MEASURING THE TOTAL FACTOR PRODUCTIVITY: A COMPARISION OF THE MEXICAN AND BRAZILIAN ECONOMIES BY 1995-2011

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Abstract

The aim of this paper is to make a comparison of the sectorial rates of Total Factor Productivity (TFP) growth for Mexico and Brazil by 1995-2011 and to estimate the technical change and inter industry structure.

To do this, we used an input-output framework to measure the involvement of the total factor productivity in the economic growth. the change in the sectorial total production was separated into two effects: the effect generated by the changes in the technical coefficients of the intermediate and primary inputs and added value; and the effect caused by variations in the quantity of inputs.

The results show that Brazilian industry have been more productive than the Mexican and we also found two general patterns, that can explain these differences: the first one is related to the TPF rates shape and the second one is about the relation of the TPF with TC and AVC.

Key words: Factor productivity, economic growth, technical change, inter-industry structure, output share.

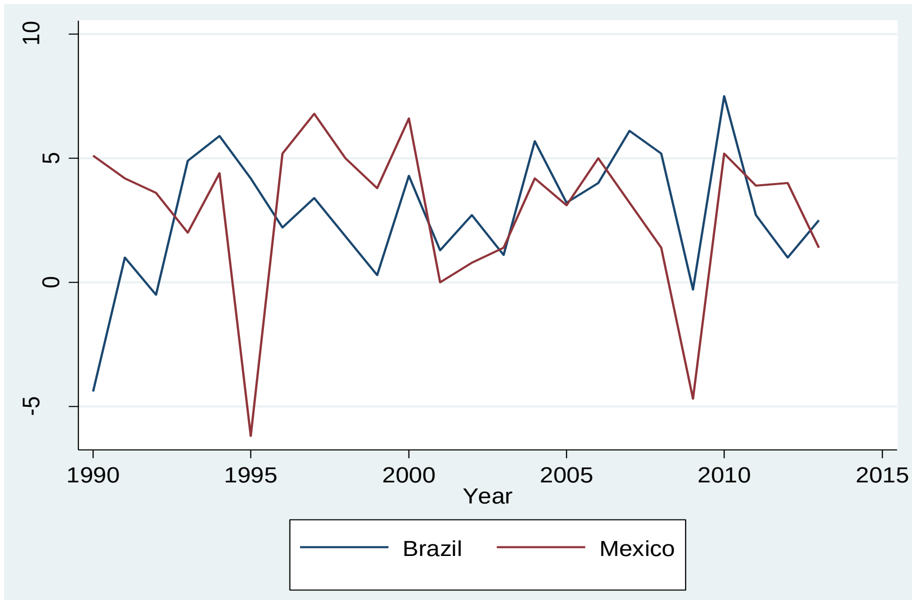
[redacted]INTRODUCTION

One of the principal variables that are used to explain income differences across countries, and to obtain a measure of the health of an economy, is the growth of its productivity, which is defined as the level of input that is necessary to produce a unit of output.

The Mexican and Brazilian economies have showed similar rates of growth. In the 70’s both economies had a protectionism process, follow by an openness and liberalization process, which take place in the 80´s in the case of Mexico, and in the 90´s in Brazil. Both economies present crises in the 90’s; the “Tequila effect” in 1994, in the case of Mexico, and the “Samba effect” in 1998, in Brazil. However, in the recent years these economies have exhibited a completely different performance (Guilhoto et al., 2012, Moreno-Brid and Ros, 2010).

Figure 1-1, shows the rate of growth of the Mexican and Brazilian economies. As it is shown here, in Mexico there have been 3 crisis periods in the last decades: 1994, 2001 and 2009; while in Brazil the crisis years have been 1998, 2001 and 2009.

Figure 1-1 Rate of growth of the Mexican and Brazilian economies



Data from CEPAL

In this context the aim of this paper is to compare the rates of Total Factor Productivity (TFP) growth for the most important sectors in Mexican and Brazilian economies by 1995 to 2011, and to estimate the Technical Change (TC) and Changes in the Added Value (CAV). To do this, we used an input-output framework, following the methodology proposed by Miller and Blair (2009), which is based on the texts of Baumol and Wolff (1984), Wolff (1985, 1994, 1997) and ten Raa (2005).

In section 1 we revisit the literature about TFP and the stylized facts for the Mexican and Brazilian economies. In section 2 we present the data and the methodology used in our analysis. In section 3 we exhibit the estimations and results of the model for the Mexican and Brazilian economies.

