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ECONOMIC EFFICIENCY OF THE MEXICAN METROPOLITAN REGIONS BETWEEN 1998 AND 2008

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ABSTRACT

This paper attempts to add evidence on the issue of disparities in economic efficiency among the metropolitan economies in the period 1998-2008 by examining the differences and evolution of efficiency. The analysis includes estimates of the technical efficiency for the 56 metropolitan regions in Mexico by means of data envelopment analysis for the years 1998, 2003 and 2008. The paper will provide information on the functionality and relative productive performance of metropolises in Mexico in order to guide further analysis as well as private and public policy projects and programs that support an improved performance and participation in the global and local scenes. Even though economic efficiency is a partial vision of the complex running of a metropolis, it is a subject of valid relevance.

Key words: Technical efficiency, productivity, competitiveness, Metropolitan regions, Mexico

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I. Background: metropolisation and metropolitan economies

Nowadays metropolitan spaces are key territorial references for analysis and action because of their critical economic, social and political importance. In effect, metropolitan areas are considered the most economically active territorial component, and therefore an engine of economic and social development. Indeed the trend towards a greater concentration of population and economic activities in the metropolis has increased because of the opportunities for wealth, investment, employment and value added creation. They are also conceived as the strategic spaces for the insertion of national economies to the global economy. Hence in a globalised economy where competition is clearly advocated by several investment and resources, has increased the interest in promoting economically to metropolitan regions. However beyond the general processes in the metropolitan areas, great heterogeneity in their trajectories is documented. Namely some metropolises show greater capacity to turn into competitive and productive areas. Furthermore, even if these metro areas offer greater opportunity for economic revitalization they are unstable because of the potential conflicts associated with competition for resources with other regions.

Thus the economic analysis of metropolitan territories must allow for these two complementary arguments: the presence of generic economic advantages of metropolitan spaces vis-a-vis their differential economic behaviour (Méndez, 2007). The economic heterogeneity reflects in indicators such as GDP, GDP per capita, productivity per worker and efficiency performance, each representing a different phenomenon. Therefore a profound knowledge and diagnosis about the specificities and differences among metropolises is called for.

Specifically numerous analyses have been directed to the study of the economic efficiency of cities, metropolises and regions. Efficiency as well as productivity is a concept employed as reference to measure economic units' performance. Not occasionally they are treated interchangeably and as synonymous although these terms are not exactly identical. Generally both terms refer to processes where those units transform inputs into goods or services. Yet productivity can be defined as the relationship between the outputs of an economic production process and the inputs provided to create those outputs. On the other hand, Farrell in 1957 conceptualises economic or global efficiency as having two components: technical and allocative efficiency. Technical efficiency is the ability to maximise outputs from a given combination of inputs; it conceives the production function as a production frontier where efficient allocations are on the boundary while inefficient allocations situate under the frontier being this is a purely technical concept of optimal assignation of resources. Allocative efficiency is the capability of producers to combine inputs to obtain outputs in the best way taking into account prices and marginal productivities (Fuentes, 2000).

At the territorial level the concept of economic efficiency refers to how close a particular territory is to its optimal production levels given a production technology and factor endowments. At the metropolitan scale resource efficiency: "can also be defined as the ratio of total effective outputs to the corresponding total inputs under a certain production and technology level, which is a comprehensive indicator of resources allocation, operation situation and management level of metropolises" (Guo et al., 2011, p. 747).

The relevance of economic efficiency at the metropolitan scale is that high efficiency means reasonable resources allocation, appropriate management, coordinated development of various urban aspects and therefore strong competitiveness (Guo et al., 2011). In the literature a number of works address this aspect of the economic performance of territories or their economic sectors. In the urban and metropolitan contexts (Charnes et al., 1989) assess the urban economic performance of 28 cities in China for 1983 and 1984 using Data Envelopment Analysis (DEA); while Guo et al. (2011) investigate efficiency, its changes and causes in 31 Chinese metropolises for the years 1990, 2000 and 2006 by implementing DEA and the Malmquist index. Emrouznejad (2003) analyses the production efficiency of OECD countries in 1983 and 1988 employing a dynamic DEA approach, whereas Fare et al. (1994) analyse productivity growth in seventeen OECD nations over 1979-1988 calculating the Malmquist index. At the continental level Ezcurra et al. (2009) examine productivity, efficiency and technological change in the European Union regions over the period 1986-2006 by means of DEA and Malmquist index.

