tres bloques de variables, uno para la demanda de la producción interna, otro para la demanda de importaciones y el tercero para los precios. Suponiendo también una función de producción Cobb-Douglas con rendimientos constantes a escala, del problema de minimización de costos, las demandas óptimas son:

$$PRODNINT_i = \frac{OFTOT_i}{aescot_i}\left[\frac{P_{RDMIND}TC}{P_{PIi}(1+\tau_i^{IP})}\frac{\alpha_{PIi}}{\alpha_{Mi}}\right]^{\alpha_{Mi}} \qquad (3OT.1)$$

$$DEMIMPORT_i = \frac{OFTOT_i}{aescot_i}\left[\frac{P_{PIi}(1+\tau_i^{IP})}{P_{RDMIND}TC}\frac{\alpha_{Mi}}{\alpha_{PIi}}\right]^{\alpha_{PIi}} \qquad (3OT.2)$$

Y del supuesto de competencia perfecta:

$$P_{OTi}OFTOT_i = PRODNINT_i P_{PIi}\left(1+\tau_i^{IP}\right) + DEMIMPORT_i P_{RDMIND}TC \qquad (3OT.3)$$

El bloque de variables de la oferta total se determina por la condición de equilibrio de vaciamiento de los mercados. Este bloque también lo ponemos al final, en la sección de macro-cierres.

Consumo privado

El consumo privado total está dado por la suma de las demandas de los hogares:

$$CONSPRIVTOT = \sum_h CONSPRIV_h \qquad (3CP.1)$$

Queda por definir el precio del bien agregado de consumo privado, dado también por la condición de precio unitario igual a costo medio unitario:

$$P_{CP} = \sum_i P_{OTi} \mathrm{rucp}_i \qquad (3CP.2)$$

Resto del mundo

Finalmente está el resto del mundo, cuyas ecuaciones son:
Ingreso del resto del mundo (a precios del resto del mundo)

$$INGRDM=[\sum_h IMPORTHOG_h + IMPORTGOB + INVIMPORT]P_{RDMIND} + \sum_i DEMIMPORT_i\, P_{RDMIND} + dotcaprdm\frac{P_{CAP}}{TC} \quad (3R.1)$$

Gastos del resto del mundo a precios del resto del mundo:

$$TRRDMHOG=\alpha_{TRRDM}INGRDM \quad (3R.2)$$

$$AHRRDM=\alpha_{AHRRDM}INGRDM \quad (3R.3)$$

$$TRABRDM=\alpha_{TRABRDM}INGRDM \quad (3R.4)$$

$$EXPORT_i = \frac{\beta_{EXPORTi}(\alpha_{EXPORT}INGRDM)}{P_{OTi}/TC} \quad (3R.5)$$

Cierres macroeconómicos

Las dos primeras ecuaciones de cierre, son las de equilibrio en los mercados de factores productivos:

$$\sum_i DEMCAP_i = captotecon \quad (3M.1)$$

$$\sum_i DEMTRAB_i = trabtotecon - TRABRdM \quad (3M.2)$$

Cierre ahorro-inversión básico (PMA fija, inversión variable):

$$\left[AHRTOT-(INVIMPORTP_{RDMIND}TC)(1+\tau^{IMPINV})\right]\beta_{INVi}=INV_iP_{OTi} \quad (3M.3)$$

Cierre ahorro-inversión alternativo (inversión fija, PMA variable):

$$AHRHOG_h = \left[\left(\sum_i INV_i\, POT_i\right) + INVIMPORTPRDMINDTC(1+\tau^{IMPINV})\right]\tau_h^{ahrhog} - \left(AHRGOB + \tau^{deprec} captoteconP_{CAP} + AHRRDMTC\right)\tau_h^{ahrhog}$$

Cierre mercado de bienes:

$$OFTOT_i = \sum_i DEMINS_{i1,i} + CONSPRIVTOTrucp_i + CONSPUB_i + INV_i + EXPORT_i \qquad (3M.4)$$

Así, queda plenamente especificado un modelo cuyas principales novedades con respecto a otros que se han hecho para México, son: a) que se trata de un modelo parsimonioso y robusto, b) que es un modelo transparente cuyos resultados pueden ser replicados y validados (o rectificados) por otros investigadores, c) que se trata de un modelo general que puede ser modificado, ampliado y adecuado al análisis de otras cuestiones de la economía mexicana.

3. Análisis de la eliminación del exceso impositivo sobre el sector minería

De acuerdo con la MIP publicada por el INEGI para el 2003, los impuestos pagados por los sectores productivos, así como la producción total se presentan en el cuadro 14. Los otros impuestos a la producción se toman del cuadro 58 de las CByS, en donde se puede apreciar que los otros impuestos sobre la extracción de petróleo y gas (254,939,712), representan el 99.71% de los otros impuestos sobre la Minería, y 99.32% de los impuestos totales, prácticamente la totalidad. La tasa impositiva se calcula dividiendo los impuestos totales entre la producción antes de impuestos.

Considerando los Impuestos sobre los productos, sumados a los otros impuestos a la producción pagados por los sectores, se observa que para el 2003 el sector minería en conjunto pagó impuestos en torno al 90%, que refleja el gravoso régimen al que se encuentra sometida Pemex. También podemos ver que el siguiente sector que paga la tasa más alta, es la actividad 12 (Dirección de corporativos y empresas) con 10.86%. Después, todas las demás actividades presentan tasas menores al 2%.

Cuadro 14

Impuestos sobre los sectores productivos (millones de pesos, 2003)

Sector	Producción total	Impuestos a los productos neto*	Otros impuestos a la producción netos	Impuestos totales	Tasa impositiva (%)
A1	423,557,304	1,512,320	116,266	1,628,586	0.39
A2	541,488,761	1,001,063	255,678,756	256,679,819	90.12
A3	238,541,112	2,309,191	627,801	2,936,992	1.25
A4	968,319,580	3,335,418	1,738,039	5,073,457	0.53
A5	4,059,426,635	10,517,962	9,920,465	20,438,427	0.51
A6	1,461,397,342	520,780	11,004,983	11,525,763	0.8
A7	836,505,025	13,673,333	413,802	14,087,135	1.71
A8	313,967,631	877,344	1,279,667	2,157,011	0.69
A9	308,010,790	-51,584	4,296,371	4,244,787	1.38
A10	887,319,369	180,963	7,756,705	7,937,668	0.9
A11	390,910,772	570,349	925,821	1,496,170	0.38
A12	41,358,042	56,065	3,994,833	4,050,898	10.86
A13	221,259,048	241,187	1,041,525	1,282,712	0.58
A14	416,365,676	69,654	992,998	1,062,652	0.26
A15	293,306,066	349,763	624,935	974,698	0.33
A16	41,011,314	29,602	315,696	345,298	0.85
A17	279,946,186	329,269	1,145,674	1,474,943	0.53
A18	279,697,039	435,751	630,546	1,066,297	0.38
A19	422,687,560	814,655	2,373,132	3,187,787	0.76
Total	12,425,075,252	36,773,085	304,878,015	341,651,100	

Fuente: elaboración propia.

Por su parte, el cuadro 15 contiene las tasas del ISR pagada por los hogares y por el capital, según la MCS-Mx03, con una progresividad que va del 1.19% para el decil más pobre, hasta 5.16% en el decil más rico. El capital paga una tasa de 3.79%.

El ejercicio que se llevó a cabo consiste en disminuir el exceso impositivo pagado por el sector minería hasta un nivel similar al de los demás sectores, compensándolo con un incremento uniforme al ISR pagado por actividad y empresas, de modo que la recaudación global se mantiene en el mismo nivel y el gasto público, por tanto, no se ve afectado.

Cuadro 15

Tasa del ISR pagada por los contribuyentes según la MCS-Mx03

Contribuyente	Tasa de ISR	Contribuyente	Tasa de ISR
Decil I	0.012	Decil VI	0.027
Decil II	0.015	Decil VII	0.033
Decil III	0.017	Decil VIII	0.040
Decil IV	0.020	Decil IX	0.044
Decil V	0.023	Decil X	0.052
Empresas	0.038		

Fuente: elaboración propia.

Para esto, se especifica el siguiente macro-cierre: a) tasa de ahorro fija e inversión variable, que es la alternativa "realista" en el sentido de que normalmente se espera que los hogares mantengan una tasa de ahorro consistente; b) ingreso del gobierno fijo, de tal modo que la tasa del ISR se ajusta para lograr el mismo nivel de gasto público inicial, manteniendo un déficit igual a cero; c) tipo de cambio fijo, que se puede considerar como la alternativa "realista".

Al implementar esta simulación con el MEGA-Mx03 arriba especificado, encontramos que el incremento necesario en el ISR pagado por actividad y empresas, para disminuir la carga impositiva del sector minería al nivel del siguiente sector con los mayores impuestos (12.15%), es del 61%.

Alternativamente, se realiza una segunda simulación, especificando el siguiente macro-cierre: a) Inversión fija al nivel inicial y tasa de ahorro privado variable, de tal modo que se ajusta para lograr el nivel de inversión requerido. Este cierre tiene el propósito de evitar el sesgo, en la medición de la variación equivalente (VE), dado por variaciones en el ahorro e interpretado como consumo futuro. b) Se mantiene fijo el ingreso del gobierno (de modo que el gasto en bienes públicos que no están en la función de utilidad de los consumidores, también se mantiene constante), y variable la tasa del ISR. Pero, c) se fija el ingreso del resto del mundo, dejando al tipo de cambio como variable de ajuste, para evitar que variaciones en el ahorro externo sesguen la medición de la variación equivalente.

Los resultados de ambas simulaciones para la variación equivalente, se presentan en el cuadro 16, en donde se puede ver que efectivamente la variación equivalente, considerando el segundo macro-cierre, disminuye prácticamente hasta la mitad. Este resultado es una consecuencia lógica de fijar la inversión, pues entonces el ahorro excedente se dedica al consumo actual. Las implicaciones de política económica son claras: en ambos casos se observa un consistente efecto negativo sobre el bienestar de los hogares.

Cuadro 16
Variación equivalente de las dos simulaciones

Primera simulación		**Segunda simulación**	
Decil	**Variación equivalente**	**Decil**	**Variación equivalente**
I	-2.070	I	-1.072
II	-3.153	II	-1.599
III	-3.953	III	-1.954
IV	-5.111	IV	-2.339
V	-6.212	V	-3.000
VI	-8.330	VI	-4.130
VII	-11.738	VII	-6.130
VIII	-16.786	VIII	-8.928
IX	-26.308	IX	-14.660
X	-68.910	X	-34.530
Total	-152.571	Total	-78.342

Fuente: elaboración propia.

Por construcción, el modelo se basa en el supuesto de competencia perfecta (aunque en el caso de Pemex se trata de un monopolio, el supuesto de país pequeño implica que no puede modificar los precios internacionales), lo cual implica que la formación de precios tiene lugar a partir de los costos más los impuestos, por lo que lógicamente al disminuir los impuestos se reducen los precios, lo que a su vez impacta la formación de precios en los demás sectores, de modo que se observa una tendencia a la baja, esto implica una mejora en la competitividad de la economía en términos de precios internos con respecto a los del exterior.

Con la primera simulación se observa el siguiente resultado: los precios del sector minería disminuyen en un 43% (aunque en la práctica Pemex continuaría vendiendo a los precios internacionales, sobre todo el petróleo exportado, pero también podría disminuir sus precios a la industria nacional para mejorar la competitividad). En consecuencia, los precios en los demás sectores disminuyen desde 0.15% en la actividad 9 hasta 3.58% en la actividad 5. Dado que la regla de asignación del ahorro es fija, la inversión en bienes del sector minería aumenta en 73.1%.

Mientras que con el segundo macro-cierre, en donde la inversión se mantiene fija en el nivel inicial, los precios muestran una disminución similar, lo que demuestra que el modelo es bastante robusto.

Conclusión

La investigación realizada en este trabajo ha resultado tanto en el diseño de un modelo de equilibrio general aplicado a la economía mexicana, como en su aplicación al estudio de un problema importante para la misma economía mexicana: los altos impuestos en el sector minería, que son causados por una política gubernamental de asfixia financiera en contra de Pemex, como lo demuestra el hecho de que en algunos años la paraestatal ha tenido que pagar impuestos incluso superiores al 100% de sus ingresos.

Una preocupación fundamental de esta investigación es la de aportar datos transparentes y un modelo parsimonioso, por lo cual incluimos la MCS utilizada, y ponemos el código computacional del modelo a disposición de quien lo solicite al autor, con el propósito de que los resultados puedan replicarse y en su caso validarse o discutirse y corregirse si hubiera lugar, lo cual es necesario, desde nuestro juicio, si la investigación ha de cumplir con el principio científico de la reproducción, verificación y validación de resultados.

Por otra parte, tanto la matriz de datos como el modelo pueden ser modificados y enriquecidos para analizar diversas problemáticas de la economía de México. Para comenzar, la matriz puede ser inmediatamente desagregada de los 79 subsectores del SCIAN, para realizar análisis más detallados. También es posible desagregar otros elementos como el impuesto al valor agregado, para estudiar reformas alternativas a este. Otra posibilidad es la de analizar diversos efectos de cambios en políticas de gasto público, realizar simulaciones para evaluar programas de combate a la pobreza o analizar cuestiones de comercio internacional, entre otros.

Finalmente, es importante tener presente que un modelo es, por definición, una representación simplificada de la realidad, y necesariamente se basa en la especificación de supuestos más o menos realistas de donde, la utilidad de un modelo como el presente consiste en aportar criterios y elementos de juicio para informar la toma de decisiones; no se trata, pues, de una esfera mágica para predecir con exactitud los resultados futuros de una posible reforma. Considerando además la inexactitud de la base de datos utilizada (en este caso, la MCS-Mx03), ya sea por errores de medición o de procesamiento, los resultados numéricos no se deberían tomar como una predicción exacta, sino como un indicador de la dirección y magnitud de los cambios en las variables de interés.

Apéndice

A. Abreviaturas utilizadas en la MCS-MX03ETD

Abreviatura	Descripción
H1	Primer decil de los hogares
H2	Segundo decil de los hogares
H3	Tercer decil de los hogares
H4	Cuarto decil de los hogares
H5	Quinto decil de los hogares
H6	Sexto decil de los hogares
H7	Séptimo decil de los hogares
H8	Octavo de los hogares
H9	Noveno decil de los hogares
H10	Décimo decil de los hogares
Soc	Sociedades (financieras y no-financieras)
Gob	Gobierno
ISR	Impuesto sobre la renta
ContSoc	Contribuciones sociales
ISP	Impuestos sobre productos
OIP	Otros impuestos a la producción
Ahr/Inv	Ahorro/inversión
Cap	Capital
Trab	Trabajo
A1	Agricultura, ganadería, aprovechamiento forestal, pesca y caza
A2	Minería
A3	Electricidad, agua y suministro de gas por ductos al consumidor final
A4	Construcción
A5	Industrias manufactureras
A6	Comercio
A7	Transportes, correos y almacenamiento
A8	Información en medios masivos
A9	Servicios financieros y de seguros
A10	Servicios inmobiliarios y de alquiler de bienes muebles e intangibles
A11	Servicios profesionales, científicos y técnicos
A12	Dirección de corporativos y empresas
A13	Servicios de apoyo a los negocios y manejo de desechos y servicios de remediación
A14	Servicios educativos
A15	Servicios de salud y de asistencia social
A16	Servicios de esparcimiento culturales y deportivos, y otros servicios recreativos
A17	Servicios de alojamiento temporal y de preparación de alimentos y bebidas
A18	Otros servicios excepto actividades del gobierno
A19	actividades del Gobierno y de organismos internacionales y extraterritoriales
ConsPriv	Consumo privado
RdM	Resto del mundo

Fuente: elaboración propia.