[redacted]ECONOMIC GROWTH AND TOTAL FACTOR PRODUCTIVITY

The economic growth has been studied in different forms. Neoclassical approaches about technical change were provided by Solow (1956) and

Mankiw, Romer and Wiel (1996), who consider a simple dynamic model where changes in technology are given by changes in labor innovations in the long run. Lucas (1986) modifies this model by adding the human capital into the variables that explain the change; where this new component and the physical capital have different natures, and explain the technical change not only by the accumulation of ideas, but the improvement of the skills to produce. Recent research has involved Dynamic General Equilibrium Models (DGEM) where technical change is the principal cause of the economic growth (Acemoglu, 2003; Jones, 2005; Kortum 1997).

There are two trends in the analysis of this issue. One that argue that income differences are mainly explained by the dissimilarities in the TFP levels and its growth rates, and other that conceive the TFP's growth as endogenous, and as a result of the input’s growth and the accumulation of the physical capital. Klenow & Rodríguez (1997) argue that the TPF levels and its changes can indirectly affect physical and human capital accumulation, through the relative price of physical and human capital. In the same line, Prescott (1998) claims that the reason of current incomes differences is the sustained growth in TFP. On the other hand, Kaldor (1966, 1967) maintain that, the causal relationship between the input and the TFP growth rates goes from the input to TFP, and that is explained by the existence of decreasing returns to scale in the industrial sectors. Ross (2013) supports this hypothesis concluding that the productivity does not growth as a cause but as a result of the low rates of output growth, which in turn is caused by the low rate of capital accumulation in the Mexican case. Córdoba and Ripoll (2008) find that countries with higher factor intensities tend to exhibit higher TFP, and also show that covariance between factor intensities and TFP is explained mostly by the second affecting the first rather than the other way around, where the covariance would be negative rather than positive.

Since the decade of 1980's, Latin-American's economies have presented lows growth rates -which is about 1.8% in the region across 1990-2008- and low productivity rates. In this context, Aravena et al. (2014) find that growth in labor productivity is considerably lower in Latin American countries than in the United States, and also there is a negative contribution of TFP in México, Chile and Brazil, given that TFP subtracted 0.32 percentage points in Brazil, 0.74 in Chile, and was even more negative in Mexico, -0.88 pp. However, the contribution of capital per hour worked was negative in two Latin American countries: Argentina (-0.65 pp) and Brazil (-0.30 pp) and very high in Chile (2.46 pp) and Mexico (2.26 pp). Doing this analysis by sectors in the Brazilian economy, Aravena et al. (2014) find that the same problem in all sectors but Agriculture and Fishing; Electricity, Gas and Water; and Financial Intermediation.

Ros (2014) analyses this situation for some Latin American countries (Mexico, Colombia, Brazil, Chile and Argentina) and find that labor productivity average rate decrease from 1950-1980 to 1990-2005, in the case of Mexico and Brazil, opposing to Argentina's and Peru´s behaviors, see Table 2-1.

Table 2-1 Labor productivity average rate

	1950-1980	1990-2005
Mexico	3.2%	1.1%
Brazil	4.3%	0.7%
Argentina	0.8%	2.4%
Peru	2.4%	3.4%

Data from Ros (2014).

He also finds that the labor productivity average rate of growth by sector (Agriculture, Industry, Manufacture and Services) downs for Mexico and Brazil excepting Agriculture in Brazil, see Table 2-2.

Table 2-2 Labor productivity average rate by sector

	Brazil		Mexico	
	1950-1980	1990-2005	1950-1980	1990-2005
Agriculture	2.8%	4.0%	2.9%	2.4%
Industry	4.2%	1.8%	2.3%	1.4%
Manufacture	4.8%	1.7%	2.4%	2.0%
Services	2.0%	-0.7%	1.6%	1.0%

Data from Ros (2014).

As the Table 2-2 shows, downloads have been dipper in the service sector for Mexico and Brazil, which has become a low-productivity sector and also has increased its participation in total employment after 1980; then there is a reallocation process of the labor force from high to low productivity sectors since 1980.