Other papers focus on the efficiency and/or productivity of particular sectors - mainly of manufacturing- in regions or cities in diverse latitudes, by using parametric and non-parametric methods of efficiency computation (see for instance Maudos et al. (2000) Karadağ et al. (2005), Angeriz et al. (2006), Jajri and Ismail (2006) and Roberts et al. (2007)).

Within the OECD, 78 metropolitan areas with more than 1.5 million each are calculated. Along with their demographic weight, they concentrate even a higher proportion of economic activity and employment, with labour productivity and GDP per capita above the respective national average in 66 of these cases. In the European Union alone, the agglomerations with over one million people also have a level of per capita income 25% higher to the EU average and up to 40% compared to the national average for each country (Mendez, 2008).

Latin America offers a variety of situations to examine since their metropolitan spaces have evolved within widely diverse physical, economic, social and political contexts, influencing its dynamics and production structures. Productive activities have been structured to meet, on the one hand, the needs of external demand or, on the other hand, to meet the demand of the metropolis itself. That is, different productive networks coexist in the metropolitan economies, ranging from global complexes to formal and even informal local level structures (Cuadrado-Roura & Fernández Güell, 2005). Not to mention that Latin American metropolitan areas have experienced comparatively high economic, social and environmental costs, selective relocation, unemployment, poverty, exclusion, insecurity and congestion (Mendez, 2008).

Mexico is a Latin American middle income country that change, at the onset of the 1980's, to an open and export oriented strategy of industrialisation and development. In the previous import substitution economic model, the urban structure in this country was characterised by the existence of a principal city, Mexico City, where the national government offices, the largest concentration of population (and the market), industry, services and infrastructure seated. Two other cities with more than a million people were Guadalajara (in the centre-west) and Monterrey (in the North), however the urban system became more complex. In addition to an economic reformation, a spatial restructuring took place in the form of the emergence of several cities with qualities of metropolitan areas.

In 2005 the government established officially the existence of 56 Metropolitan Zones (MZs), only 7% of the country´s surface. Nevertheless, the 56 MZs account for 56% of total population and 79% of urban population. These metropolitan agglomerations concentrate more than 75% of national GDP and therefore the largest part of the economic prosperity and growth is expected to originate within them (SEDESOL et al., 2005).

Apart from having the opportunities to expand economically and improve the quality of life of their population, the former and emerging metropolitan areas are facing economic challenges such as the creation of jobs and the conditions for capital accumulation. Additionally it seems that the most mobile factors of production -many forms of labour, capital and technology- are dominated by a few urban centres, thus other cities are left with obsolete physical capital and the less qualified labourers which in turns translates into a heterogeneous metropolitan distribution of productivity, profits and efficiency. Consequently there is not just the need of competitive and efficient metropolis what the country faces but also the challenge to extend the urban development benefits to all cities and inhabitants.

There are several examples of competitiveness, and labour or factor productivity studies of Mexican cities or states. Nonetheless there is little empirical research on the technical efficiency of territories, and as far as we are aware there has been a relatively scarce or none recording of economic efficiency in cities and metropolitan areas in Mexico. At the regional or state level Becerril Torres et al. (2007) and O. Becerril-Torres et al. (2010) analyse technical efficiency and convergence among Mexican states by using a stochastic frontier model approach. In (O. U. Becerril-Torres et al., 2010) they look at the effect of infrastructures on convergence in efficiency across states in Mexico. Bannister and Stolp (1995) on their part analyse efficiency and geographic concentration of the Mexican manufacturing sector, while Trejo Nieto (2011) evaluates the location and efficiency of the service sector in Mexico.

This paper attempts to add evidence on the issue of disparities in economic efficiency among the metropolitan economies in the period 1998-2008 by examining the differences and evolution of efficiency. The analysis includes estimates of the technical efficiency for the 56 metropolitan regions in Mexico by means of data envelopment analysis for the years 1998, 2003 and 2008. The paper will provide information on the functionality and relative productive performance of metropolises in Mexico in order to guide further analysis as well as private and public policy projects and programs that support an improved performance and participation in the global and local scenes. Even though economic efficiency is a partial vision of the complex running of a metropolis, it is a subject of valid relevance.