B. La MCS-Mx03ETD (millones de pesos, 2003), Parte 1

	H1	H2	H3	H4	H5	H6	H7
H1							
H2							
H3							
H4							
H5							
H6							
H7							
H8							
H9							
H10							
Soc							
Gob							
ISR	1,335,016	2,689,145	3,868,252	5,641,042	7,539,925	10,455,749	16,222,711
CS							
ISP	8,951,495	13,445,949	16,945,318	20,182,310	23,210,127	27,354,256	32,810,818
OIP							
Ahr/Inv	3,641,739	6,246,306	8,093,815	14,961,139	16,489,101	28,160,506	42,069,556
Capital							
Trabajo							
A1							
A2							
A3							
A4							
A5							
A6							
A7-A8							
A9							
A10							
A11							
A12							
A13							
A14							
A15							
A16							
A17							
A18							
A19							
A20							
ConsPriv	113,953,979	171,169,102	215,716,638	256,924,071	295,468,662	348,224,092	417,687,006
RdM	1,842,747	3,215,401	4,857,643	6,406,878	9,229,620	9,184,880	13,971,139
Total fila	129,724,976	196,765,904	249,481,666	304,115,440	351,937,434	423,379,484	522,761,229

Nota: el apéndice B consta de 6 partes.
Fuente: elaboración propia.

B. La MCS-Mx03ETD (millones de pesos, 2003), Parte 2

	H8	H9	H10	Soc	Gob	ISR	CS
H1				92,412,601	14,008,481		
H2				122,330,660	12,178,828		
H3				140,667,440	11,327,864		
H4				166,779,369	9,344,973		
H5				182,925,627	10,959,570		
H6				226,021,551	13,467,300		
H7				278,269,176	7,457,450		
H8				340,167,323	11,235,171		
H9				512,427,163	11,094,642		
H10				1,451,248,164	12,166,590		
Soc							
Gob						396,615,598	147,620,939
ISR	24,951,512	40,435,560	113,370,061	170,106,626			
CS							
ISP	39,686,365	54,999,862	114,053,807				
OIP							
Ahr/Inv	71,396,819	109,989,776	456,853,548	779,607,425	116,045,713		
Capital							
Trabajo							
A1					0		
A2					0		
A3					0		
A4					29,384		
A5					1,815,688		
A6					0		
A7-A8					0		
A9					43,604		
A10					30,082,722		
A11					0		
A12					12,088,532		
A13					0		
A14					0		
A15					269,065,467		
A16					162,308,618		
A17					4,222,283		
A18					0		
A19					0		
A20					412,665,245		
ConsPriv	505,213,828	700,157,125	1,451,923,369				
RdM	21,716,314	38,373,935	111,631,227	24,457,720	126,289,117		
Total fila	662,964,838	943,956,257	2,247,832,012	4,487,420,844	1,247,897,242	396,615,598	147,620,939

Nota: el apéndice B consta de 6 partes.
Fuente: elaboración propia.

B. La MCS-Mx03ETD (millones de pesos, 2003), Parte 3

	ISP	OIP	Ahr/Inv	Capital	Trabajo	A1	A2
H1					20,293,113		
H2					54,470,940		
H3					85,677,302		
H4					114,974,425		
H5					144,756,682		
H6					164,200,588		
H7					220,976,689		
H8					281,221,651		
H9					401,426,504		
H10					751,208,474		
Soc				4,487,420,844			
Gob	388,413,392	310,630,588	4,616,725				
ISR							
CS						3,126,941	2,158,630
ISP						1,512,320	1,001,063
OIP						118,460	260,503,024
Ahr/Inv							
Capital						209,815,285	134,894,798
Trabajo						47,085,001	32,504,327
A1			17,984,710			37,038,413	0
A2			62,493,176			75,598	5,917,262
A3			0			4,931,145	3,089,478
A4			886,029,260			923,712	353,383
A5			361,200,176			46,958,163	26,030,899
A6			87,736,300			22,587,553	12,130,118
A7-A8			20,670,254			8,670,152	6,176,312
A9			0			1,385,547	1,242,217
A10			0			5,241,326	14,635,281
A11			0			971,679	9,749,663
A12			0			5,051,063	4,104,100
A13			0			0	5,191,917
A14			0			5,900	1,875,404
A15			0			0	0
A16			0			0	0
A17			0			0	0
A18			0			39,658	1,107,602
A19			0			1,401,338	2,795,361
A20			0			239	31
ConsPriv							
RdM			288,895,965			26,617,811	16,027,891
Total fila	388,413,392	310,630,588	1,729,626,566	4,487,420,844	2,239,206,369	423,557,304	541,488,761

Nota: el apéndice B consta de 6 partes.
Fuente: elaboración propia.

B. La MCS-Mx03ETD (millones de pesos, 2003), Parte 4

	A3	A4	A5	A6	A7-A8	A9	A10
H1							
H2							
H3							
H4							
H5							
H6							
H7							
H8							
H9							
H10							
Soc							
Gob							
ISR							
CS	2,199,190	11,897,718	28,354,802	16,413,354	10,803,848	3,117,214	3,702,926
ISP	2,309,191	3,335,418	10,517,962	520,780	13,673,333	877,344	-51,584
OIP	639,647	1,770,833	10,107,649	11,212,630	421,610	1,303,812	4,377,437
Ahr/Inv							
Capital	56,135,474	280,857,906	825,868,118	812,115,742	356,640,240	139,863,845	119,623,673
Trabajo	33,115,058	179,154,022	426,962,267	247,149,769	162,682,692	46,938,530	55,758,098
A1	0	1,691,961	179,686,461	0	0	0	0
A2	1,851,929	12,076,629	275,010,135	0	7,029	532	0
A3	33,437,453	3,094,215	49,112,356	14,935,672	4,485,651	2,101,890	961,559
A4	579,321	62,592,496	6,448,286	510,917	1,063,144	73,406	510,362
A5	41,258,500	194,290,794	559,674,155	55,316,713	84,392,048	12,875,917	3,392,468
A6	20,023,361	65,355,295	286,675,302	28,747,650	34,665,705	6,765,024	1,815,393
A7-A8	9,523,175	23,783,221	104,148,216	12,911,257	22,679,873	7,355,846	4,051,722
A9	942,115	5,862,350	23,449,654	20,294,570	6,878,471	16,881,710	7,546,715
A10	3,805,767	5,682,482	19,789,113	42,032,858	16,223,623	5,338,868	35,163,185
A11	1,109,374	13,176,425	43,315,225	46,190,181	13,334,891	11,969,250	10,191,016
A12	1,832,349	18,648,445	54,371,004	75,464,543	16,175,838	8,799,646	17,204,421
A13	0	101,263	15,636,558	581,681	266,752	18,627,991	45,475
A14	2,691,184	8,461,440	53,308,191	10,510,634	16,597,152	7,606,651	24,242,286
A15	107,579	5,720	3,866	0	277,606	16,681	815,062
A16	0	0	0	0	0	0	0
A17	0	424	12,118	0	6,171	299,022	16
A18	659,950	2,837,940	12,620,499	77,429	4,491,754	398,578	1,390,741
A19	2,367,770	5,130,771	19,960,683	6,478,071	14,182,088	2,094,827	3,035,222
A20	1,277,835	30,524	137	0	3,241,159	0	1,199,264
ConsPriv							
RdM	22,674,890	68,481,288	1,054,393,878	59,932,891	53,314,347	20,661,047	13,035,333
Total fila	238,541,112	968,319,580	4,059,426,635	1,461,397,342	836,505,025	313,967,631	308,010,790

Nota: el apéndice B consta de 6 partes.
Fuente: elaboración propia.

B. La MCS-Mx03ETD (millones de pesos, 2003), Parte 5

	A11	A12	A13	A14	A15	A16	A17
H1							
H2							
H3							
H4							
H5							
H6							
H7							
H8							
H9							
H10							
Soc							
Gob							
ISR							
CS	598,191	4,365,578	782,581	6,448,413	17,723,013	7,930,580	490,851
ISP	180,963	570,349	56,065	241,187	69,654	349,763	29,602
OIP	7,903,062	943,290	4,070,209	1,061,177	1,011,724	636,727	321,653
Ahr/Inv							
Capital	787,250,822	207,590,051	5,444,236	65,871,005	87,608,386	94,318,021	20,673,132
Trabajo	9,007,474	65,736,202	11,783,988	97,099,221	266,870,412	119,417,451	7,391,157
A1	0	0	0	0	0	17	817
A2	222,023	4,271	0	4,002	10	192	605
A3	6,694,012	2,235,677	69,172	959,354	2,555,727	3,441,982	643,320
A4	3,303,577	64,449	293,482	231,582	1,108,787	422,310	28,859
A5	15,584,523	19,524,494	1,017,539	10,378,220	4,255,758	22,068,423	2,795,724
A6	5,796,449	10,283,343	291,043	4,517,652	2,196,342	8,749,160	975,872
A7-A8	2,973,666	5,601,677	793,722	2,297,506	1,528,952	3,196,456	467,154
A9	7,817,394	10,520,480	1,526,962	4,173,957	8,081,111	2,565,583	1,042,380
A10	2,980,428	1,355,245	3,006,679	783,656	507,269	367,244	295,546
A11	9,682,073	13,682,392	1,103,736	3,641,681	5,418,057	4,671,640	1,343,101
A12	4,157,112	15,058,102	5,253,759	7,521,324	6,499,634	2,478,268	1,030,330
A13	15,202	0	888,523	1,024	0	0	0
A14	15,418,153	9,730,947	516,792	5,640,691	4,995,270	8,573,306	1,829,179
A15	1,815	212,008	0	0	607,911	235,862	8,631
A16	0	0	0	0	0	0	0
A17	3,085	2,241	30	2,293	57,117	1,279	12,370
A18	304,245	2,005,404	955,714	935,229	890,734	893,348	82,128
A19	1,419,646	2,112,206	219,507	471,456	867,186	1,790,983	601,253
A20	6,542	0	0	0	0	0	0
ConsPriv							
RdM	5,998,912	19,312,366	3,284,303	8,978,418	3,512,622	11,197,471	947,650
Total Fila	887,319,369	390,910,772	41,358,042	221,259,048	416,365,676	293,306,066	41,011,314

Nota: el apéndice B consta de 6 partes.
Fuente: elaboración propia.

B. La MCS-Mx03ETD (millones de pesos, 2003), Parte 6

	A18	A19	A20	ConsPriv	RdM	Total Fila
H1					3,010,782	129,724,976
H2					7,785,476	196,765,904
H3					11,809,060	249,481,666
H4					13,016,673	304,115,440
H5					13,295,556	351,937,434
H6					19,690,045	423,379,484
H7					16,057,914	522,761,229
H8					30,340,692	662,964,838
H9					19,007,948	943,956,257
H10					33,208,783	2,247,832,012
Soc						4,487,420,844
Gob						1,247,897,242
ISR						396,615,598
CS	3,587,319	4,442,414	19,477,375			147,620,939
ISP	329,269	435,751	814,655			388,413,392
OIP	1,167,291	642,443	2,417,909			310,630,588
Ahr/Inv					76,071,123	1,729,626,566
Capital	144,914,350	136,186,748	1,749,013			4,487,420,844
Trabajo	54,017,295	66,893,194	293,287,321		16,352,891	2,239,206,369
A1	6,029	238	0	152,682,442	34,466,216	423,557,304
A2	113,953	351	0	0	183,711,064	541,488,761
A3	9,781,982	3,196,193	7,547,589	84,427,471	839,214	238,541,112
A4	853,486	93,548	1,607,285	1,198,544	0	968,319,580
A5	17,517,792	19,013,955	16,437,575	1,208,462,405	1,335,164,706	4,059,426,635
A6	6,116,306	8,300,783	5,804,204	670,820,538	171,043,949	1,461,397,342
A7-A8	2,755,921	3,323,282	7,410,597	527,912,466	58,273,598	836,505,025
A9	4,944,201	5,867,040	7,826,681	167,572,906	7,501,983	313,967,631
A10	4,581,970	1,301,513	8,526,066	93,735,190	12,574,759	308,010,790
A11	9,890,603	6,166,833	5,407,725	676,289,836	13,988	887,319,369
A12	3,831,929	3,770,560	11,867,793	114,350,189	1,351,831	390,910,772
A13	0	1,656	0	0	0	41,358,042
A14	9,098,006	2,937,208	12,472,618	21,230,808	3,517,228	221,259,048
A15	393	21	3,724,631	141,282,423	0	416,365,676
A16	0	0	0	130,997,448	0	293,306,066
A17	23,083	409	1,103,931	35,265,442	0	41,011,314
A18	134,386	247,540	5,127,096	244,746,211	0	279,946,186
A19	2,683,878	369,196	5,768,658	201,200,056	4,746,883	279,697,039
A20	0	3,086	0	4,263,498	0	422,687,560
ConsPriv						4,476,437,873
RdM	3,596,744	16,503,077	4,308,838		102,560,129	2,175,412,491
Total Fila	279,946,186	279,697,039	422,687,560	4,476,437,873	2,175,412,491	

Nota: el apéndice B consta de 6 partes.
Fuente: elaboración propia.

Referencias

Adelman, I., Taylor, J. y Vogel, S. (1988). “Life in a mexican village: A SAM perspective”. *Journal of Development Studies*, 25(1), 5-24.

Apolonio, G. (1992). *Impuesto sobre los activos de las empresas: un enfoque de equilibrio general computable*. (Tesis de maestría). Centro de Estudios Económicos, El Colegio de México.

Ayala, E. (1985). *El impuesto sobre los ingresos del capital de México en un modelo de equilibrio general.* (Tesis de maestría). Centro de Estudios Económicos, El Colegio de México.

Barbosa-Carrasco, I., Vázquez-Alvarado, J. y Matus-Gardea, J. (2009). “Matriz de Contabilidad Social 2004 para México”. *Agrociencia*, 43(5), 551-558.

Decaluwé, B. y Martens, A. (1988). “CGE modeling and developing economies: A concise empirical survey of 73 applications to 26 countries”. *Journal of Policy Modeling*, 10(4), 529-568.

Defourney, J. y Thorbecke, E. (1984). “Structural path analysis and multiplier decomposition within a social accounting framework”. *The Economic Journal*, 94(373), 111-136.

Dixon, P. y Jorgenson, D. (2013). *Handbook of Computable General Equilibrium Modeling*. North-Holland.

Estrada, E. (1987). *El impuesto sobre la renta de las empresas y la reforma fiscal: un análisis de equilibrio general aplicado.* (Tesis de maestría) Centro de Estudios Económicos, El Colegio de México.

Francois, J. y Shiells, C. (Eds.) (1994). *Modelling trade policy: Applied general equilibrium assessments of North American free trade*. New York: Cambridge University.

Gibson, B., Lustig, N. y Taylor, L. (1986). “Terms of Trade and Class Conflict in a Computable General Equilibrium Model for Mexico”. *The Journal of Development Studies*, 23(1), 40-59.

Guerrero, R. (1989). *La política comercial mexicana en 1983-88: Una evaluación con base en un modelo de equilibrio general aplicado.* (Tesis de maestría). Centro de Estudios Económicos, El Colegio de México.

Hierro, J. (1983). *Un modelo econométrico de equilibrio general y su aplicación a la política comercial en México*. (Tesis de maestría). Departamento de Economía, Instituto Tecnológico Autónomo de México.

Ibarra, L. (1988). Incidencia de las tasas diferenciales del impuesto al valor agregado: Un Análisis de equilibrio general. Instituto Tecnológico Autónomo de México. Departamento de Economía.

INEGI (2010a). *Cuentas de Bienes y Servicios 2003-2008. Año base 2003. Tomos I y II. Segunda Versión*. México.

INEGI (2010b). *Cuentas por Sectores Institucionales 2003-2008. Año base 2003. Tomos I y II. Segunda Versión*. México.

INEGI (2008). *Matriz de Insumo Producto de México 2003. Clasificación SCIAN 2002*. México.

INEGI (2005). *Encuesta Nacional de Ingresos y Gastos de los Hogares (ENIGH) 2004*. México.

Johansen, L. (1960). *A Multi-Sector Study of Economic Growth*. North-Holland.

Kehoe, T., Serra-Puche, J. y Solis, L. (1984). "A General Equilibrium Model of Domestic Commerce in Mexico". *Journal of Policy Modeling*, 6(1), 1-28.

Kehoe, T. y Serra-Puche, J. (1983a). "A computational general equilibrium model with endogenous unemployment: An analysis of the 1980 fiscal reform in Mexico". *Journal of Public Economics*, 22, 1-26.