In a similar work, Aravena et al. (2012) studied the sectorial productivity in Mexico, Brazil, Chile and Argentina for the period 1995-2009; founding that, in the case of Mexico and Brazil their TFP are -1.0 and -0.3, respectively, while their total Value Added (VA) is 2.8 for Brazil and 1.9 for Mexico. The sectorial contribution to the labor productivity is almost equal in the case of the services for both countries, but bigger in transformation and extraction sectors in Brazil, than in Mexico. The most productive sector in Brazil is the agricultural and the less productive is the industrial, the same happen with their VA, even though the average working hours decreased in the agricultural sector and increased in the industrial one. In the case of Mexico, the most labor productive sectors are agriculture and transportation, even though agricultural sector has the negative TFP rates and the transportation has the biggest TFP rates.

[redacted]THE MODEL

Based on the basic Input-Output model we derive our measure of TFP, due to TC and CAV. We assume the Leontief's input-output model described by the equation:

$$(1) \qquad x_j = \sum_i a_{ij}\, x_j + v_j x_j = \left(\sum_i a_{ij} + v_j\right) x_j,$$

where, $X = [x_i]$ is the column vector of total output, $A = [a_{ij}]$ is the technical coefficient's matrix and $V = [v_j]$ is the a row vector of the added value. Then, taking the total differential of these variables, we obtain:

$$(2) \qquad dx_j = d\left[\left(\sum_i a_{ij} + v_j\right) x_j\right] = \left(\sum_i a_{ij} + v_j\right) dx_j + \left(\sum_i da_{ij} + dv_j\right) x_j,$$

where d is the differential operator. Now, we define the TFP growth for the j-sector in the model, as the growth in its total output that is not due to the growth in input, and corresponds to:

$$(3) \qquad \tau_j = -\left(\sum_i da_{ij} + dv_j\right).$$

This last equation measures the changes in total output given by the sum of the variations due to the changes on the technical coefficients -defined as TC-, and the change caused by the variations on the Value Added, defined as CAV.

Now, we can rewrite (2) as:

$$(4) \qquad dx_j = \left(\sum_i a_{ij} + v_j\right) dx_{j-}\tau_j x_j$$

Another form to express these changes is by using the identity $dlog(z)/dz = 1/z$, then $\mathrm{dz} = \mathrm{zlog}(\mathrm{z})$. Substituting into equation (3) we obtain:

$$(5) \qquad \tau_j = -\left(\sum_i \alpha_{ij}\, dlog(a_{ij}) + v_j dln(v_j)\right)$$

Finally, to obtain the TFP in terms of prices, we can deflected to prices in our reference year, as:

$$(6) \qquad \tau_j = -\frac{\sum_i p_i d\alpha_{ij} + p_j v_j dv_j}{p_j}\mathrm{z}$$

- THE DISCRETE MODEL

Now, as we have annually input-output data, we must to obtain a linear discrete approximation to the previous model. Assume data in years 0 and 1, we can use the finite difference form of the differentials given by $\mathrm{d}x_j \cong \Delta x_j = x_j^1 - x_j^0$, $\mathrm{d}a_{ij} \cong \Delta a_{ij} = a_{ij}^1 - a_{ij}^0$ and $\mathrm{d}v_j \cong \Delta v_j = v_j^1 - v_j^0$. Substituting in equation (2) can be given by,

$$(7) \qquad \mathrm{d}x_j \cong \Delta x_j = \Delta\left[\left(\sum_i a_{ij} + v_j\right)x_j\right] = \left(\sum_i a_{ij}^0 + v_j^0\right)\Delta x_j + \left(\sum_i \Delta a_{ij} + \Delta v_j\right)x_j^0$$

or specifically,

$$x_j^1 - x_j^0 = \left(\sum_i a_{ij}^0 + v_j^0\right)\left(x_j^1 - x_j^0\right) + \left[\left(\sum_i a_{ij}^1 + v_j^1\right) - \left(\sum_i a_{ij}^0 + v_j^0\right)\right]x_j^0$$

The TFP in finite-difference form is:

$$(5) \qquad \tau_j = -\left(\sum_i \Delta a_{ij} + \Delta v_j\right) = -[(i'\Delta A)' + \Delta v]$$

where i' is a transposed vector of 1's.

DATA AND METHOD

For our analysis, we consider the National Input-Output Tables (NIOT) for Brazil and Mexico, reported by the World Input-Output Database (WIOD) for the available period, 1995 to 2011. We begin the study by making an Spectral Analysis -exposed by Solís and García (2009)- which uses the Hermitian Matrix, obtained by forming a matrix with complex entries that combines the information of buys and sales of the sectors, to identify sectors with dominance over the clusters of sectors that are strongly related. In this sense, we obtain the ten most important sectors for each country in the year 2011, and we take these eight sectors that coincide in both countries (see Table 4-1).