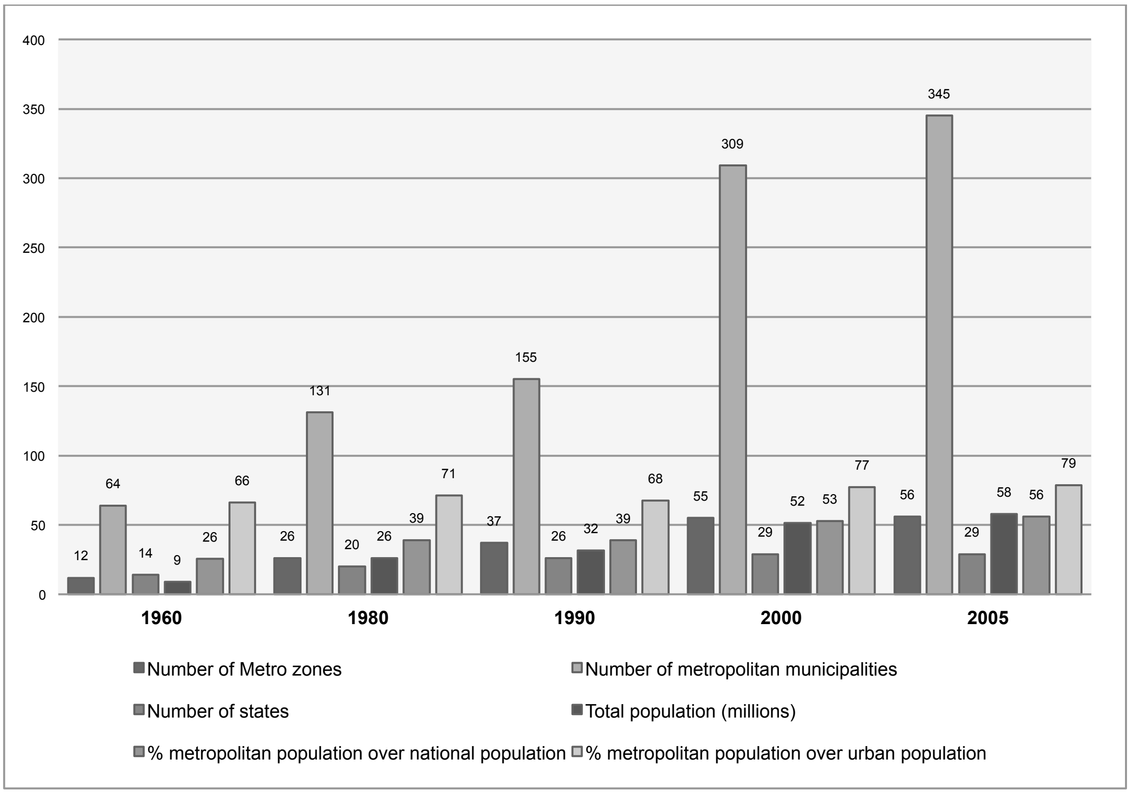
II. The Mexican Metropolitan System

As pointed out by Garza (2010) the process of urbanisation in Mexico has a manifest metropolitan character; in order to deepen our knowledge about the type of the spatial structuring of economic activities and population, as well as the implications for economic development, the analysis of the evolution of metropolisation and metropolis is fundamental. In recent literature various reviews such as SEDESOL et al. (2005), Rionda-Ramírez (2007), Garza (2007), (Garza, 2010) and Jalomo Aguirre (2011) have documented the metropolitan character of urbanisation in Mexico. The origin of the metropolitan phenomenon in the country dates back to the 1940's when the physical expansion of cities exceeded the boundaries of two or more states or municipalities resulting in the formation and growth of metropolitan areas. This phenomenon started to shape the 'new urbanisation' that has been consolidated in recent decades.

Metropolisation was prompted largely by the stimulus to industrial development that was characterised by a strong centralisation of employment and manufacturing production. Such economic centralisation encouraged permanent rural-urban migratory movements with which the metropolitan phenomenon began to spread, so that from the 1970's Mexico developed into a predominantly urban country.

As for the progression of the metropolitan system in Mexico in the 1940's there were 5 cities with characteristics of metropolises. In 1960 twelve MZ's were identified, in the 1980´s 26, 37 in the 1990´s and 55 in 2000. In 2005 fifty six official metropolitan areas were classified by the federal administration. These 56 MZ´s represent only 7% of the land surface but comprise 56% of the total national population and 79% of the urban population, while they generate about 75% of production. As shown in Figure 1, currently the metropolitan system comprises a total of 345 municipalities, with 29 federal states out of 32 (including the Federal District/Mexico City) containing at least one metropolitan zone (SEDESOL et al., 2005).