Kehoe, T. y Serra-Puche, J. (1983b). "A general equilibrium appraisal of energy policy in Mexico". *Empirical Economics*, 16(1), 71-93.

Levy, S. (1987). "A Short-Run General Equilibrium Model for a Small, Open Economy". *Journal of Development Economics*, 25(1), 63-88.

Núñez, G. (2004). *Un Análisis Estructural y de Equilibrio General de la Economía Mexicana*. (Tesis Doctoral). Universidad Autónoma de Barcelona, España.

Núñez, G. (2008). "A Social Accounting Matrix of Mexico for the year 2000". *International Input - Output Association.Working Papers in Input-Output Economics,WPIOX 08-001*.

Pérez, A. (1989). *Efectos de la apertura comercial en el empleo y el bienestar de México: Un enfoque de equilibrio general*. (Tesis de maestría). Centro de Estudios Económicos, El Colegio de México.

Robinson, S., Burfisher, M., Hinojosa-Ojeda, R. y Thierfelder, K. (1993). "Agricultural policies and migration in a U.S.-Mexico free trade area: A computable general equilibrium analysis". *Journal of Policy Modeling*, 15(5-6), 673-701.

Robles, H. (1987). *Impuestos óptimos en un modelo de equilibrio general: Reformas fiscales alternativas a la reforma fiscal mexicana de 1987.* (Tesis de maestría). Centro de Estudios Económicos, El Colegio de México.

SAT (2003). *Compilación de Legislación Fiscal 2003 Tomo I*. SHCP. México.

Serra-Puche, J. (1979). *A Computational General Equilibrium Model for the Mexican Economy: An Analysis of Fiscal Policies.* (Tesis doctoral). Yale University.

Serra-Puche, J. (1984). A general equilibrium model for the Mexican economy. En Scarf, H. y Shoven, J. (Eds.) *Applied general equilibrium analysis.* Cambridge: Cambridge University Press.

Sidaoui, J. and Sines, R. (1979). *Estimaciones de equilibrio general de los efectos de las distorsionesen los mercados de factores: El caso de México*. Banco de México.

Sobarzo, H. (1992). "A general equilibrium analysis of the gains from trade for the Mexican economy of a North American Free Trade Agreement". *The World Economy*, 15(1), 83–100.

Sobarzo, H. (1998). "Applied general equilibrium models: The Mexican experience of NAFTA". *Documentos de Trabajo. Centro de Estudios Económicos, El Colegio de México.*

Taylor, J., Yúnez-Naude, A. y Hampton, S. (1999). "Agricultural Policy Reforms and Village Economies: A Computable General-Equilibrium Analysis from Mexico". *Journal of Policy Modeling*, 21(4), 453-480.

Ensayos Revista de Economía–Volumen XXXIV, No.1, mayo 2015, pp. 75-102

Mexico and the United States: cycle synchronization, 1980.1-2013.4

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Fecha de recepción: 24 IV 2014 Fecha de aceptación: 30 IX 2014

All the investigators cherish the same ultimate aim –namely to attain better understanding of the recurrent fluctuations in economic fortune that modern nations experience… The way we have chosen is to observe the business cycles of history as closely and systematically as we can.
Burns and Mitchell (1946)

Abstract

We estimated the progressive, structural synchronization of the Mexican growth cycle with that of the US (total and industrial) for 1980.1-2013.4. By applying the Quandt-Andrews (1993) and Bai-Perron (2003) unknown-breakpoint tests, we identified that before 1994.4 there was no statistically significant relationship between the Mexican GDP growth cycle and the US industrial output cycle, but a weak (statistically significant) relationship with total US GDP cycle. However, since 1997.4 and particularly since 2001.2, there is a vast and increasing synchronization and determination from the US industrial cycle to the Mexican cycle (R^2 = 0.96). The degrees of freedom of Mexican domestic economic policy have thus drastically decreased.

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This article is part of the research project *Mexico: growth, cycle and labor precariousness 1980-2020* (IN302514), DGAPA, UNAM. We thank Catalina Libreros for her assistance. The usual disclaimer applies. The insightful comments of two anonymous reviewers are gratefully acknowledged.

JEL Classification**:** C24; F15; F62.
Keywords**:** Mexico-US growth cycles, synchronization, end-of-sample correction, unknown-breakpoint tests (Quandt-Andrews, 1993 and Bai-Perron, 2003).

Resumen

Estimamos la sincronización estructural y progresiva de los ciclos de crecimiento de México y Estados Unidos (total e industrial) del primer trimestre de 1980 al cuarto trimestre de 2013. Aplicando las pruebas de cambio estructural desconocido de Quandt-Andrews (1993) y Bai-Perron (2003), identificamos que antes del cuarto trimestre de 1994 no había sincronización estadísticamente significativa entre el PIB de México y el del producto industrial de los Estados Unidos; pero una relación débil (estadísticamente significativa) con el PIB total de Estados Unidos. Sin embargo, desde el cuarto trimestre de 1997 y, particularmente, desde el segundo trimestre de 2001 la sincronización es alta y creciente desde el ciclo del producto industrial de Estados Unidos hacia el ciclo de México (R^2 = 0.96). Esto significa que los grados de libertad de la política económica interna han decrecido notablemente.

Clasificación JEL**:** C24; F15; F62.
Palabras Clave**:** ciclos de crecimiento de México – Estados Unidos, sincronización, corrección al final de la muestra, pruebas de cambio estructural múltiple con fecha desconocida (Quandt-Andrews, 1993 y Bai-Perron, 2003).

Introduction

Mexico has experienced deep economic changes since 1985. One of them was the trade liberalization process and the country's integration to globalization. On January 1st, 1994, when the North American Free Trade Agreement (NAFTA) came into force, the Mexican economy was quickly incorporated into the United States' (US) industrial production process and, thus, transformed itself from a closed economy to one that is integrated to the rest of the world, in particular to the US economy.

Trade liberalization began with the unilateral decision of the Mexican government to dismantle the trade protection apparatus by entering into the General Agreement on Tariffs and Trade (GATT) in 1986, and the subsequent signing of NAFTA. This process generated profound and relevant changes in the internal structure of the Mexican economy.

The integration ultimately brought a significant increase in the volume of trade and the growth cycle convergence to US industry. These two conditions shifted the Mexican growth engine to its export manufacturing sector, and de facto replaced the old engine for economic growth based on public investment within a protected domestic market. This resulted in a gradual synchronization of the Mexican growth cycle with the US industrial growth cycle.

The aim of this paper is to calculate the growth cycles of Mexico's GDP and US total and industrial output in order, and thereby demonstrate that there has been a progressive (i.e. dynamic) synchronization process of Mexico's GDP growth cycle to the US's industrial output since 1995. It is not the aim of this article to probe deeper into the numerous implications of this phenomenon, but rather to analyze a process that has been dynamic in nature. A key insight obtained is that the Mexican economic cycle depends an estimated 96% on the US industrial growth cycle, which suggests that there is very little leeway for domestic policy to influence this important variable, and sets this article apart from most of the related literature.

By applying the X12-ARIMA filter, the St-Amant and van Norden (1997) end-of-sample-correction procedure and a $\lambda = 1{,}096$ for the HP filter for Mexico, as proposed by Sarabia (2010), we were able to calculate rigorously the cyclical component of GDP in both countries. We proved Granger causality that runs from the US total and industrial output cycles to the Mexican GDP cycle, and by applying the Quandt-Andrews (1993) and Bai-Perron (2003) unknown-breakpoint tests we estimated endogenously and measured the synchronization process. We used the modern growth cycle approach by Lucas (1977).

The synchronization of the cycles is evidence of a progressive process of economic integration, brought about deliberately by Mexican authorities in their search for a new engine of growth, and also as part of the incorporation of Mexican industries into the value chain of the US economy. All of these processes have evolved with great intensity since the second half of the 1990s, and it is reasonable to speculate that the synchronization has undergone different stages, responding to the dynamics of the integration as such, but also to the various stances adopted by the Mexican economic authorities over the years.

Arriving at the conclusion that the observed synchronization has been a consequence of economic integration and, furthermore, that it has been progressive, required an econometric tool which differs from the technique that is ordinarily applied. The approach presented in this article allows for an accurate characterization of this profoundly dynamic process, leading to an evaluation of the progressive nature of the synchronization of the cycles. Therein lies the main contribution of this text, and also the key feature that sets it apart from most of the related literature.

With these objectives in mind, a synchronization parameter was recursively estimated. The parameter is ordinal in nature and indicates the relative intensity of the synchronization, based on Quandt-Andrews (1993) and Bai-Perron (2003) structural-change tests, which calculate endogenously the evolution of this important measure.

Section 1 reviews the literature about the economic integration of the Mexican economy to the US and locates our contribution. Section 2 presents the economics of synchronization. Section 3 presents the econometric issues and discusses the convenience of the HP filter to identify the growth cycles. In Section 4 we discuss the main empirical results. The last section concludes.

1. Literature review

There is a general consensus in the literature supporting the existence of a significant synchronization between the cycles and/or the growth of the economies of Mexico and the United States.

With the exception of Herrera (2004) and Mejía, Gutiérrez and Farias (2006b), who do not investigate the synchronization of the cycles but rather the presence of common trends with cointegration, partial correlation methods are predominant in the study of cycle synchronization. This has been the basis for research in comovement, determining the existence or absence of synchronization between the cycles of sectors and/or countries. Primary efforts are usually directed towards analyzing the presence of three distinct types of partial correlation: a) negative synchronization, $r_{i,j} < 0$; b) positive synchronization, $r_{i,j} > 0$, and c) absence of synchronization, $r_{i,j} = 0$. However, this type of analysis is static in that it neither studies nor measures whether the relationship has evolved over time, or whether the direction of causality has changed; this is due to the fact that the entire period of interest is analyzed jointly[1], which yields only one partial correlation coefficient.

[1] According to Mejía *et al* (2006b), it is customary to consider a five-year period, leaving the choice of period length up to the researchers' best judgment. Our analysis relies on the search for structural changes using structural-break tests, a more robust methodology in that it avoids imposing synchronization periods exogenously.

In that sense, Torres and Vela (2003) ─through comovement analysis─ identified a relationship between the Mexican and the US business cycles to study regional integration implications (1991-2001). They found that the manufacturing sectors of both economies were highly integrated, so US industrial fluctuations affected the demand for Mexican exports and, in turn, these influenced the Mexican business cycle. They reported that Mexican exports and imports have converged as a result of the business cycle synchronization of both countries, which in turn has reduced the trade balance volatility. The authors further state that this synchronization has stabilized Mexican trade through the balancing of fluctuations in exports and imports. This has brought about a reduction of volatility in trade[2].

Chiquiar and Ramos-Francia (2005) present evidence that the economic links between Mexico and the United States were strengthened by NAFTA, due to the positive effect of commerce on the synchronization of the cycles.

Castillo, Díaz and Fragoso (2004) made a comparison for each manufacturing division in Mexico and the US (1980-2007) and found that it was unlikely that the synchronization of business cycles between these two countries has emerged only in manufacturing. Thus, they included the dynamics of services and aggregate consumption in the process. They applied the Johansen cointegration procedure to demonstrate that these variables shared common trends and cycles.

Herrera (2004) applied the econometric methodology proposed by Vahid and Engle (1993), and proved the existence of common trends and cycles between the Mexican and the US economies (1993-2001).

Mejía, Gutiérrez and Pérez (2006a), by applying the Kydland and Prescott (1990) methodology for quarterly data (1980.1-2004.1), analyzed the synchronization between the Mexican business cycle and some key variables of the external sector. Their results showed that those relationships were volatile during the 1980s. However, they found that the economic cycles of Mexico and the US have synchronized since the mid 90s, a phenomenon that is associated to economic liberalization and particularly to NAFTA.

Mejía *et al* (2006b) analyzed the degree of economic integration between Mexico and the US through the association between industrial and manufacturing sectors. To assess a long-term relation between Mexico's GDP and the US's, using annual data (1989-2002) they applied the Johansen

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[2] As requested by a referee, this point has been particularly demonstrated for 2000-2012 in Section 2.

procedure and found that the series shared a common trend. They concluded that, because of NAFTA, both economies are highly synchronized.

Delajara (2012) analyses the synchronization of the economic cycle of various regions of Mexico with that of the US. The author's empirical analysis is carried out with a linear, structural time series model as framework, and finds that the covariance between cyclical disturbances in the US and the Mexican regions under consideration has a regional pattern, with higher covariance for the northern regions than for central and southern provinces.

Mejía and Erquizio (2013) analyzed and measured the effects of the most recent international economic cycle (2007-2009) on output and employment in Mexico and in the State of Mexico. Using quarterly and monthly data (2007-2010), they found that trade is the most important transmission mechanism.

This article updates the analysis on the matter (up to 2013.Q4) by using a different statistical methodology.

Parting from the notion that the synchronization of the cycles is a consequence of economic integration, we apply a statistical tool that allows for a dynamic, and thus more accurate portrayal of the synchronization process. The technique employed here differs from more common procedures in that it enables us to estimate periods of structural changes endogenously, which in turn support our finding that the synchronization process has been progressive. More specifically, this methodology enabled us to identify structural breaks, which reflect variations in the synchronization process. Consequently, we argue that the relationship has intensified progressively and significantly since the introduction of NAFTA in the 1990s. The endogenous structural-change-techniques applied here allow for a statistically rigorous measurement of specific stages. In that sense, our contribution is of a dynamic nature, unlike the aforementioned static approaches.

2. Synchronization factors

In Mexico, the liberalization and the globalization process[3] began with the entry into GATT in 1986. This process was eminently dynamic and eventually led to a synchronization to the US economy after NAFTA came into effect in 1994. The main objective was that, in the future, Mexican economic growth would depend on increasing production efficiency and

[3] Which reduced and eliminated tariffs and other non-tariff protectionist policies.

foreign investment. Serra (2008)[4] points out that the entry into GATT reallocated resources toward tradable sectors. It was the end of the import-substitution model that had been in effect in previous decades.

Kose, Meredith and Towe (2005) claim that, with this new economic model, Mexico found a new engine for economic growth by its insertion to the largest free market that had so far been built, NAFTA.

The structural crisis that began in 1982 –arising from the external debt crisis– represented the end of an economic model. Mexico entered then a long stagflation phase, which simultaneously generated enormous volatility in the main macroeconomic variables and caused a stark fall in expectations.

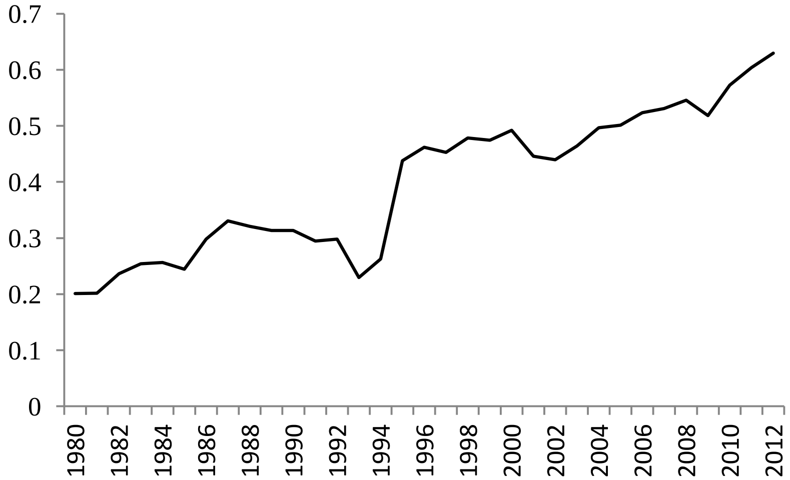
In this context, the new administration of Mexico (1988-1994) saw in NAFTA the potential for developing a new engine of growth or growth model; achieving a new industrialization process; broadening the range of available products in the country; increasing the consumer's surplus; and opening the economy to enhance competition and productivity and reduce prices. Additionally, the country sought to enter a new stage of macroeconomic stability by connecting itself to a strong and stable economy; boost savings and multiply its sources of financing for growth; increase foreign investment (both direct and portfolio) and domestic investment; and, lastly, have access to new technologies. Another equally important aspect is that the economic integration with the US could improve the functioning of Mexican institutions and generate new growth expectations. Taken together, these effects would result in better conditions for growth and economic development. This was the main objective of the integration.