Table 4-1 Ten most important sectors for Mexico and Brazil

Mexico	Brazil
2. Mining and quarrying	2. Mining and quarrying
8. Coke, refined petroleum and nuclear fuel	3. Food
9. Chemicals and chemical	8. Coke, refined petroleum and nuclear fuel
10. Rubber	9. Chemicals and chemical
12. Basic metals and fabricated metals	12. Basic metals and fabricated metals
13. Machinery, nec.	14. Electrical and optical equipment
14. Electrical and optical equipment	15. Transport equipment
15. Transport equipment	17. Electricity, gas and water supply
17. Electricity, gas and water supply	28. Financial intermediation
30. Renting of M&Eq and other business activities	30. Renting of M&Eq and other business activities

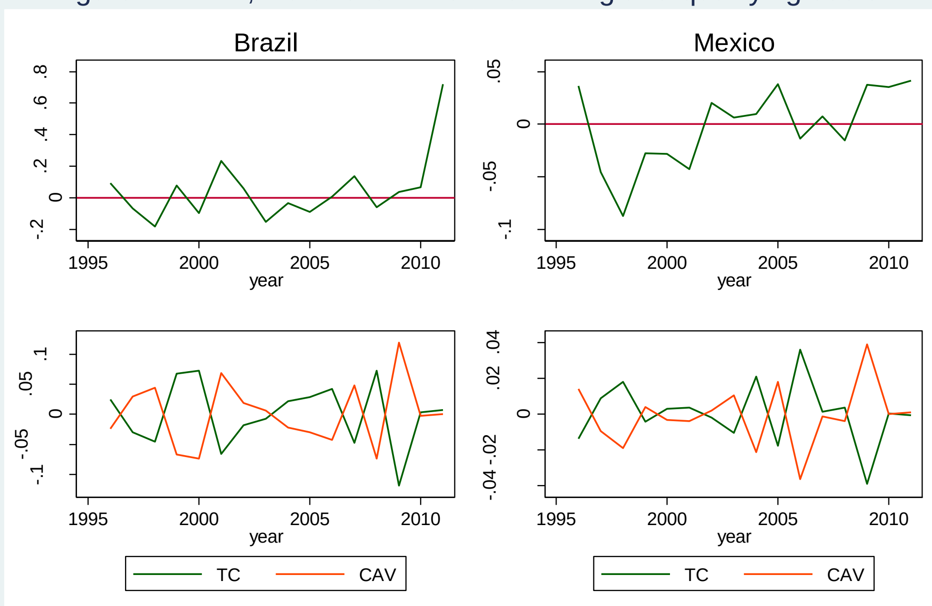
Data from WIOD

The time series were smoothed with stata's lowess option, which carries out a locally weighted regression of the variable. This was made in order to have a better comprehension of the growth dynamic in the period.

[redacted] TOTAL FACTOR PRODUCTIVITY FOR MEXICO AND BRAZIL: RESULTS

In this section, we analyze the TFP and their determinants for the eight most important sectors for both countries in order to see their increasing, decreasing or stagnated productivity rates.