Figure 1. Indicators of the metropolitan process in Mexico, 1960-2005



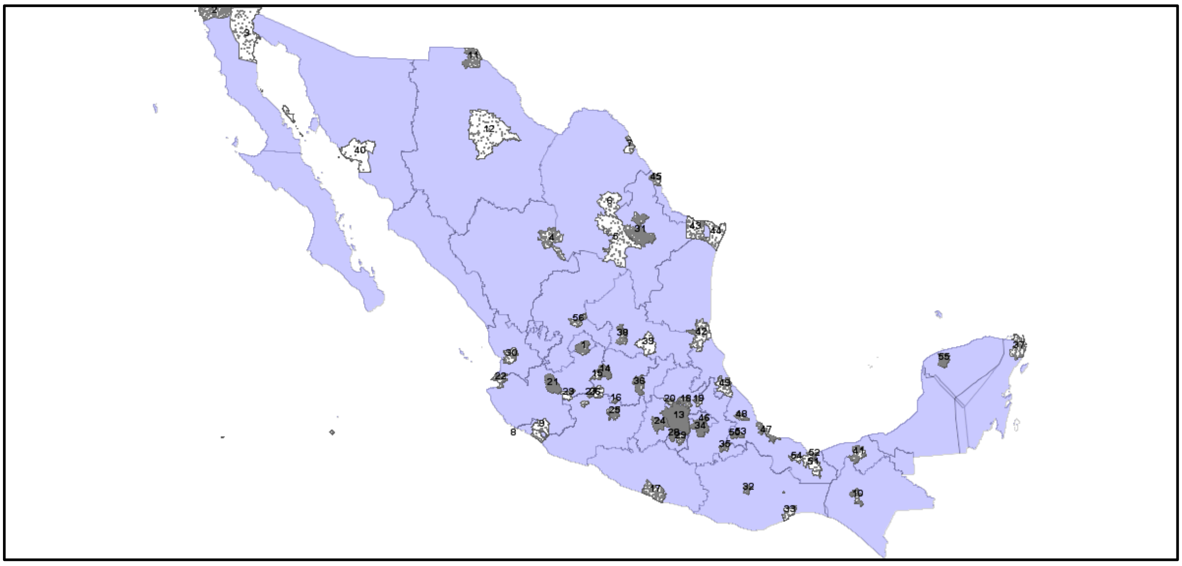
Source: Author´s elaboration based on information from the Ministry of Social Development, Council of National Population, National Institute of Statistics, Geography and Informatics (2007).

Of the 56 metropolitan areas, 7 are located at the United States (US) border: Tijuana, Mexicali, Ciudad Juarez, Piedras Negras, Matamoros, Nuevo Laredo and Reynosa-Rio Bravo; 9 are seaports or have touristic developments: Tijuana, Guaymas, Puerto Vallarta, Tecoman, Acapulco, Cancun, Coatzacoalcos, Veracruz and Tampico; the rest are located inland. Of these a major proportion settles in the centre of the country (Figure 2).

In this regard Garza (2010) draws attention to the emergence in the 1980's and the subsequent development of a megalopolis phenomenon in the urban subsystem in the centre of the country, namely the union of two or more overlapping ZM's, in this case the Metropolitan Areas of the Mexico Valley, Toluca, Puebla, Cuernavaca, Queretaro, and

Pachuca. Such poly nucleus region is still evolving as some MZ's have not been fully incorporated.

Figure 2. Metropolitan Zones in Mexico and population density 2010



Source: Author´s elaboration based on information from INEGI, Population and Housing Census Mexico 2010

According to their absolute population sizes, the largest MZ's are Mexico City Metropolitan Zone (MCMZ), Guadalajara (GMZ), Monterrey (MMZ), Puebla-Tlaxcala (PTMZ) and Toluca (TMZ) all with over a million people in 2010 and of which three are located in the centre of the country (MCMZ, PTMZ and TMZ). An noteworthy instance is MCMZ which by itself has 20 million people one of the biggest metropolis in the world. The smallest MZ´s are Tecoman, Ocotlan, Rio Verde-Ciudad Fernandez, Moroleon-Uriangato and Acayucan which generally do not exceed the 150 thousand inhabitants (see Table 1).