Figure 1 clearly shows strong volume effects on trade from both commercial treaties. GATT, for example, increased the rate of trade openness despite the fact that Mexico stagnated between 1985 and 1989. NAFTA, meanwhile, provided new economic momentum since 1994. Trade openness reached its peak around the year 2000 as did GDP growth (6.6%). The 2001-2003 recession seriously affected trade openness. But thereafter, both variables recuperated.

Because of NAFTA, between 1993 and 2012 total exports and imports grew almost seven times over: from \$117 billion dollars to more than \$750 billion. About 90% of this flow was due to the US-Mexico trade.

[4] Former Industry Secretary under Salinas administration (1988-1994).

Figure 1
Mexico: trade openness rate, 1980-2012



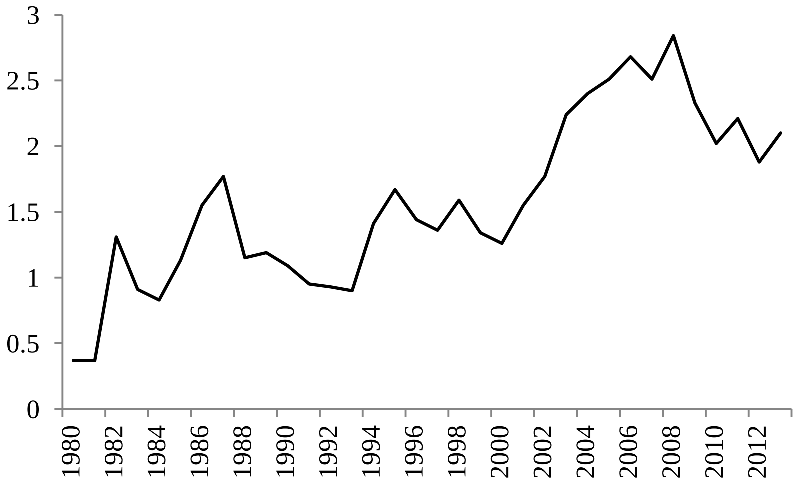
Note: trade openness rate = (exports + imports)/GDP.
Source: World Bank (2013).

Delgado (2009) and Portnoy (2003) highlighted the benefits that NAFTA represented for Mexico:

a) New markets for Mexican products and better conditions to attract domestic and foreign capital, because the trade agreement was expected to raise investment and domestic savings rates.
b) Relocation of labor intensive activities to Mexico, which would lead to job creation and wage increase. It was assumed that eventually the traditional wage gap would vanish (Loría, 2014).
c) Domestic consumers would benefit as they acquired goods and services at competitive prices.
d) Strengthening efficiency of domestic producers because of international competition.
e) NAFTA would facilitate the economic process and improve the institutional life in Mexico due the implementation of new and clear "rules of the game". That is, after several years of stagnation and political turmoil, the integration to the US would put the rule of law in action. The goal here was to strengthen the democratic transition by modernizing the Mexican society and making institutions more transparent (Loría, 2014).

Despite the absence of a labor mobility agreement within NAFTA, there has been a large, de facto migration to the US, which has generated nonnegligible remittances to many Mexican families as a source of income and consumption. This labor flow has linked labor market conditions in the US to consumption and savings in the Mexican economy (Figure 2)[5]. It's worth mentioning that this effect was the opposite to the objectives of the integration[6].

Figure 2
Remittances to Mexico, 1980-2013
(% GDP)



Source: Banxico (2014).

Another important effect of this economic integration is that the dynamics of Mexican imports and exports have coupled since 2000, as well as the growth of these variables and the growth of US industrial output (Figure 3)[7]. Thus, synchronization of the cycles and growth rates brought about a reduction of volatility, since the standard deviation of US growth is lower than it is

---

5 It is precisely after 1994 that an exponential increase of migration to the United States began. The Mexican immigrant population in that country grew from 4 million in 1994 to 10 million in 2000, going from 10% to 22% of the total immigrant population of the United States (Migration Policy Institute, 2014).

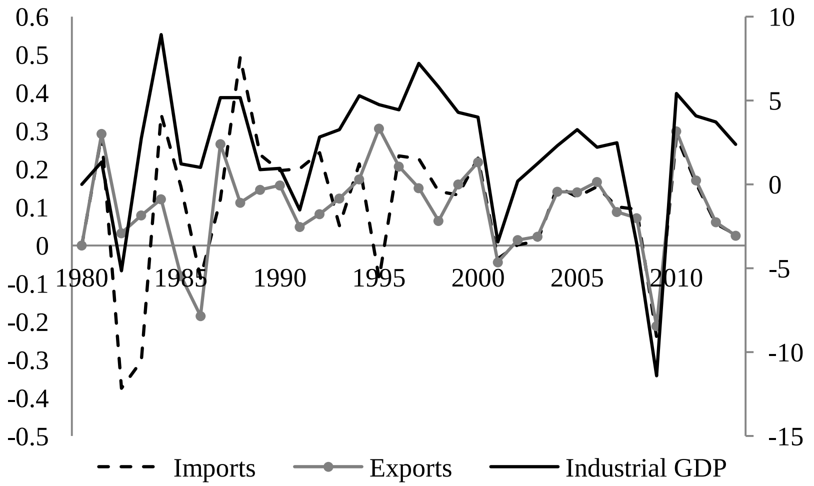
6 In words of the then president of Mexico, Carlos Salinas, at MIT in 1993: "NAFTA is an agreement of wage improvements… It is also an agreement for reducing migration, because Mexicans will no longer have to migrate north to find employment, they will now be able to find it in [my country]." (Loría, 2014).

7 This last remark was prompted by a referee. It is worth highlighting that, since the year 2000, the partial correlation between growth in Mexican trade and in the US industrial product is 90%, with a correlation of 79% against total US GDP growth. Both correlations are significant at a 99% level.

Mexico. Between 1980 and 2000 the standard deviation of Mexican growth was 3.65, while that of the United States was[1] 1.8. Between 2000 and 2012 these were 2.9 and 1.7, respectively. However, it must be said that the volatility of industrial output increased from 3.1 to 4.6, which is likely a result of the relocation of activities to Mexico and also of the entering of China into the WTO, which had large deindustrializing effects for Mexico. These processes are also evident in the growth rates of Mexican GDP, US industrial output and US GDP, which were 2.7%, 3.1% and 3.3% for the period 1980-2000, and 2.2%, 0.47% and 1.6% for the period 2000-2012, respectively.

Figure 3

Rates of Growth

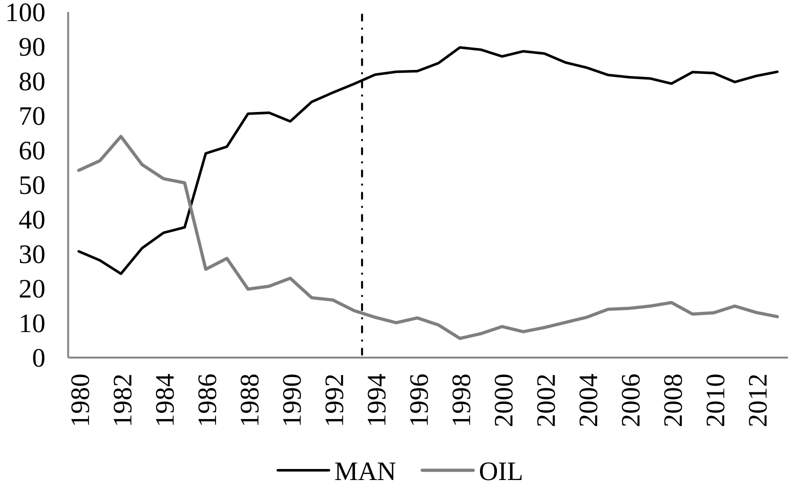


Source: own calculations based on: INEGI (2014) and FRED (2013).

The opening of the Mexican economy has been associated to a profound change in the composition of exports, to the extent that, in the mid-1980s, oil exports accounted for 57% of total exports, while manufacturing exports were only 40%. Currently, oil accounts for 16% and manufacturing 79% (Figure 4). This could be one of the most important outcomes of the economic integration: the new growth engine became manufacturing associated to the US industrial output. In other words, we can claim that the Mexican economy integrated into the US industrial production value chain.

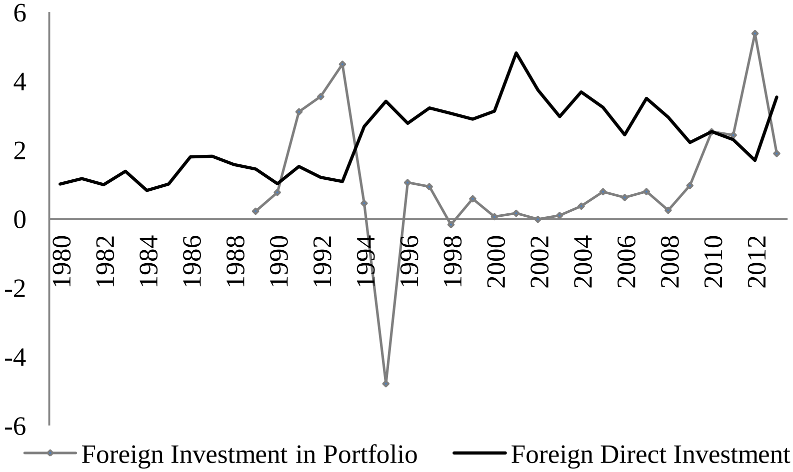
[1] Although the term *Great Moderation* was coined later (Bernanke, 2004), to refer to the period of stabilization since the mid-1980s in the United States, it was thought that this effect would be transmitted to Mexico.

Figure 4
Oil Exports and Manufacturing Exports, 1980-2013
(% of total exports)



Source**:** Banxico (2014).

Figure 5
Foreign Direct Investment and Foreign Investment in Portfolio,
1980-2013,(% GDP)



Source: Banxico (2014).

Another synchronization factor to be acknowledged has to do with the intra-firm trade increase (Mejía *et al*, 2006a). Figure 5 shows that, since the second half of the 1980s, FDI grew rapidly and portfolio investment (FPI) did it as soon as the NAFTA negotiations started[2].

3. Econometric issues

3.1. Cycle estimation

X-12-ARIMA (U.S. CENSUS BUREAU, 2002) is a statistical method widely used, based on weighted moving averages, which explains the seasonal variation of a time series (Cortez, 2008 and Makridakis, Wheelwright and Hyndman, 2008). It has two[10] modules: the RegARIMA, which adjusts the series, and the X11 module, which decomposes the original series into trend-cycle, seasonal and irregular components.

In a strictly statistical sense (Enders, 2004), a time series (y_t) can be represented as follows:

$$y_t = y_t^{tr} + y_t^{s} + y_t^{c} + \varepsilon_t \qquad (1)$$

Where the trend, y_t^{tr}, represents the underlying (secular) evolution of the time series; seasonality, y_t^{s}, reflects the periodic occurrence of phenomena in its evolution; cycle, y_t^{c}, represents periodic oscillations around the trend; and innovations, ε_t, are the erratic movements that do not follow a specific pattern. By definition, this component must be white noise.

Separating the trend and the cyclical components that the X-12 filter jointly estimates is necessary for the subsequent analysis.

In the literature, the HP filter (Hodrick and Prescott, 1997) has been very popular since its introduction, but very criticized as well[11].

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[2] It is not the goal of this article, but it is worth mentioning that this variable plummeted with the political crisis of 1993 and only recovered after the introduction of non-conventional monetary policy in 2009.

[10] RegARIMA models are ARIMA regression models, based on seasonal autoregressive integrated moving average (SARIMA) (Cortez, 2008; Makridakis *et al*, 2008).

[11] For ease of reading, we relegate to the statistical appendix a summary of these criticisms and of the procedures with which they were handled. A broad discussion of the criticisms and advantages of the HP filter versus other filters can be found in Loría and Salas (2014).

In order to deal with the end-of-the-sample problem[12], the St-Amant and van Norden (1997) procedure was applied to the conventional filter. Therefore, a new correction term that adjusted the estimation at the end-of-the-sample was introduced: $\sum_{t=T-j}^{T}(\Delta y_t^{tr} - u_{ss})$.

Therefore, the HP adjusted filter was defined as:

$$\min_{\{y_t^{tr}\}_{t=1}^{T}} \sum_{t=1}^{T}(y_t - y_t^{tr})^2 + \lambda \sum_{t=1}^{T-1}\left((y_{t+1}^{tr} - y_t^{tr}) - (y_t^{tr} - y_{t-1}^{tr})\right)^2 + \lambda ss t=T-jT\Delta yttr-uss \quad (2)$$

where λ_i refers to the adjustment factors that soften the series and $u_{ss}$is the long-run growth rate.

Finally, for the total US and US industrial output series, we only made the correction at the end-of-sample, following the St-Amant and van Norden (1997) procedure. The traditional $\lambda = 1{,}600$ was maintained.

The cyclical component relates the variations of a time series to its secular component, giving it the property of being stationary[13].

To prove statistically that Mexico's economic cycle is determined by the US cycle, it is convenient to prove Granger causality (Table 1).

Table 1

Mexico and US cycles. Grange causality tests, 1980.1-2013.4

Cause / Response	$\mathbf{Y^c_{MXt}}$	$\mathbf{Y^c_{INUSt}}$	$\mathbf{Y^c_{USt}}$
Y^c_{MXt}	----	0.73(12)	1.17(12)
Y^c_{INUSt}	2.21(12)*	----	1.71(12)
Y^c_{USt}	2.75(12)*	4.18(12)*	----

Note: Y^c_{MXt} = Mexico Output's Cycle; Y^c_{INUSt} = US Industrial Output's Cycle; Y^c_{USt} = US Output's Cycle. * Rejects null hypothesis: Non-Granger-causality at 5%; number of lags in parenthesis.

Source: own elaboration based on INEGI and BEA (2014).

The results are conclusive in the sense that for the whole sample there is a statistical precedence of Y_{USt}^c and Y_{INDUSt}^c to Y_{MXt}^c at up to 12 lags for the whole period, and there is no evidence for causality in the opposite direction.

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[12] Sarabia (2010) documents this problem. Many other authors, including Knoteck (2007) and Ball, Leigh and Loungani (2013), also report complications in estimating the trend and, subsequently, the cycle. See Statistical Appendix at the end of the article.

[13] We explicitly demonstrated this feature by applying several unit root tests, which are available upon request.

3.2. Cycle synchronization

To measure the growth cycle synchronization of the two countries, given the fact that Granger causality has been proved and also that all the variables are stationary, it is then justified to do the following OLS regression:

$$Y^c_{MXt} = \beta_0 + \beta_1 * Y^c_{USt} + \varepsilon_t \quad (3)$$

Statistical results are reported in Table 2a. The coefficient of determination is relatively high (65%). The synchronization parameter (β_1) is statistically significant and positive, indicating procyclicality. The parameter β_0 has no direct economic meaning but incorporates useful information for regression, even though is not statistically significant.

Table 2a

Y^c_{MXt} and Y^c_{USt} synchronization. normalized variables, 1980.1-2013.4, OLS estimation

Statistic	
β_0	4.86E-08
t- statistic	(2.75E-11)
β_1	172.0549
t- statistic	(15.60)
R^2	0.6518
Quandt- Andrews Maximum LR F-statistic	3.4093
P value	0.8257
Structural Change	2001.3

Table 2b

Y^c_{MXt} and Y^c_{USt} synchronization, Bai-Perron multiple-break-point tests

Sequential F-statistic determined breaks:			
Break Test	**F-statistic**	**Scaled F-statistic**	**Critical Value****
0 vs. 1	3.248464	6.496927	11.47
Recursively determined partitions			
Break Test	**Break**	**F-statistic**	**F-statistic**
0 vs. 1	2001.3	3.248464	6.496927

Note: * significant at the 0.05 level. ** Bai-Perron (2003) critical values. Trimming 0.15, Max. breaks 5, Sig. level 0.05.