Figure 2 1 TFP, TC and CAV for the Mining and quarrying sector

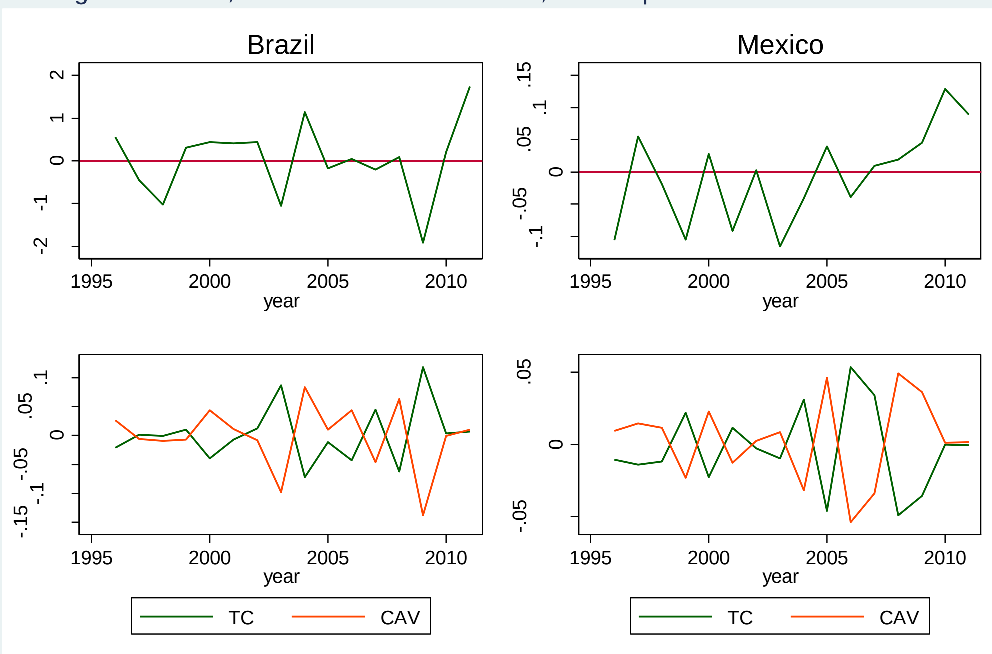


Data from WIOD

As we observe in figure 2-1, the mining and quarrying sector had a big decrease in its TFP after the 1994's Mexican crisis, which seems to be produced by the change in added value inputs. This means that more labor or capital inputs were required to do the same amount of output that in the year before. It is not until 2004 when the TFP growth turns from a negative rate to a positive one.

In the case of the Brazilian economy, even though it had bigger TFP growth rates in this sector than Mexico since 2006, at the beginning of the period it showed a stagnation on its productivity. It is clear that the predominant effect in the determination of the TFP growth is a change in AV in both countries.

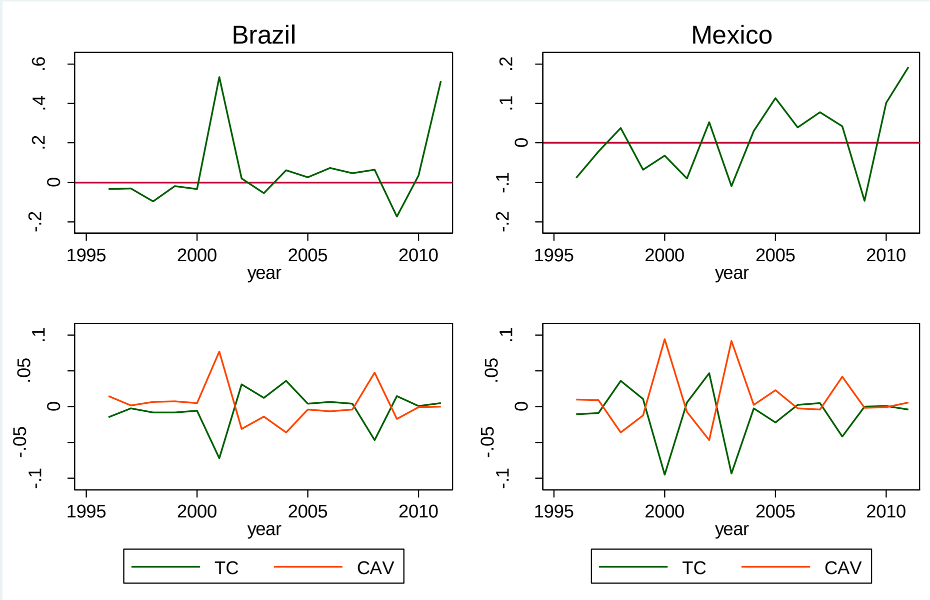
Figure 2 2 TFP, TC and CAV for the Coke, refined petroleum and nuclear fuel



Data from WIOD

As we can observe in figure 2-2, the TFP of the Mexican's Coke, refined petroleum and nuclear fuel sector presented negative rates until 2006, when it began to exhibit positive and increasing rates. It is important to show up that, when the TFP rate became positive, TC and CVA exchanges their sing. In Brazilian case, we obtain positive TFP growth rates between the years 1999 and 2005 which were boost by CVA, while the growth after 2009 was boost by TC (the use of less inputs to produce the same).