The average population in the MZ´s has shifted from about 750 thousand people in 1990 to over 1 million 100 thousand in 2010, yet heterogeneity between them is wide; e.g. 100 thousand people live in Uriangato whereas 20 million live in MCMZ. Thus the MCMZ continues to dominate the metropolitan system; however the full upright hierarchical scheme has been restructured from the 1990's. The relative decline of Mexico City compared to other cities has made them gain some influence, and the relations while still "subordinated" are less vertical (Rionda-Ramírez, 2007).

Table 1. MZ´s by population size 1990, 2000, 2010

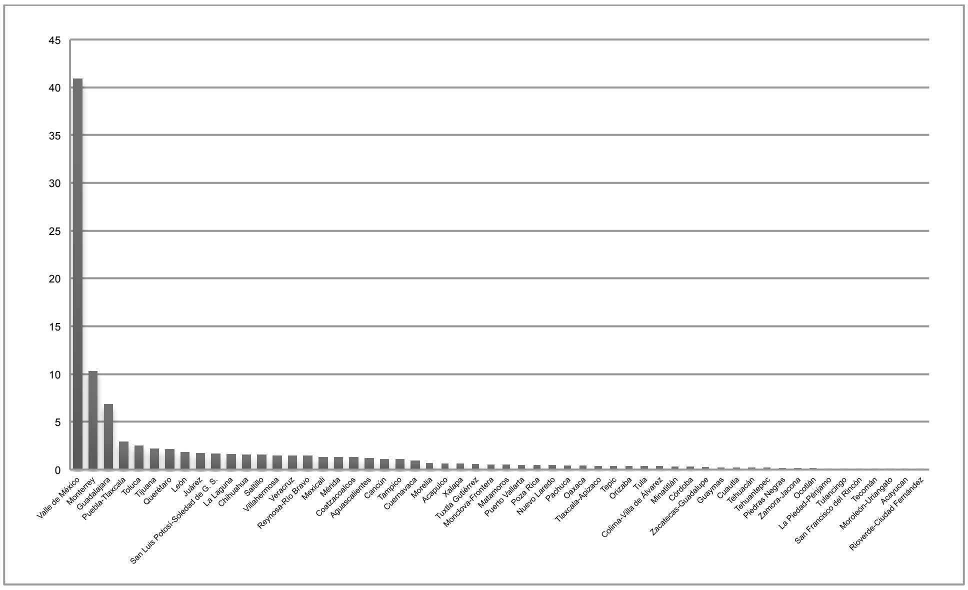
	1990		2000		2010	
1	Mexico City	15,563,795	Mexico City	18,396,677	Mexico City	20,116,842
2	Guadalajara	3,003,868	Guadalajara	3,699,136	Guadalajara	4,434,878
3	Monterrey	2,666,809	Monterrey	3,374,361	Monterrey	4,089,962
4	Pueb-Tlaxcala	1,735,657	Pueb-Tlaxcala	2,199,513	Pueb-Tlaxcala	2,668,437
5	Toluca	1,061,065	Toluca	1,471,146	Toluca	1,846,116
52	San Fco del Rincón	114,034	Rioverde-Cd Fdez	128,935	Tecomán	141,421
53	Tecomán	110,481	Tecomán	127,863	Ocotlán	141,375
54	Ocotlán	101,905	Ocotlán	125,027	Rioverde-Cd Fdez	135,452
55	Moroleón-Uriangato	94,901	Acayucan	102,992	Acayucan	112,996
56	Acayucan	91,323	Moroleón-Uriangato	100,063	Moroleón-Uriangato	108,669
Aver		759,910		950,333		1,115,434

Source: INEGI, Population and Housing Census Mexico 1990, 2000 y 2010.

The distribution by economic size in 2008 (measured as the share in total metropolitan GDP) shows that the five biggest MZ´s are also de biggest metropolises by population (Mexico City, Monterrey, Guadalajara, Puebla-Tlaxcala and Toluca). Mexico City Metropolitan Zone (or Mexico Valley) is once more the biggest, but whereas Guadalajara is the second by population Monterrey follows Mexico City in economic size. Figure 3 shows the distribution of total GDP among all MZ´s. There is a clear pattern of polarisation: Mexico City accounts for more than 40% of metropolitan product, Monterrey above 10%, Guadalajara almost 7%, Puebla around 3% and Toluca over 2.5%. Only these five MZ´s generate approximately 63% of GDP, meanwhile 37% is distributed across the remaining 51 metropolises.