To prove the structural stability of the estimation, we applied the Quandt-Andrews (1993) and the Bai-Perron (2003) unknown-breakpoint tests, which initially suggest a structural break in 2001.3. Nevertheless, we should reject it at 82% confidence (Table 2a) in the first test, and at 95% in the second test (Table 2b). Therefore, we can fairly conclude that for this estimation there is no structural change.

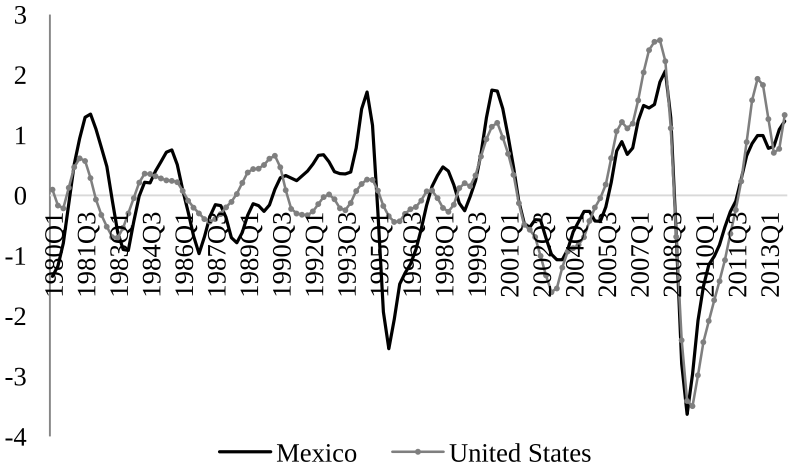
A second evaluation step relies on the fit of the regression (Figure 6). It is noteworthy that just before that date (2001.3), the synchronization was relatively weak and it strengthened considerably afterward. The relatively high volatility of the Mexican cycle up to 2001.3, which tends to disappear in the second phase, should be highlighted. This suggests that the synchronization significantly reduced Mexican GDP volatility relative to that of US GDP.

Since we have already determined that NAFTA linked the Mexican economy to the US industrial structure, in what follows we measured the synchronization process through the following OLS regression:

$$Y^c_{MXt} = \beta_0 + \beta_1 * Y^c_{INUSt} + \varepsilon_t \quad (4)$$

Figure 6

$Y^c_{MXt} - Y^c_{USt}$ Synchronization. normalized variables, 1980.1-2013.4



Note: since we are analyzing variables in different units (MX real pesos and US real dollars), to be comparable, both variables were normalized according to the following normalization procedure: $\frac{x_{it}-\overline{x_t}}{\sigma}$, where σ = standard deviation and $\overline{x_t}$ = arithmetic mean.

Source: own elaboration based on INEGI (2014) and BEA (2014).

Table 3a

Y^c_{MXt}-Y^c_{INUSt} synchronization, Quandt-Andrews OLS estimation, 1980.1-2013.4

Statistic	Period				
	1980.1 2012.4	**1980.1 1994.4**	**1995.1 2012.4**	**2001.2 2012.4**	**2008.3 2013.4**
β_0	-0.000000492	4155.27	-4020.24	755.46	6550.92
t- statistic	-2.43E-07	-1.42	-1.82	-0.38	-2.27
β_1	11305.49	-481.22	13112.4	12556.7	14320.8
t- statistic	-12.44	-0.19	-16.74	-21.24	-28.8
R^2	0.5437	0.0006	0.8	0.9093	0.9643
Quandt- Andrews Maximum LR F-statistic	19.1089	11.3567	20.93	9.8931	6.4749
P value	0.0018	0.0544	0.0008	0.0988	0.3523
Structural Change	1995.1	1991.1	2001.1	2008.2	2010.3
Y^c_{INUSt} does not Granger Cause Y^c_{MXt}	2.081 (12)*	0.833 (12)	2.963 (12)*	4.020 (12)*	6.449 (4)*
Y^c_{MXt} does not Granger Cause Y^c_{INUSt}	0.778 (12)	2.069 (12)	0.003 (12)	0.423 (12)	1.190 (4)

Note: * rejects null hypothesis: Non-Granger-Causality at 5%; number of lags in parenthesis.
Source: own elaboration based on INEGI and BEA (2014).

Table 3b

Y^c_{MXt} and Y^c_{INUSt} synchronization, Bai-Perron multiple-break-point tests

Sequential F-statistic determined breaks:

Break Test	**F-statistic**	**Scaled F-statistic**	**Critical Value****
2 vs. 3 *	11.42544	22.85087	14.03

Recursively determined partitions

Break Test	**Break**	**F-statistic**	**F-statistic**
0 vs. 1 *	1995.1	22.75000	45.50001
1 vs. 2 *	1987.3	9.069477	18.13895
1 vs. 2 *	2001.1	15.41282	30.82565

Note: * significant at the 0.05 level. ** Bai-Perron (2003) critical values. Trimming 0.15, Max. breaks 5, Sig. level 0.05. This test identifies also 2008.2; nevertheless, according to the F values is non-significant.

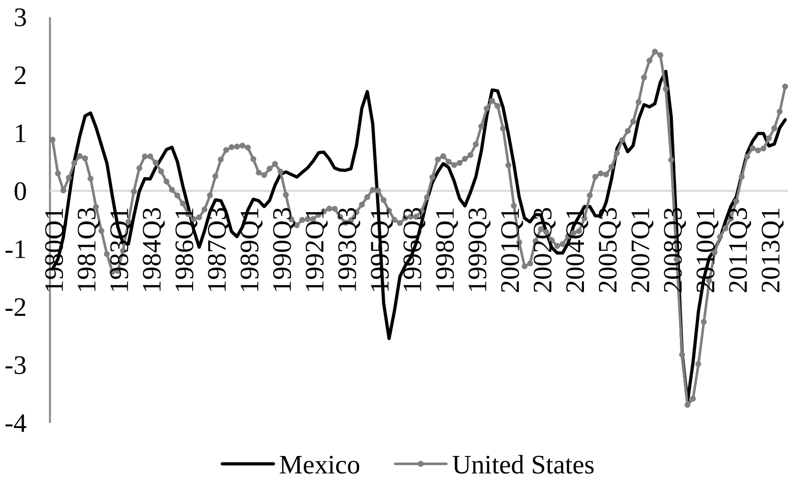
From the results in Table 3 (a and b), the following analysis arises:

1) By applying the Quandt-Andrews (1993) and Bai-Perron (2003) tests, we can suggest that, contrary to the $Y^c_{MXt} - Y^c_{USt}$ stable relation, there is no strong relation between Y^c_{MXt} and Y^c_{INUSt} for the entire estimation period, although we found a relatively high determination coefficient

(54%) and a high synchronization parameter, which is positive and statistically significant. See Table 3a and Figure 7.

Figure 7

$Y^c_{MXt} - Y^c_{INUSt}$ Synchronization. normalized variables, 1980.1-2013.4



Note: since we are analyzing variables in different units (MX real pesos and US real dollars), to be comparable, both variables were normalized according to the following normalization procedure: $\frac{x_{it}-\overline{x_t}}{\sigma}$, where σ = standard deviation and $\overline{x_t}$ = arithmetic mean.
Source: own elaboration based on INEGI and BEA (2014).

2) The same Quant-Andrews (1993) recursive unknown-breakpoint test identified four sub-periods that are critical for analyzing the dynamics of the synchronization process. See Table 3a. Meanwhile, the Bai-Perron (2003) test detected only 3 breaks: 1987.3 1995.1 and 2001.1. See Table 3b.

3) The parameter β_1 –which we have termed "synchronization parameter"– is ordinal in nature; that is, to a higher value of this coefficient corresponds a greater degree of synchronization. It cannot be interpreted as an elasticity or marginal propension. However, the ordinal interpretation is crucial to support our hypothesis.

4) There is a first subsample (1980.1-1994.4), in which many important issues arise: a) the coefficient of determination is zero; b) the synchronization parameter β_1 is negative, very small, and non-significant, and c) there is no Granger Causality. All of this suggests that the cycles had no common features during that period.

5) For the second subsample (1995.1-2012.4) there is a high, positive, and significant synchronization; however, there is an undeniable structural change in 2001.1, which led us to detect two additional sub-periods: 2001.2-2008.2 and 2008.3-2013.4.

6) Taking into account these two sub-periods, we found that all parameters progressively improved as did the regression statistics, to the extent that the R^2 reached 96% and the two structural parameters (β_0 and β_1) increased notably and became significant.

7) Within the last sub-period (2008.3-2013.4), although the Quandt-Andrews (1993) test points to another structural change in 2010.3, it is rejected with a probability of 35% (See Table 3a). Coincidentally, the Bai-Perron test did not register this break (See Table 3b).

8) In sum, we can fairly claim that after 1995.1 there has been an increasing synchronization process, as measured by the coefficient of determination and by β_1 (the synchronization parameter)[14].

9) Figure 8 clearly shows the above-mentioned relationship. Prior to 2001.2, Y_{MXt}^{c} volatility was higher than Y_{INUSt}^{c} and tended to decrease gradually.

4. Economic analysis

Whether the cycle synchronization was advantageous or detrimental for Mexico[15] is beyond the ambitions of this article, since an evaluation of such matters would be entirely subjective. What does fall within the scope of this analysis is the fact that the synchronization was a consequence of the economic integration that Mexico has had with the United States.

This is a very significant concept, particularly because the integration process began in a single direction (i.e. Mexico initially synchronized to the US cycle, and not the other way around). Though this may seem trivial, it becomes quite relevant when we look at the evidence of the growing synchronization: Mexico did find an engine for growth, which it was lacking since the great crisis of 1982, but it also surrendered its sovereignty over

[14] As recommended by one of the reviewers, we applied Granger Causality Tests for each subsample, which corroborated our main results. See last two rows of Table 4a.
[15] This question was posed by a referee.

economic policy, particularly in the industrial sector, since the country sought to encourage industrial relocation from the United States to Mexico[16].
The economic integration with the United States was initially through trade, finance and investment, with no effects for the labor markets. However, the mobility of the labor force towards the United States accelerated rapidly, generating strong economic links[17]. Furthermore, the fact that the linkage was primarily to US industrial output resulted in Mexico's GDP growth and growth cycle being largely associated with this sector; this can help to explain, along with many other factors, the convergence to very low growth rates (See Table 4).

Table 4
Growth rates, 1980-2013

$\mathbf{Y_{USt}}$	$\mathbf{Y_{INUSt}}$	$\mathbf{Y_{MXt}}$
2.7%	2.1%	2.5%

Note: Y_{USt} = US Output; Y_{INUSt} = US Industrial Output. Index, 2007.2 = 100; Y_{MXt} = Mexico Output.
Source: own elaboration based on INEGI (2014) and BEA (2014).

Conclusion

We estimated the growth cycle synchronization of Mexican GDP to US (total and industrial) output for 1980.1-2013.4. Through the St-Amant and van Norden procedure (1997), we corrected the end-of-sample problem inherent to the HP filter. Following Sarabia (2010), to estimate the secular (trend) component of the Mexican GDP, a λ = 1,096 was assigned. By doing so, we properly estimated the trend and the cycle components of Mexico's GDP.

The main conclusions that can be drawn from the study are the following:

1. The crisis of 1982 resulted in a context marked by: a lost decade; several crises (1982-1983, 1986); stagflation; an external debt crisis; the fall of the economic model; a lack of an engine for growth; and, in general, a crisis of expectations.

2. In this context, Mexico looked to NAFTA for a new engine (model) of growth, a new industrialization, broadening the range of products available in

[16] For a detailed analysis on sectors and regions, in addition to the literature recommended in Section 1, please see also Mejía and Morales (2011).
[17] Although decidedly significant, this topic is beyond the scope of the article and will not be discussed here.

the country, increasing the consumer surplus, opening the economy to boost productivity and competition in the domestic market and reduce prices.

3. Additionally, the country sought to attain macroeconomic stability by linking itself to a strong economy, boost savings and multiply the sources of financing for growth, increase total investment (FDI, FPI and domestic investment) and gain access to new technologies.

4. Once NAFTA was signed, Mexico found that one of the outcomes of synchronization to another economy is sharing its volatility profile. In this case, during the 1990s the United States was already undergoing a process known as the *Great Moderation* (Bernanke, 2004). Although mainly a synchronization to US industrial output was achieved, the process still resulted in a reduction of volatility as a collateral effect.

5. The objective of measuring structural breaks is evaluating the dynamic nature of a process. The analysis presented here demonstrates an important fact: NAFTA prompted a deep alteration in the relationship between the two countries; namely, the two economies went from having a negative synchronization (although statistically non-significant) to having a positive one. This shift resulted from the economic integration, which was itself a product of existing complementarities that encouraged an exploitation of wage disparities and geographic proximity (through FDI, as evidenced by the growth of the manufacturing industry in Mexico), giving rise to the strong connection with the industrial sector of the United States.

6. Twenty years after the introduction of the treaty, economic integration (i.e. financial and trade integration) with the United States has become a key factor for Mexico's growth, causing the domestic economic policy variables to have very little influence over the dynamics of the economic cycle, as evidenced by the result that 96% of the dynamics of Mexico's economic growth cycle is dependent on the US industrial cycle.

7. The most significant shift that resulted from the synchronization process was the sign change after NAFTA came into effect. This is because, along with an increase in trade volumes, an important increase of FDI can be observed, which suggests that the trade integration and the relocation of labor-intensive production (to exploit wage differentials) were among the main transfer mechanisms of this synchronization.

8. We proved (dynamically) Granger causality running from the US total and industrial growth cycles to the Mexican cycle. This information allowed us to identify the business cycles' synchronization and demonstrate that it has been increasing progressively. This highlights the dynamic nature of the cycle

synchronization and represents an original contribution, since the literature on the matter estimates or calculates co movements or partial correlations for whole periods, yielding inherently static calculations that measure partial correlations for specific periods, without taking into consideration structural breaks.

9. By applying the Quandt-Andrews (1993) and the Bai-Perron (2003) unknown- breakpoint tests, we detected endogenously several synchronization periods.

In sum, the synchronization of the Mexican cycle to the US industrial cycle began with the entry into force of NAFTA, which created an integrated industrial production chain.

Statistical Appendix. HP filter criticisms.

First, the a priori selection of the smoothing parameter λ has been criticized, as it is exogenously determined and could potentially affect the calculation of the cycles. This issue was addressed defining a cycle marker by the presence of local maximums and minimums, thus demonstrating the relative unimportance of the smoothing parameter for the identification of cycles.

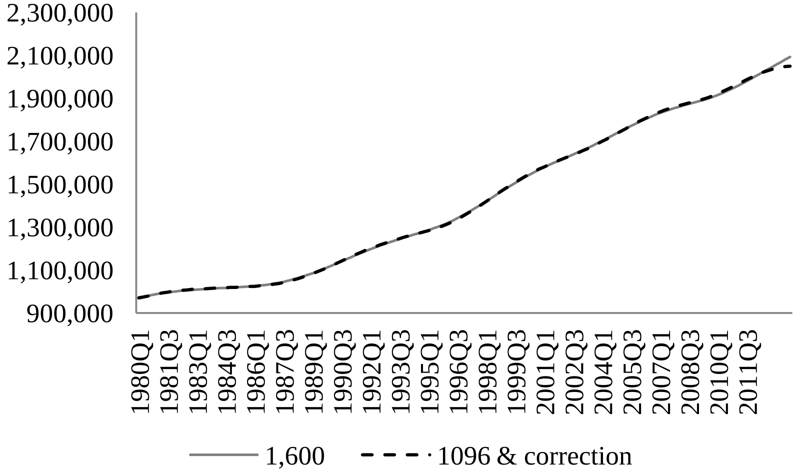
A second criticism in the literature is directed at the issue of end-of-sample estimation, which was address using the correction developed by St-Amant and van Norden (1997).