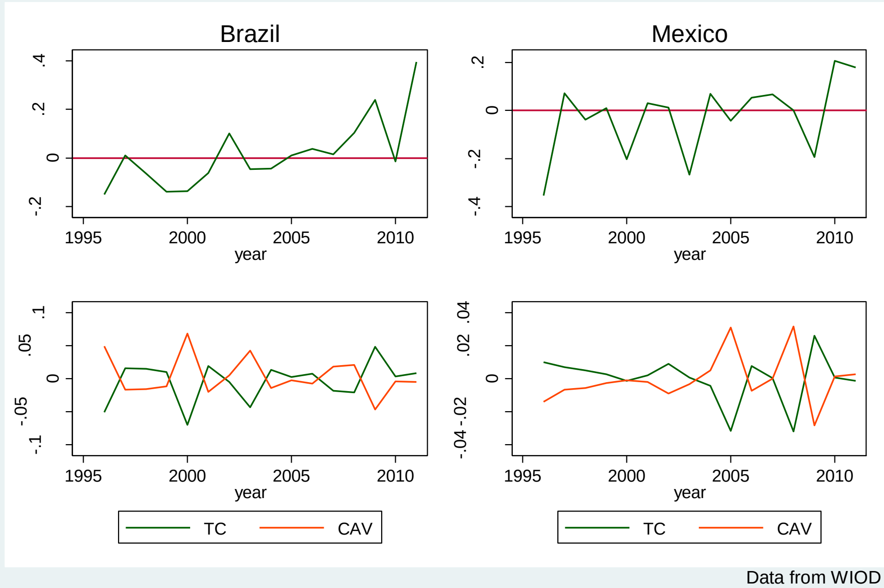
Figure 2 3 TFP, TC and CAV for Electricity, gas and water supply



Data from WIOD

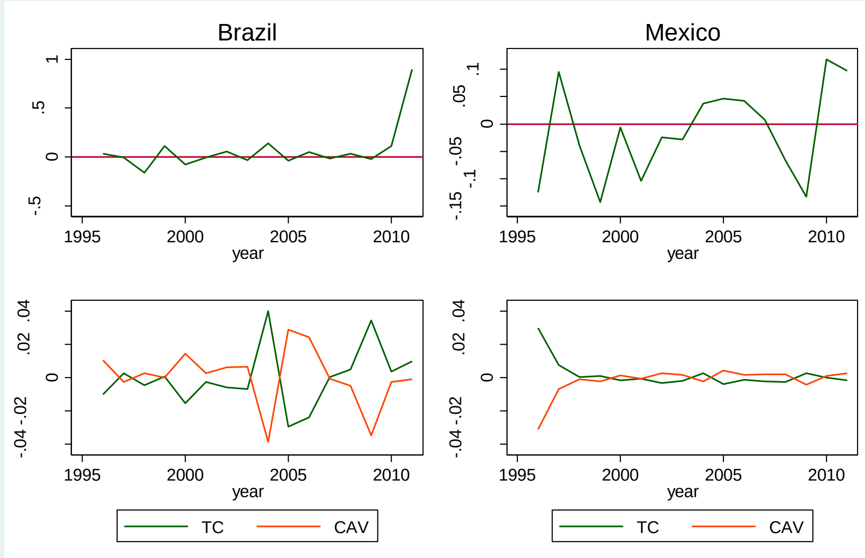
With the results presented in figures 2-2 and 2-3, we can conjecture that the electricity, gas and water supply sector was deeply related with the coke, refined petroleum and nuclear fuel sector. This can be explain by the close dependence of gas extraction and energy production with oil. This sector, electricity, gas and water supply, is more productive in Brazil than in Mexico, and for both countries it seems to be boost by the technical change, which means that this sector requires fewer inputs to produce outputs. CVA in Mexico seems to be related to its TFP growth rate till 2001; but after that, the raise in the TC appears to explain the raise in the TFP growth rate.

Figure 2 4 TFP, TC and CAV for Chemicals and chemical



Chemicals and chemical sector is very important, especially in Mexican economy. As we can see in figure 2-4, this sector shows higher TFP growth rates in Brazil than in Mexico. In the first case, it appears that the positive TFP growth rates were boost by the TC since 2004. It seems that in the second case the Mexican TFP was boost by TC since 2006.