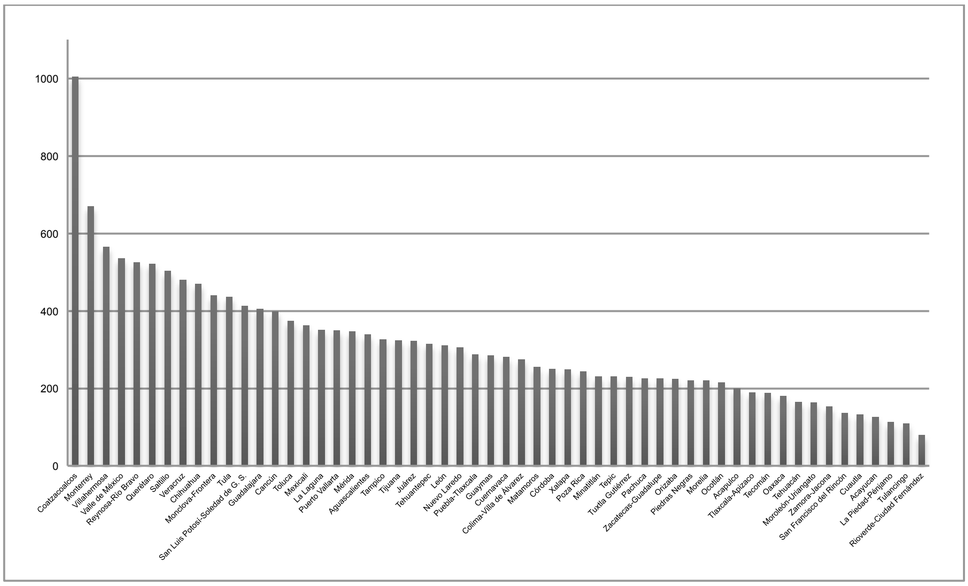
The metropolitan distribution of GDP per capita (pc) is less heterogeneous and shows that the hierarchy is different (figure 4). A pattern of metropolitan disparities is patent; nonetheless GDP pc is not as polarised as absolute GDP. In 2008 among the MZ´s with the highest GDP pc are Coatzacoalcos and Villahermosa; however the result for these metropolitan spaces is affected by some oil related economic activities. The income generated by these productive branches is allocated by the central administration to all federal states and municipalities, and therefore is not truly representing those metropolitan zones-specific GDP. Otherwise the richest per capita metropolises are Monterrey, Mexico City, Reynosa-Rio Bravo, Queretaro and Saltillo. Reynosa is an industrial city close to the border with the US and with an important proportion of maquiladora plants. Saltillo is in the Northeast of the country, relatively close to the US and highly specialised in the car industry. Queretaro is in central Mexico, somewhat close to Mexico City, more linked to the domestic economy and with a growing modern industrial sector and an expanding population. The less prosperous metropolises are, in general, those with the smallest economies.

Figure 3. MZ's by GDP size in 2008 (share in total metropolitan GDP %)



Source: Own elaboration with data from INEGI Mexican economic censuses 2008.