A third criticism refers to $\lambda = 1{,}600$, which is the conventional value for quarterly data applied to the US economy in the original paper. Sarabia (2010) proposed $\lambda = 1{,}096$ instead, to more accurately capture the inherently higher volatility of Mexican economic time series. Figure 8 compares the filtering results from the application of both HP filters (1,600 and 1,096)[18].
A key element in the debate over the calculation of the cyclical component is the smoothing parameter. This point is not to be underestimated, since the value of the trend component that the filter calculates will be decisive for the definition of the cycle.

[18] This value is not arbitrary, since a large range of estimates for the Mexican economy in the same period with the smoothing index support its accurate identification (Loría & Salas, 2014).

Figure 8

Mexico's Potential Output with two λ´s and St. Amant and Van Norden correction,1980.1-2013.4, billions of 2005 pesos



Source: own calculations.

To ascertain the effects of the choice of lambda in the determination of the cycle through local maximums and minimums, we calculated 31 different cycles with the same number of different λ´s, based on Guerrero (2011), with smoothing index levels from 92.55% to 94.43%, associated to lambda values from 1000 to 3700.

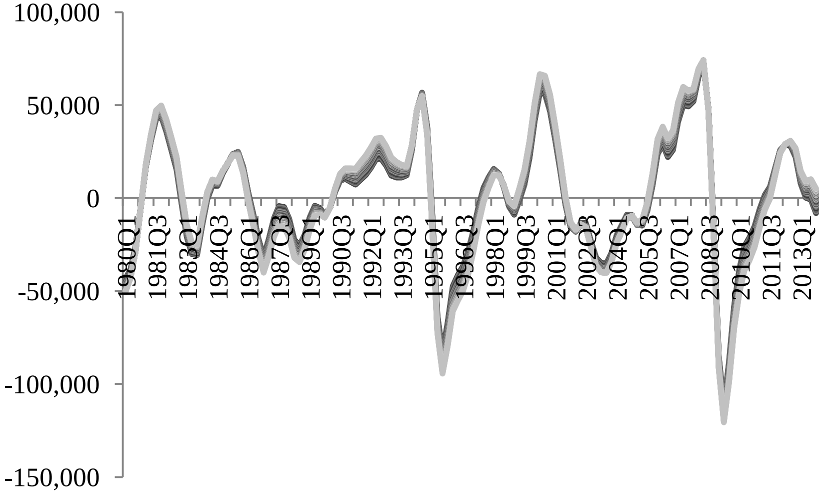
Lower levels, like the 170 lambda used by Guerrero (2011), were omitted, as they result in a relatively low smoothing index of merely 87.01%.

As can be seen in Figure 9, the cycles derived from 31 different λ´s of the Hodrick Prescott filter[19] for the Mexican cycle generally demonstrate a behavior that, although divergent, does present significant regularities in the identification of the growth cycle.

[19] Which began with a lambda of 1,000 and grew at a factor of 90 until 3,700 was reached.

Figure 9

Mexico: Cycles generated by 31 iterations of the HP filter.1980.1- 2012.4



Source: own calculations.

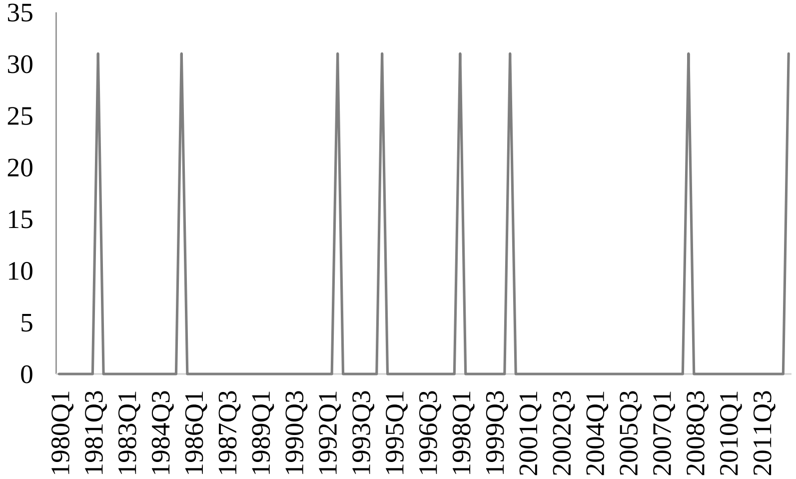
It is thus essential to identify local maximums and minimums, which are values of a function at which the maximum (minimum) is greater (less) than the values around it, but not in relation to all the values of the function. More formally, if $f(x)$ is defined in set *A*, the definitions are:

Function f has a local maximum at *c* if there is an interval (α,β) centered around *c* such that $f(x) \leq f(c)$ for every $x \in A(\alpha, \beta)$. Conversely, function f has a local minimum at *d* if there is an interval (α,β) centered around *c* such that $f(d) \leq f(x)$ for every $x \in A(\alpha, \beta)$, (Sydsaeter and Hammond, 1996).

Since the determination of the interval is arbitrary, we choose a value of 3 for α, β, resulting in an interval that encompasses 6 periods, which at a quarterly frequency corresponds to a year and a half.

Figure 10 shows that all 31 different cycle calculations from Figure 9 generate the same maximum values, which can be interpreted as the cycle markers being identical for all calculations, regardless of the lambda value.

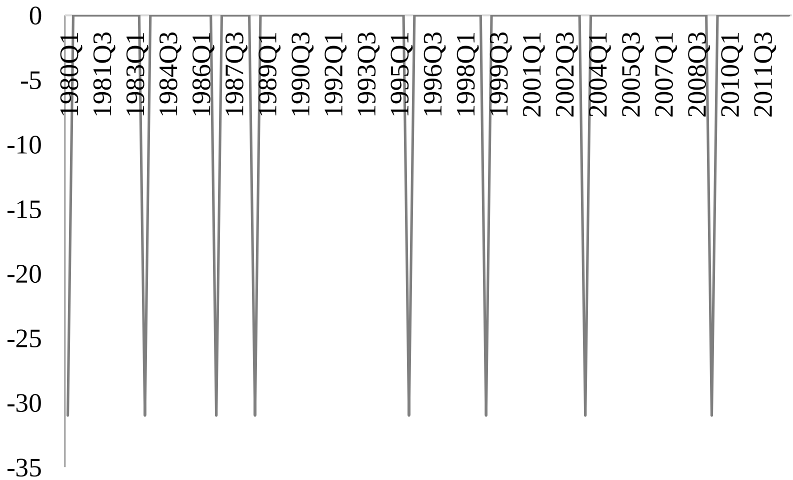
Figure 10
Cycles. Local maximums.1980.1- 2012.4



Source: own calculations.

In the case of minimums (Figure 11) the same relation holds, as all calculations coincide with the same cycle thorough. These results suggest that the lambda value is relatively unimportant within the range proposed in the smoothing index.

Figure 11
Cycles. Local minimums. 1980.1- 2012.4



Source: own calculations.

References

Andrews, D. W. (1993). "Tests for parameter instability and structural change with unknown change point". *Econometrica,* 61(4), 821-856.

Bai, J. and Perron, P. (2003). "Computation and analysis of multiple structural change models". *Journal of Applied Econometrics*, 18(1), 1-22.

Ball, L. M., Leigh, D., and Loungani, P. (2013). Okun's Law: Fit at Fifty? National Bureau of Economic Research, NBER Working Paper No. 18668.

Banxico (2014). *Banco de México*: http://www.banxico.org.mx.

BEA (2014). *U.S Bureau of Economic Analysis*: http://www.bea.gov/index.htm. February 5, 2014.

Bernanke, B. (2004). The Great Moderation: Remarks by Governor Ben S. Bernanke at the meetings of the Eastern Economic Association, Washington, DC February 20, 2004.

Burns, A. F. and Mitchell, W. C. (1946). *Measuring business cycles*. NBER Books.

Castillo, A., Díaz, A. and Fragoso, E. (2004). "Sincronizado entre las economías de México y Estados Unidos: el caso del sector manufacturero". *Comercio Exterior*, 54(7), 620-627.

Chiquiar, D. and Ramos-Francia, M. (2005). "Trade and business-cycle synchronization: Evidence from Mexican and US manufacturing industries". *The North American Journal of Economics and Finance*, *16*(2), 187-216.

Cortez, J. (2008). "Desestacionalización –X12 ARIMA– con efecto calendario Índice de Supermercados". *Instituto Nacional de Estadísticas de Chile, Estudio No. 12*.

Delajara, M. (2012). "Sincronización entre los ciclos económicos de México y Estados Unidos: Nuevos resultados con base en el análisis de los índices coincidentes regionales de México". *Banco de México Working Paper No. 2012-01*.

Delgado, G. (2009). *Estructuras política, económica y social* (2nd ed). México: Pearson Prentice Hall.

Enders, W. (2004). *Applied econometric time series*. John Wiley and Sons.

FRED (2013). Federal Reserve Economic Data http://research.stlouisfed.org/fred2/.

Guerrero, V. (2011). "Medición de la tendencia y el ciclo de una serie de tiempo económica desde una perspectiva estadística". *Realidad, Datos y Espacio: Revista Internacional de Estadística y Geografía*, 2(2), 50-73.

Herrera J. (2004). "Business cycles in Mexico and the United States: Do they share common movements?". *Journal of Applied Economics*, 7(2), 303-323.

Hodrick, R. J. and Prescott, E. C. (1997). "Postwar US business cycles: an empirical investigation". *Journal of Money, Credit, and Banking*, 29(1), 1-16.

INEGI, (2014). *Banco de Información Económica*: http://www.inegi.org.mx/sistemas/bie/.

Knotek, E. S. (2007). "How Useful Is Okun's Law?". *Federal Reserve Bank of Kansas City, Economic Review,* Fourth Quarter, 73-103.

Kose, A., Meredith, G. and Towe, C. (2005). How has NAFTA affected the Mexican economy? Review and evidence. In Langhammer, R. and Vinhas de Souza, L. (Eds.), *Monetary Policy and Macroeconomic Stabilization in Latin America* (35-81). Springer Berlin Heidelberg.

Kydland, F. and Prescott, E. (1990). "Business Cycles: Real Facts and Monetary Myth". *Federal Reserve Bank of Minneapolis Quarterly Review*, 14(2), 3-18.

Loría, E. (2014). TLC: Una evaluación a 20 años. http://www.economia.unam.mx/cempe/PDFs/Reuniones/14-1_una_evaluacion_a_20.pdf

_____and Salas, E. (2014). "Ciclos, crecimiento económico y crisis en México, 1980.1-2013.4". *Estudios Económicos*, 29(2), 131-161.

Lucas Jr, R. (1977). "Understanding business cycles". *Carnegie-Rochester conference series on public policy*, 5(1), 7-29).

Makridakis, S., Wheelwright, S. C. and Hyndman, R. J. (2008). *Forecasting methods and applications*. John Wiley and Sons.

Mejía, P., Gutiérrez, E. and Pérez, J. (2006a). Los claroscuros de la sincronización internacional de los ciclos económicos. *CIENCIA ergo sum*, *13*(2), 133-142.

_____Gutiérrez E. and Farías, C. (2006b). "La sincronización de los ciclos económicos de México y Estados Unidos". *Investigación Económica*, *65*(258), 15-45.

_____Morales, M. (coordinadores) (2011). *Integración y recesión económica en el binomio México-Estados Unidos.* México: Universidad Autónoma del Estado de México.

_____Ochoa, S. and Díaz, M. Á. (2013). "De la recesión a la recuperación: Producción y empleo en México y el Estado de México". *Problemas del Desarrollo*, 44(173).

_____ and Erquizio, A. (2013). *Expansiones y recesiones en los estados de México*. Pearson.

Migration Policy Institute (2014). http://migrationpolicy.org/.

Portnoy, A. (2003). "El proceso hacia la firma del tratado de libre comercio. Una visión histórica de las relaciones entre México y Estados Unidos". *Revista de Humanidades*: *Tecnológico de Monterrey*, (14) 127-162.

Sarabia, A. A. (2010). "El problema al final de la muestra en la estimación de la brecha del producto". *Economía Mexicana NUEVA ÉPOCA*, *19*(1), 5-29.

Serra, J. (2008). La Apertura Comercial de México. LXX Aniversario de La Casa de España. Disponible en: www.sai.com.mx/admin/uploads/archivos/arch201106020315465525Apertura.pdf

Sydsaeter, K. and Hammond, P. (1996). *Matemáticas para el análisis económico*. Pearson, Prentice Hall.

St-Amant, P. and Van Norden, S. (1997). "Measurement of the Output Gap: A discussion of recent research at the Bank of Canada". *Bank of Canada Technical Report No. 79*.

Torres, A. and Vela, O. (2003). Trade integration and synchronization between the business cycles of Mexico and the United States. *The North American Journal of Economics and Finance*, *14*(3), 319-342.

U.S. CENSUS BUREAU (2002). *X-12-ARIMA. Reference Manual, Final Version 0.2*. Washington DC, USA: US Census Bureau.

Vahid, F. and Engle, R. (1993). "Common Trends and Common Cycles". *Journal of Applied Econometrics*, 8(4), 341-360.

World Bank (2013). http://data.worldbank.org/country/mexico.

Ensayos Revista de Economía–Volumen XXXIV, No.1, mayo 2015, pp. 103-120

The relationship between bank competition and financial stability: a case study of the Mexican banking industry

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Fecha de recepción: 22 VII 2013 Fecha de aceptación: 19 I 2015

Abstract

This paper tests both the competition-fragility and competition-stability hypotheses in the Mexican banking sector for the period 2001-2008. In order to account for the degree of competition we use Lerner index, and the Z-index and the ratio of non-performing loans over total loans as proxies of financial stability and bank portfolio risks respectively. The main results indicate there is support for both hypotheses. However, the benefits of greater competition on the overall stability of the system outweigh the increases in bank portfolio risks.

JEL Classification: D4; G15; G21; L11; N2.
Keywords: Financial Stability, Lerner index, Bank Competition, Mexican Banking Sector, Generalised Method of Moments (GMM).

Resumen

Este artículo analiza las hipótesis de competencia-fragilidad y competencia-estabilidad en el sistema bancario mexicano, para el periodo 2001-2008. Para medir el nivel de competencia, se emplea el índice de Lerner y el índice-Z, así como la razón de créditos morosos entre créditos totales como proxies de estabilidad financiera y riesgo de portafolio, respectivamente. Los resultados indican que existen argumentos para sustentar ambos modelos. Sin embargo, los beneficios de un mayor nivel de estabilidad financiera en el sistema tienen más peso que el incremento en los riesgos de portafolio.

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***Clasificación JEL*: D4; G15; G21; L11; N2.
Palabras Clave: estabilidad financiera, índice de Lerner, competencia bancaria, sector bancario mexicano, método generalizado de momentos (GMM).

Introduction

There have been recent debates on the relationship between banking competition and the overall stability of the financial system. As such, two opposing views have emerged: competition-fragility and competition-stability. The competition-fragility view suggests a negative relationship between bank competition and financial stability, while the competition-stability view proposes a positive relationship. Many authors have tested these relationships in various countries and regions and have obtained contrasting results. However, as far as we know, no such study has been done for the Mexican banking industry.

Beck (2008) explains that similarly to other non-financial industries, competition in the banking sector is desirable since it often generates a more efficient market, with all the benefits that come along (e.g. efficient allocation of resources and better prices for consumers). However, there are theories suggesting that more competitive banking sectors may increase the instability of the financial system. As greater banking competition decreases bank profit margins, banks are encouraged to take on riskier investments in order to boost their profits, supporting the competition-fragility view (Berger et al., 2008). However, Boyd and De Nicolo (2005) argue that greater bank concentration in the lending markets may increase instability through increased risks, since higher interest rates charged on consumers may make it harder for them to repay their loans, thus supporting the competition-stability view. It is therefore interesting to test both hypotheses and find whether bank competition is desirable in order to increase financial stability.

More specifically, it is interesting to test these relationships in the Mexican banking industry. This industry has recently experienced a period of banking consolidation and a reduction in competition, whilst at the same recovered from the recent international financial crisis. To the best of our knowledge no country specific studies have been done with regards to the Mexican banking industry.

This paper is divided into six sections: Section 1 addresses the background of the Mexican banking industry, Section 2 presents the literature review on the competition-stability relationships, Section 3 introduces the data and methodology used, Section 4 presents the main results of the study, and finally Section 5 summarizes the main conclusions of the study.