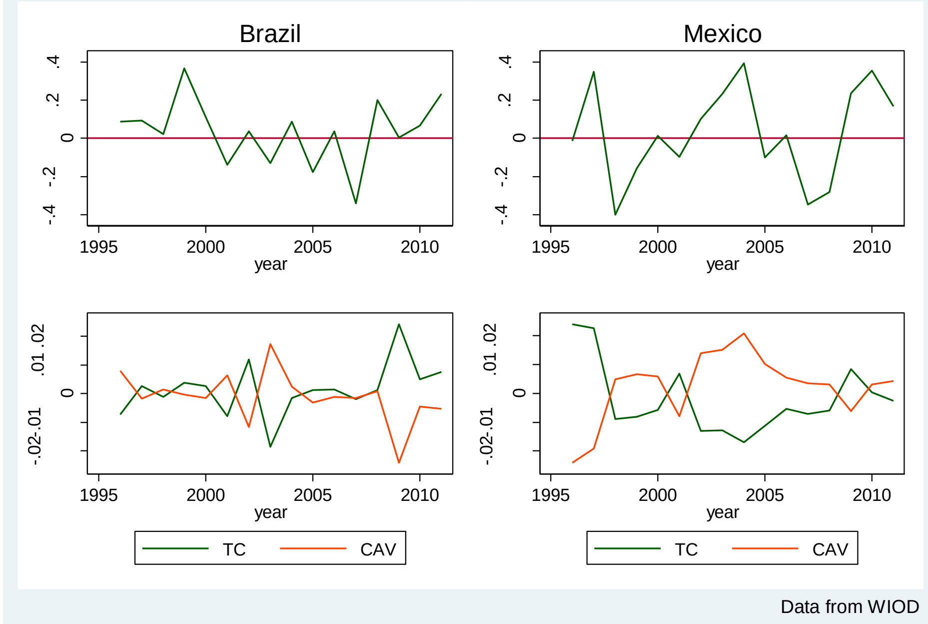
Figure 2 5 TFP, TC and CAV for Basic metals and fabricated metals



Data from WIOD

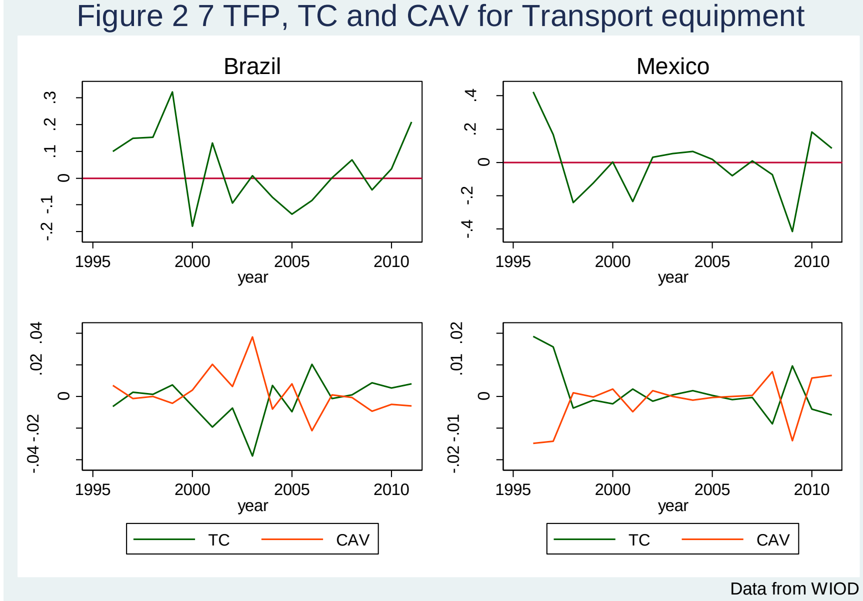
Basic metals and fabricated metal sector is the most productive of the eight sectors analyzed for Brazil, which seems to be due to TC, meaning that since 2001 this sector employs lees inputs to produce. In the Mexican case this sector present the same pattern as the rest of the Mexican sectors, a negative TFP growth rate previous to 2006 and a positive one after this year. In this case it is difficult to notice to which one is the predominant effect, aimed that both changes are stagnated since 2001.

Figure 2 6 TFP, TC and CAV for Electrical and optical equipment



It is noticeable that Mexico is more productive than Brazil, in electrical and optical equipment sector. In the Brazilian case, the changes in TPF seems to be due to TC; while in the Mexican case the behavior of the TPF seems no to be related to neither of the TC or CVA changes.