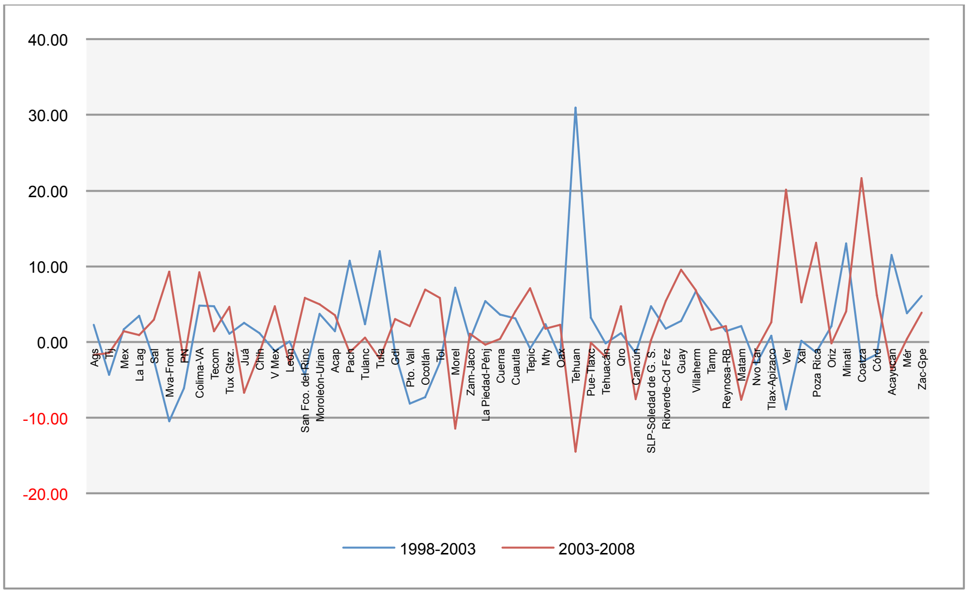
Figure 4. MZ's by GDP pc size in 2008 (thousand pesos)



Source: Own elaboration with data from INEGI Mexican economic censuses 2008.

Concerning GDP pc dynamics, figure 5 shows the heterogeneity in metropolitan growth rates and their instability between 1998-2003 and 2003-2008. There is not a clear pattern on the characteristics of growing metropolises; yet the highest rates in the two periods correspond to MZ´s where oil related activities are developed (Tula, Tehuantepec, Coatzacoalcos, Poza Rica), although they are also the more unstable. Also a group of small MZ´s have significant growth rates (Colima, Guaymas, Tepic, Acayucan, Tecoman).

Figure 5. GDP pc Average Annual Growth by MZ 1998-2003 y 2003-2008 (%)



Source: Own elaboration with data from INEGI Mexican economic censuses 1998, 2003 and 2008.

III. Efficiency and its Measurement with Data Envelopment Analysis (DEA)

Farrell in 1957[1] proposed a measure for efficiency in cases where the production function is unknown, which is generally the case. In such cases it is necessary to estimate first a theoretic efficient production frontier. For that various methods exist and they differ in the kind of indicator they produce, the data they require, and the assumptions about the production technology and the underlying behaviour of economic agents. Coelli et al. (1998) suggests various methods among them the so called Data Envelopment Analysis (DEA). DEA was presented initially by Rhodes in 1978 and is considered an extension of Farrel's work. It is a non-parametric method which uses linear programming and principles of frontier analysis which builds an envelope surface, efficient frontier or empiric production function using a data set of similar cross section units or decision making units (DMUs). DEA compares input-output relations of decision making units assuming that any DMU uses the same kind of inputs to produce the same kind of outputs, nonetheless input and output quantities vary across DMUs. Some of these units determine the maximum output achievable, which are the efficient units. By measuring the distance from a specific input-output relation to the efficient frontier, an efficiency score is derived for all other DMUs.

In other words the estimated frontier is obtained using the best practice technology from a given vector of inputs produced by the most productive units in the sample. These will be the referents of comparison for future improvement. Therefore DEA provides a relative measure of efficiency and thus the efficiency estimates are more properly described as efficiency relative to the "best practice" frontier (Bannister & Stolp, 1995). Moreover DEA measures efficiency from an internal perspective in the sense that it only compares the use of inputs and/or the achievement of certain level of output among similar economic units and do not consider absolute efficiency. That is to say, a unit being on the production frontier does not mean that it has reached its maximum efficiency but that the inefficient units can improve their performance.

[1] Cited by Coelli et al. (1998).

To sum up the method is used to obtain efficiency indicators, identify efficient and inefficient units, compare units of analysis and implement actions of improvement for inefficient firms to increase their efficiency.

DEA has been widely used by reason of a number of advantages: it does not require particular statistical assumptions about the production function (it obtains an efficient frontier within a deterministic framework); allows for multiple inputs and outputs; gives indicators of the relative efficiency of economic units; unlike econometric methods DEA estimates maximum potential output rather than mean output. Furthermore, in addition to the efficiency indices, this method gives the slacks (amount of inputs (outputs) that need to be reduced (increased) to become efficient), the peers or efficient reference units, and the projected values of input or outputs to be efficient. Consistent with Coelli et al. (1998) shortcoming also must be considered: 1) DEA is not appropriate for testing statistically hypotheses. 2) It does not take into account random factors. 3) It does not specify the optimal number of observations, and the number of output or input variables.