1. Background

The Mexican banking sector has gradually experienced a period of consolidation commencing with financial liberalisation policies implemented during the 1990s. As a result of the 1995 financial crisis in Mexico, foreign banks were permitted to enter the market and a series of mergers and acquisitions were observed[1]. This new merger wave generated a concentrated market with the three largest banks controlling close to 60% of the market share[2]. One of the main benefits of such consolidation has been the contribution to the capitalisation of the banking industry as well as the improvement in the quality of bank assets (Hernandez-Murillo 2007). Figure 1 shows the Herfindahl-Hirschman[3] index (HHI) in the Mexican banking industry for the period 1996-2008. Overall, there seems to be no important change in the degree of concentration throughout this period; however, it is important to note that during 2006-2008 several new banks entered the market which has resulted in a recent marginal decline in the Herfindahl-Hirschman index[4].

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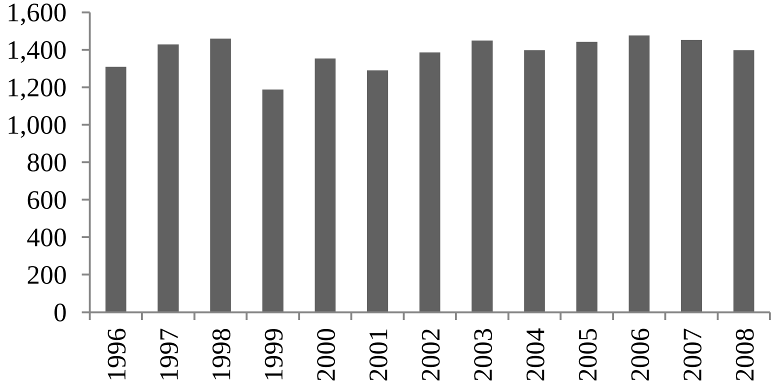
[1] Whilst Mexican banks had been protected from foreign competition for many years, restrictions were relaxed after the signing of the North American Free Trade Agreement (NAFTA), removing all of them by the end of 1998 (see Yacaman, 2001).
[2] As of September 2000, BBVA-Bancomer, Banamex and Santander-Serfin controlled 59% of the market share in terms of assets (see Yacaman, 2001).
[3] The Herfindahl-Hirschman index is calculated as the sum of the squared market shares (in terms of assets) of all the banks.
[4] Registered new commercial banks for the period 2006-2008 include: BANCOPPEL, THE BANK OF NEW YORK MELLON, CIBANCO, DEUNO, VOLKSWAGEN BANK, BANCO FACIL, UBS, BANCO AMIGO, BANCO REGIONAL, BANCO WALMART, ACTINVER, MULTIVA, BANCO DE AHORRO FAMSA, COMPARTAMOS, BARCLAYS BANK, and AUTOFIN.

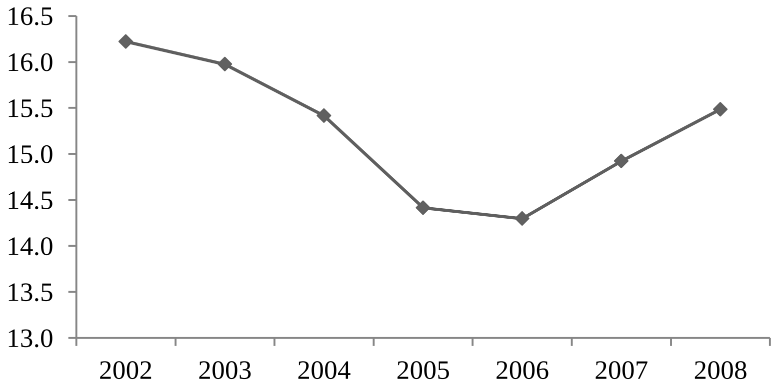
Figure 1
Herfindahl-Hirschman Index (in terms of total assets)



Source: National Banking Supervisor (CNBV).

Figure 2 shows the average capitalisation level of the Mexican banking industry for the period 2001-2008. As seen in Figure 2, the capitalisation index suggests that the banking sector has developed a strong financial position throughout this last decade. A slight decline in the index is observed from 2002 to 2006, followed by a stiff recovery. However the capitalisation levels are almost twice as the regulatory 8% minimum.

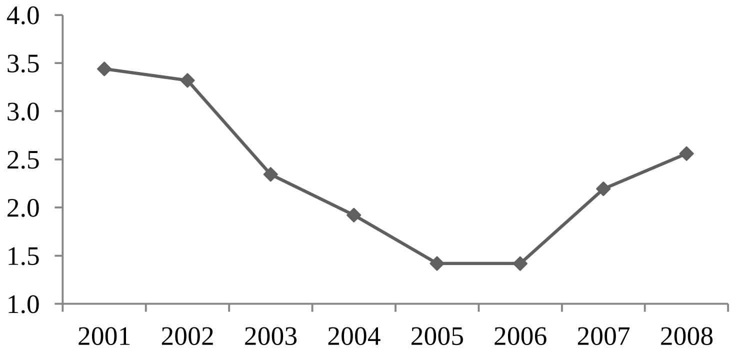
Figure 2
Capitalisation index (total capital over total assets)



Source: National Banking Supervisor (CNBV).

One of the benefits of allowing foreign ownership in the Mexican banking industry has been the decline in bad debt, through better risk assessment and market analysis (Hernandez-Murillo 2007). Figure 3 shows the level of non-performing loans in terms of total loans in Mexico. In general, there is a steep decline in the level of non-performing loans in the industry from 2001 to 2006, however a recent rise can be observed, from 2006 onwards, probably due to the recent financial crisis which has affected the quality of the banks' assets.

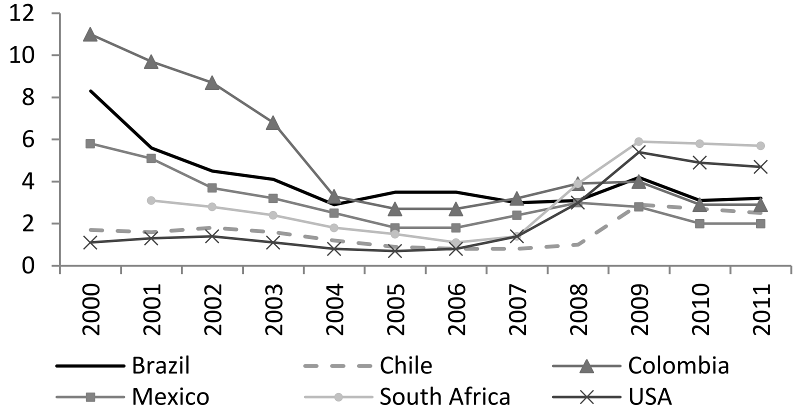
Figure 3
Non-performing loans (in terms of total loans)



Source: National Banking Supervisor (CNBV).

At the same time the levels of non-performing in terms of total loans in the Mexican banking sector have been declining and if compared to other developed and emerging economies are low (see Figure 4).

Figure 4
Non-performing loans (in terms of total loans)



Source: World Bank.

2. Literature Review

There is an ongoing debate in the literature discussing the implications of the degree of bank competition on the overall stability of the financial system. As observed in the recent financial crisis, the banking industry is a major conduct through which instability may be transmitted to the wider economy. The main mechanisms of transmission are through the disruption of the interbank lending markets and payment mechanisms, the reduction of the supply of credit, and the freezing of deposits (Berger *et al*. 2008).

There is vast literature which suggests that greater bank competition produces financial instability by decreasing the degree of market power in the sector, which consequently erodes profits and reduces franchise value, supporting the competition-fragility view[5]. Thus, banks are encouraged to take on more risks to increase their returns, deteriorating the quality of their portfolios (Marcus, 1984; Keeley, 1990 and Carletti and Hartmaan, 2002). There are various empirical studies supporting this relationship. Keeley (1990) finds that increased banking competition and deregulation in the US during the 1990s decreased monopoly rents and contributed to bank failures. Hellmann, Murdock and Stiglitz (2000) conclude that the removal of interest rate ceilings, and thus generating more competitive prices, decreases franchise value and encourages moral hazard behaviour in banks. Jimenez, Lopez and Saurina (2007) study the banking sector in Spain and find that greater

[5] For a review of the literature on the "competition-fragility" see Carletti and Hartmaan (2002).

banking competition is associated with a higher risk loan portfolios (increased non-performing loans). Berger *et al.* (2008) study 23 developed nations and find arguments in favour of the competition-fragility view, suggesting that higher market power reduces the risk exposure of banks. However, they also find that greater market power increases loan portfolio risks which could be interpreted as some evidence supporting the competition-stability view. Vives (2010) reviews the theoretical and empirical literature on the competition-stability relationship and argues that although competition is not a determinant of instability, it may exacerbate instability problems.

However, recent studies have argued in favour of a positive relationship between bank competition and financial stability. Beck, Demirguc-Kunt and Levine (2006) study a group of 69 countries and find that countries experiencing less market concentration are less likely to suffer a financial crisis. Boyd and De Nicolo (2005) suggest that greater market power in the loan markets increases bank risks since higher interest rates charged on consumers are harder to repay. This may exacerbate moral hazard problems and, at the same time, higher interest rates attract riskier borrowers due to adverse selection problems. Moreover, in highly concentrated markets, financial institutions may believe they are “too-big-to-fail” and this may lead to riskier investments (Berger *et al.*, 2008). Empirically, there are several recent studies which have supported this hypothesis. Boyd, De Nicolo and Jalal (2006) and De Nicolo and Loukoianova (2006) both find an inverse relationship between higher market concentration and financial stability suggesting that the risk of bank failures increase in more concentrated markets. They estimate financial stability by the Z-index (an inverse measure of bank risks) and market concentration by the Herfindahl-Hirschman index. Schaeck, Cihak and Wolfe (2006) study the banking sectors of a group of countries by applying a Logit model and duration analysis. Furthermore, they estimate the Rosse-Panzar H-statistic as a measure of competition[6]. Their main findings argue that more competitive banking sectors have a lower likelihood of bank failure (they are more stable than in monopolistic systems).

Other studies have applied the Lerner index of competition and bank stability measures to examine the competition-stability relationship in banking. Berger *et al.* (2008) study a sample of over 8,000 banks in 23 countries by

[6] Many authors employ the Rosse-Panzar H-statistic as a measure of competition in banking (Claessens and Laeven, 2004; Schaeck *et al*., 2006; and Molyneux and Nguyen-Linh, 2008), however, there are issues when applying the H-statistic, particularly that it requires to be in long-run equilibrium.

employing the Generalised Methods of Moments (GMM) dynamic panel data framework. They include measures of market concentration, Herfindahl-Hirschman index, as well as the Lerner index of competition to account for market power. Moreover, they include the Z-index as a proxy for bank stability and non-performing loans over total loans as a measure of bank portfolio risks in order to test both the competition-stability and competition-fragility relationships respectively. Their main results indicate that banks with a higher degree of market power have less overall risks supportive of the competition-fragility hypothesis; on the other hand, they also find evidence of a positive relationship between competition and stability, implying that market power increases total loan risks. Turk-Ariss (2010) studies how the degree of market power affects both bank efficiency and financial stability in the banking sector for a group of emerging economies; however she does not include Mexico in the sample. She applies three different specifications of the Lerner index of competition[7] and uses a Z-index to proxy for financial stability. Her main results indicate that increased market power results in greater bank stability, although with a significant loss in cost efficiency. Liu, Molyneux and Wilson (2013) analyse the competitive conditions in 11 EU countries for the period 2000-2008 in order to examine the competition-stability relationship in banking. They employ the Lerner index of competition and the Z-index in order to proxy for bank competition and bank stability respectively. Their results suggest that a non-linear relationship between competition and stability exists in European banking. More specifically, they find risk-shifting effects in highly concentrated markets, where an increase in banking competition lowers net interest margins (higher deposit rates and lower loan rates) and increases bank stability. However, they find that marginal effects exist in highly competitive markets, where increased competition reduces loan interest payments and the provisions for non-performing loans.

There are several studies that analyze the efficiency and market structure of the Mexican banking sector. Guerrero and Negrin (2006) study the evolution of the efficiency of the Mexican banking sector for the period 1997-2004. The main findings suggest two different paths, during 1997-2001, the efficiency indicators decreased significantly. In this period important banking sector reforms were adopted. On the other hand, from 2001 to 2004, the efficiency of the banking sector improved consistently as a consequence of the implemented banking sector reforms. Overall, the article finds inefficiency levels of 19% on average for the period of study, similar to other international studies. On the other hand, Ruiz, Vasquez and Nuñez (2006)

[7] The three measures of the Lerner index include: a traditional Lerner index, an efficiency-adjusted Lerner and a funding adjusted Lerner, for more information see Turk-Ariss (2010).

analyze the effects of financial globalization on the banking management in Mexico. They find empirically that financial globalization brought benefits and costs to the Mexican banking sector; the benefits included greater systemic stability, higher profitability and efficiency. Within greater costs the article highlights the level of concentration of the industry and lower credit to housing and commerce. Guerrero and Villalpando (2009) test the market structure (structure-conduct performance and relative-market power) hypotheses and the two variants of the efficient-structure (X- and scale efficiency) hypotheses in Mexico for the period 1997-2005. Their main findings suggest that the market power hypotheses are responsible for explaining bank profitability in Mexico. Ruiz *et al*. (2006) study the effects of financial globalization on Mexican banking administration. The results indicate that financial globalization brought both costs (market concentration, reduced private credit lending) and benefits (greater systemic stability, higher profitability and efficiency). Ruiz (2008) studied the banking competition-fragility relationship for a group of 47 countries, including Mexico, between 1990 and 1997. The main findings indicate that the financial structure matters for the fragility of the financial system.

3. Data and Methodology

3.1. Data

The data in this study was obtained from the National Mexican Banking Supervisor *(Comision Nacional Bancaria y de Valores*-CNBV). The sample includes 14 Mexican banks that appeared during the period of study representing 81% of the total market share on average. The 14 banks used in this study are: BANAMEX, BBVA BANCOMER, SANTANDER, HSBC, BAJIO, IXE, INTERACCIONES, MIFEL, SCOTIABANK, BANREGIO, INVEX, BANSI, AFIRME and BANORTE. The data includes annual information of balance sheet items for the period 2000 to 2008 in real terms. However, when computing the Z-index a rolling average of two years of the data was used. This method was selected since Cihak, Maechler, Schaeck and Stolz (2009) argue that a rolling average allows capturing the dynamics of bank stability[8]. The study follows the methodology of Beck, De Jonghe and Schepens. (2010). Table 1 presents the description of the variables used in this study.

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[8] In their study, Cihak *et al*. (2009) apply a 3-year rolling window average; however, because of data availability, this study applies a 2-year rolling window average.

Table 1
Variable description

Variable	Description
Z-index	Measure of bank stability: the sum of return on assets plus equity over assets divided by the standard deviation of the return on assets. $Z_{it} = \frac{ROA_{it}+EQTA_{it}}{\sigma_{it}^{ROA}}$
Lerner index	Measure of bank competition: price minus marginal cost over price. $Lerner_{it} = (p_{it} - mc_{it})/p_{it}$
NPL (%)	Measure of bank portfolio risks: the level of non-performing loans over total loans.
LnASSETS	Measure of bank size: the logarithm of assets.
LOATA (%)	Measure of liquidity: loans over total assets.
OWN	Measure of ownership: 1 if foreign 0 otherwise.

On the other hand, Table 2 presents the descriptive statistics of the main variables used in the study.

Table 2
Descriptive statistics

Variable	Mean	Standard deviation	Minimum	Maximum
Z-index	8,788.023	16,419.15	144.252	139,280.5
Lerner index	0.194	0.095	-0.193	0.354
NPL (%)	2.231	1.649	0.151	9.118
LnASSETS	6.346	1.616	4.048	9.047
LOATA (%)	37.879	11.66	17.769	69.564
OWN	0.357	0.482	0	1

Note: Z-index is a measure of bank stability, LERNER is the Lerner index of competition, LNASSSETS is the natural log of assets, LOATA is the measure of loans over assets and OWN is a measure of ownership.