Figure 2 7 TFP, TC and CAV for Transport equipment

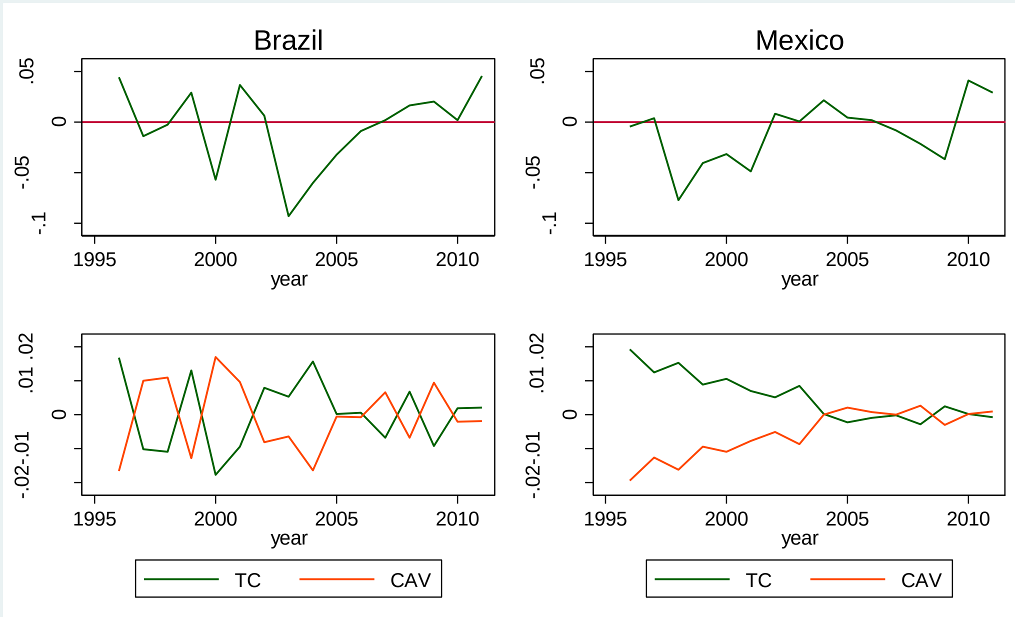


Transport equipment is an important sector for Brazilian economy and has a similar behavior than electrical and optical equipment sector. As the figure 2-7 shows, its TFP growth rate has a “U” shape behavior, decreasing before 2005 and increasing after that. This behavior seems to be due to the TC. In the Mexican case, we observed a decreasing TFP growth rate since 1995 to 2000, when it began to present a negative stagnation till 2010. This behavior can not be explained by neither TC nor CVA, which remains unchanged in the same period.

Finally, we observed that renting of m&eq and other business activities sector were important for both economies. The Brazilian TFP growth rate had a similar “U” shape behavior as the two previous sectors, decreasing until 2003 and growing after that year. In the Mexican case, the TFP growth rate has presented an increasing tendency since 1998.

For this sector it is not possible to determine the relationship between TFP and the changes in technology and VA.

Figure 2 8 TFP, TC and CAV for the Renting of M&Eq and other business activities



Data from WIOD

[redacted] Conclusions

Since the 1980's Latin-American economies have been distinguish for having low or stagnated TFP rates in most of their sectors (Ros, 2014). That can be explained because of their low rates of capital accumulation per worker and the fact that they are labor intensive economies. Even though Brazil's and Mexico's industry had growth in the last decades (at lower rates than before the 1980's when they had an important industrialization period), their industry have not been able to absorb all the labor force, sending most of them to the service sector; a sector that its characterized for having low rates of capital accumulation per worker. Because of that, in the last years, both, Brazilian and Mexican economy have presented an important growth of the services but with low productivity levels.

In general, for all eight analyzed sectors we found that Brazilian industry have been more productive than Mexican one since 2005, when Brazilian productivity began a period of stagnation and the Mexican one becomes negative.

We also found two general patterns: the first one where since around 2005 the production required less inputs compared with previous years (a positive TFP rate), the second one have an "U" shape pattern and in general between 2000-2006 the TFP was negative, which means that the production were less productive. The explanation for this is that the industry's productivity have been stagnated and the services activities are characterized for been low-productivity, as said before.

It is also important to notice that in both countries the participation of the CAV effect seems to be more important than the effect of the TC, which means that the change in labor or capital inputs affects more the Total Factor Productivity in Mexico and Brazil than the technical change. The latter supports the hypothesis that it is the relationship between the ratio capital per worker what makes an economic sector productive.

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