3.2. Methodology

The methodology involves firstly the estimation of the Lerner index of competition and the Z-index, and secondly the application of the system Generalised Method of Moments (GMM) dynamic panel data, in order to test the competition-stability and competition-fragility relationships respectively. The system GMM is chosen since it generally produces more efficient and precise estimates compared to difference GMM (see Baltagi, 2008).

This study uses the Lerner index of competition since it captures the disparity between prices and marginal costs in terms of prices, that is:

$$Lerner_{it} = (p_{it} - mc_{it})/p_{it} \quad (1)$$

Where p is the price of each bank and is measured as the number of total revenues over total assets and mc is the marginal cost of each bank which is derived from a Translog function which includes three costs and several control variables. The following Translog cost function is used:

$$lnTC = \alpha_0 + \alpha_j \sum_{j=1}^{3} w_{it}^{j} + \frac{1}{2}\sum_{j=1}^{3}\sum_{k=1}^{3} \alpha_{jk}\, lnw_{it}^{j} w_{it}^{k} + \beta_1 lnY_{it} + \frac{1}{2}\beta_2 (lnY_{it})^2 + \sum_{j=1}^{3} \beta_3\, lnY_{it} lnw_{it}^{j} + \varphi_{1t} T + \frac{1}{2}\varphi_{2t} T^2 + \sum_{j=1}^{3} \varphi_{3t}\, T lnw_{it}^{j} + \varphi_{4t} T lnY_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

Where TC are the total costs, $w$is the price of the three inputs (personnel expenses/total assets, interest rate expenses/total deposits and other operating expenses/fixed assets), Y is total assets, T is a time trend which captures the effect of technical progress, μ captures the individual fixed effects, and ε is the error term[9]. The price is estimated as total revenues over total assets and the marginal cost is derived from the translog cost function. Notice that we have imposed the followings restriction in the Translog cost function in order to obtain a valid cost function: 1) homogeneous of degree one in factor prices, 2) non-decreasing factor prices, which requires that $\delta TC/\delta w^{j} \geq 0$ for all j and 3) concavity in factor prices, which requires that the Hessian (the matrix of second-order derivatives with respect to prices) be negative semi-definite.

The next step is the estimation of the Z-index, used as a bank based proxy for financial stability. The Z-index is actually the inverse proxy for a firm´s probability of default; hence, it is an inverse measure of overall bank risks (Berger *et al.*, 2008). It is estimated as:

$$Z_{it} = \frac{ROA_{it} + EQTA_{it}}{\sigma_{it}^{ROA}} \quad (3)$$

[9] A fixed effects panel data regression with robust standard errors is run.

Where ROA is the 2-year average return on assets for each bank, $EQTA$ is the 2-year average of capital over assets for each bank, $\sigma^{ROA}$is the standard deviation for return on assets for a period of 2 years. As observed, the Z index increases when the level of return on assets and the level of capitalization increase, however, it is reduced when there is volatility in the level of returns. As a measure of bank portfolio risks, the 2 year average of the level of non-performing loans in terms of total loans is used.

The GMM methodology is employed in order to address the possible endogeneity of the measure of bank competition with regards to measures of loan risks, capitalisation levels and overall bank risks. For example, a well capitalised bank may merge with another bank and increase its market power. Moreover, if a bank increases its loan portfolio and thus its overall risk, it may obtain greater profits, which may result in greater market share (Berger *et al.*, 2008). Two different GMM equations are run addressing each of the formerly discussed hypotheses: competition-stability and "competition-fragility." The first equation refers to the competition-stability relationship where the Z-index proxies bank stability:

$$lnZ_{it} = \alpha_{it} + \delta lnZ_{it-1} + \beta_1 lerner_{it} + \beta_2 lerner_{it}^2 + \beta_3 lnassets_{it} + \beta_4 LOATA_{it} + \beta_5 OWN_i + \varepsilon_{it} \quad (4)$$

Where lnZ is the natural logarithm of the Z-index, $lerner$ is the Lerner index of competition, $lerner^2$ is the squared measure of the Lerner index, $lnassets$ $\ln assets$ is the natural logarithm of assets, $LOATA$ is a measure of total loans over total assets, OWN is a dummy variable reflecting foreign ownership and ε is the error term. The second equation refers to the competition-fragility relationship where non-performing loans proxy bank portfolio risks:

$$NPL_{it} = \alpha_{it} + \gamma NPL_{it-1} + \beta_1 lerner_{it} + \beta_2 lerner_{it}^2 + \beta_3 lnassets_{it} + \beta_4 LOATA_{it} + \beta_5 OWN_i + \varepsilon_{it} \quad (5)$$

Where NPL is the measure of non-performing loans in terms of total loans and the remaining variables have the same description as Equation 3.

4. Results

The system GMM regression is run for four models, including the Z-index as the dependent variables and the Lerner index of competition alongside other control variables as the independent variables in models 1 and 2; and NPL as the dependent variable alongside the Lerner index and other control variables in models 3 and 4. In all models the Hansen J-test is accepted as expected meaning that the instruments used are correct[10]. The results are presented in Table 3.

Table 3

GMM regression with Z-index and NPL as dependent variables

Variables	**Z-index (Model 1)**	**Z-index (Model 2)**	**NPL (Model 3)**	**NPL (Model 4)**
L.DEP	-0.081	-0.109	0.503***	0.557***
LERNER	-39.728**	-36.296**	-14.364*	-20.648***
LERNERSQ	111.197**	107.726**	38.93**	49.681**
LNASSETS	-0.968*	0.273	0.369	0.353
LOATA	0.052	0.097	0.043	0.007
OWN	1.979	-1.42	-0.726	-0.255
TIME		-0.219		0.117
CONS	15.319***	7.759	-1.738	-0.539
Inflection point	0.179	0.168	0.184	0.208
Wald test	18.84	34.45	29.01	49.53
p-value	0	0	0	0
AR(2)	-0.94	-0.94	-1.89	-1.74
p-value	-0.345	-0.346	-0.059	-0.082
Hansen-J Test	3.57	1.97	9.65	8.91
p-value	-0.467	-0.578	-0.14	-0.541
Instruments	11	11	13	18
Observations	84	84	84	84

*,**,*** indicate significance at 10, 5 and 1% confidence intervals.

Where L.DEP is the lagged dependent variables, LERNER is the Lerner index of competition, LERNERSQ is the squared Lerner index, LNASSSETS is the natural log of assets, LOATA is the measure of loans over assets, OWN is a measure of ownership, TIME is a time dummy variable and CONS is the constant term.

As observed from the main results, the Lerner index is consistently negative and significant in all models. In models 1 and 2, the inverse relationship

[10] Up to 3 lags were used as instruments for the equation in levels, and ownership and time were used as instruments in the equation in differences.

between the Lerner index and the Z-index suggests that increased banking competition results in greater financial stability. This result is supportive of the competition-stability view; on the other hand, greater bank competition results in increased bank portfolio risks, supportive of the competition-fragility view, in models 3 and 4. In every case, the LERNERSQ variable is always positive and significant and the inflection point is on average 0.18 representing approximately 40% of the accumulated Lerner distribution, which implies a non-linear relationship between competition and bank stability. With regards to the control variables, we find only LNASSETS to be significant in model 1, and inversely related to the Z-index, thus implying that bank size negatively affects financial stability. However, this variable loses its explanatory power in the remaining models. Finally, the remaining control variables show no significance with regards to the dependent variables.

The main results are supportive of both the competition-stability and the competition-fragility hypotheses, however it is important to note that the benefits of greater banking competition on financial stability outweigh the increases in non-performing loans since the Mexican banking system has relatively low levels of non-performing loans and the positive effects on financial stability are greater.

It is important to highlight the main limitations of this study: the number of observations account to 84 in total since only banks which appeared in the period of time of the study were used, as such, many banks had to be omitted from the analysis.

Conclusion

The Mexican financial system experienced a process of financial liberalization during the last two decades, which resulted in the consolidation of the banking sector, generating a more concentrated market, and as a result reduced competition. At the same time, the Mexican banking sector has proven to be resilient to the recent financial crisis. Thus, the analysis of banking competition and bank stability becomes relevant in the Mexican banking industry. This paper is the first study to address the competition-stability and competition-fragility hypotheses for the Mexican banking industry. The Lerner index of competition alongside two measures of financial stability (Z-index) and bank portfolio risks (NPL) respectively are used in order to test the two aforementioned hypotheses.

The first set of regressions test the relationship between bank competition and financial stability. We find invariably an inverse relationship suggesting that increased bank competition has resulted in greater financial stability, supportive of the competition-stability hypothesis. On the other hand, the second set of regressions test the competition-fragility hypothesis, and the main results indicate that greater bank competition increases overall bank portfolio risks. However, a stronger relationship between bank competition and financial stability is observed if compared to the increases in bank portfolio risks; furthermore, given the relatively low levels of non-performing loans in the Mexican banking sector, the benefits on the overall stability outweigh the growth in bank portfolio risks.

Appendix

The Lerner index identifies the degree of monopoly with the difference between the firm´s price and its marginal cost $(P - MC)/P$ (a) at the profit-maximizing output rate. Hence, a larger gap would suggest greater monopoly power, or the Lerner index $L_{it} = \frac{P_{it} - MC_{it}}{P_{it}}$ (b).

From equation (a) if we multiply both sides by the level of output Q_{it} and total costs TC_{it} and if we consider that $MC_{it} = \frac{\partial TC_{it}}{\partial Q_{it}}$, (c) we obtain:

$$\frac{P_{it}Q_{it}}{TC_{it}} \geq \frac{\partial TC_{it}}{\partial Q_{it}} \frac{Q_{it}}{TC_{it}}, \quad (d)$$

or

$$\frac{TR_{it}}{TC_{it}} \geq \frac{\partial lnTC_{it}}{\partial lnQ_{it}}. \quad (e)$$

Where TR_{it} denotes total revenues.

The left-hand side of equation (e) is the share of revenues to total costs for bank i in time t, explained as RC_{it}, and the right-hand side is the cost-elasticity with regards to output.

Since MC_{it} represents the long-run equilibrium price in a perfect competitive market, the deviation from the observed price from the marginal cost, meaning the distance between RC_{it} and $\frac{\partial lnTC_{it}}{\partial lnQ_{it}}$ is a measure of market power.

Equation (e) can be defined as a stochastic cost frontier model (Aigner, Lovell and Schmidt, 1977):

$$RC_{it} = \frac{\partial lnTC_{it}}{\partial lnQ_{it}} + v_{it} + u_{it} \tag{f}$$

The left-hand side of equation 5 denotes the revenue-cost ratio, while the right-hand side is the minimum level that can be reached, where the deterministic component is $\frac{\partial lnTC_{it}}{\partial lnQ_{it}}$, v_{it} is the stochastic part and u_{it} is a measure of cost inefficiency.

If we assume that total bank costs TC_{it} are a function of output Q_{it} and three input prices W_{jit}, where $j = 1,2,3$, we would obtain the translog function:

$$\begin{aligned} lnTC = {} & \alpha_0 + \alpha_j \sum_{j=1}^{3} w_{it}^{j} + \frac{1}{2}\sum_{j=1}^{3}\sum_{k=1}^{3} \alpha_{jk}\, lnw_{it}^{j} w_{it}^{k} + \beta_1 lnY_{it} + \frac{1}{2}\beta_2 (lnY_{it})^2 \\ & + \sum_{j=1}^{3} \beta_3\, lnY_{it} lnw_{it}^{j} + \varphi_{1t} T + \frac{1}{2}\varphi_{2t} T^2 + \sum_{j=1}^{3} \varphi_{3t}\, T lnw_{it}^{j} \\ & + \varphi_{4t} T lnY_{it} + \mu_i + \varepsilon_{it} \end{aligned} \tag{g}$$

References

Aigner, D., Lovell, C. A. K., and Schmidt, P. (1977). "Formulation and Estimation of Stochastic Frontier Production Function Models". *Journal of Econometrics*, 6, 21-37.

Baltagi, B. H. (2008). *Econometric Analysis of Panel Data*. 4th edition, Chichester: John Wiley and Sons Ltd.

Beck, T. (2008). "Bank competition and financial stability: Friends or foes?". *World Bank Policy Research Working Paper No. 4656.*

Beck, T., De Jonghe, O., and Schepens, G. (2010). "Bank Competition and Stability: Reconciling Conflicting Empirical Evidence". *Cass Business School Working Paper*.

Beck, T., Demirguc-Kunt, A., and Levine, R. (2006). "Bank concentration, competition, and crises: First results". *Journal of Banking and Finance*, 30(5), 1581-1603.

Berger, A., Klapper, L., and Turk-Ariss, R. (2008). "Bank competition and financial stability." *World Bank Policy Research Working Paper No. 4696.*

Boyd, J., and De Nicolo, G. (2005) "The theory of bank risk taking revisited". *Journal of Finance,* 60(3), 1329-1343.

Boyd, J., De Nicolo, G., and Jalal, A. M. (2006). "Bank risk taking and competition revisited: New theory and evidence". *IMF Working Paper No. 297.*

Carletti, E. and Hartmann, P. (2002). "Competition and financial stability: What's special about banking?". *ECB Working Paper No. 146*.

Cihak, M., Maechler, A., Schaeck, K., and Stolz, S. (2009). "Who disciplines bank managers?". *IMF Working Paper Series No. 272*.

Claessens, S., and Laeven, L. (2004). "What drives competition? Some international evidence". *Journal of Money, Credit and Banking,* 36(3), 563-583.

De Nicolo, G., and Loukoianovam, E. (2006). "Bank ownership, market structure, and risk". *IMF Working Paper No.215*.

Guerrero, R. and Villalpando, M. (2009). "Rentabilidad, concentración y eficiencia en el sistema bancario mexicano". *El Trimestre Económico,* 76(1), 237-263.

Guerrero, R. and Negrin, J. L. (2006) "Eficiencia del sistema bancário mexicano 1997-2004: uma estimación dinâmica." Monetaria, Centro de Estudios Monetarios Latinoamericanos, 0(3), pp. 235-259.

Hellmann, T. F., Murdock, K., and Stiglitz, J. (2000). "Liberalization, moral hazard in banking and prudential regulation: Are capital requirements enough?". *American Economic Review,* 90(1), 147-165.

Hernandez-Murillo, R. (2007). "Experiments in financial liberalization: The Mexican banking industry". *Federal Reserve Bank of St. Louis Review,* 89(5), 415-432.

Jimenez, G., Lopez, J., and Saurina, J. (2007). "How does competition impact bank risk taking?". *Banco de España Working Papers No. 1005*.

Keeley, M. (1990). "Deposit insurance, risk and market power in banking". *American Economic Review,* 80(5), 1183-1200.

Liu, H., Molyneux, P., and Wilson, J., (2013). "Competition and stability in European banking: A regional analysis". *Manchester School,* 81(2), 176-201.

Marcus, A. J. (1984). "Deregulation and bank financial policy". *Journal of Banking and Finance,* 8(4), 557-565.

Molyneux, P., and Nguyen-Linh, H. (2008). "Competition and risk in the South East Asian banking*". Bangor Business School Working Paper, Bangor, Wales.*

Ruiz-Porras, A., Vasquez-Quevedo, N., and Nuñez Mora, J. A. (2006). "Efectos de la globalización financiera en la administración y regulación de riesgos bancarios en México". *Contaduría y Administración*, 219, 115-141.

Ruiz-Porras, A. (2008). "Banking competition and financial fragility: Evidence from panel-data." *Estudios Economicos*, 23(1), 49-87.

Schaeck, K., Cihak, M., and Wolfe, S. (2006). "Are more competitive banking systems more stable?". *IMF Working Paper No. 143.*

Turk-Ariss, R. (2010). "On the implications of market power in banking: Evidence from developing countries". *Journal of Banking and Finance*, 34(4), 765-775.

Vives, X. (2010). "Competition and stability in banking". *IESE Working Paper No. 852.*

Yacaman, J. M. (2001). "Competition and consolidation in the Mexican banking industry after the 1995 crisis in the banking industry in the emerging economies: Competition, consolidation and systemic stability". *BIS papers No. 4.*

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