There are two orientations when measuring efficiency according to how we state the efficiency objective:

1. Input oriented: referring to an input minimisation problem to reach a specific output level.

2. Output oriented: given a set of inputs the objective is to maximize the output(s).

One of the basic and more widely used DEA specifications is the input oriented model with constant returns to scale (CRS) presented by Coelli et al (1997). The procedure consists of calculating the output/input ratios for each unit of analysis:

$$u'y_1 / v'x_1$$

In a production process where there are K inputs (x_1, x_2, ..., x_K) and M outputs (y_1, y_2, ..., y_M) u is a $Mx1$ vector of the output weights and v is a $kx1$ vector of the input weights. Through linear programming the optimal weights can be obtained:

$$\text{Max}_{u,v}\ (u'y_i/v'x_i),$$

$$\text{st}\ \ u'y_j/v'x_j \leq 1,\ j=1, 2,\ldots,N$$

$$u, v \geq 0$$

The model involves optimizing the objective function, defined as the ratio of the weighted sum of outputs and the weighted sum of inputs. From this maximisation problem the efficiency indicators are estimated. The function is optimized subject to the condition that the minimum efficiency value is 0 and the maximum level cannot be greater than one, implying that efficient units will have a score of one whereas values below 1 imply some degree of inefficiency.

After a reformulation and using duality the DEA problem can be expressed in the envelopment form of the input oriented theoretical CRS model:

$$\text{Min}_{\theta\lambda}\ \theta,$$

$$\text{S.t.}\ \ -y_i+Y\lambda\geq 0$$

$$\Theta x_i-X\lambda\geq 0$$

$$X\lambda\geq 0$$

Where θ is a scalar and λ is a vector of $Nx1$ constants. The problem is solved N times to obtain a value of θ for each unit of analysis.

This formulation gives measures of technical efficiency since it does not consider output and input prices. In addition it assumes CRS in production which in many cases is an unrealistic assumption since an optimal scale in production is not the rule. Banker, Charnes and Cooper in 1984 reformulate the model to a more general case where Variable Returns to Scale (VRS), increasing or decreasing, are possible. The VRS model does specify if units operate with increasing or decreasing returns. For that an alternative model is the Non Increasing Returns to Scale (NIRS). If VRS and NIRS results are identical then the unit operates with decreasing returns (Coelli et al., 1998). The basic model is modified by adding restrictions on the linear programming problem accordingly.

In order to avoid the problem of merging several inputs (or outputs) into a measure for overall input (or overall output) DEA uses the weighting factors (sometimes interpreted as "shadow prices") for all inputs (and all outputs), this breakdown the possibly different scales of the inputs (and outputs, respectively) onto the same scale. As these weighting factors are generally unknown, they are simply treated as variables in the linear programming estimations, and are thus related to the solution rather to the input of the efficiency assessment.

IV. Technical and scale efficiency in the MMZ´s

In this section the estimates of technical efficiency for the 56 Metropolitan Zones in Mexico are presented. These spatial units are the Decision Making Units (DMU) in the DEA analysis, although what we are really assessing is the aggregate economic activity in the MZ´s.[2]

The selection of inputs and outputs is based on the available information and the indicators used in other studies. For instance, Charnes et al. (1989) use labour (number of staff and workers, exclusive of farm labour), working fund (circulating capital), and investment (new fixes assets and capital construction) as inputs to asses China´s urban performance; the outputs are gross industrial output, profit and taxes and retail sales. As an alternative resources inputs can be capital (fixed assets and liquid capital), human resources (skilled workers), techniques (institutions, rules, skills, information, and knowledge), and natural resources (land, water, minerals); outputs can be represented by Gross Metropolitan Product (Guo et al., 2011). Similar to Ezcurra et al. (2009), here real gross value added (2003 prices) is used as the output variable, and labour (occupied workforce) and capital (the real value of fixed assets) are the inputs.

DEA analysis requires the homogeneity of inputs and outputs across DMU´s; however the mix of skilled and unskilled workers can vary importantly across metropolitan regions, likewise the characteristics of physical capital. Here a strong assumption is used, that capital and labour are homogeneous. Data were taken from the INEGI economic censuses in 1998, 2003 and 2008. A VRS DEA model with an output orientation is used. This implies that economic units operate under variable returns to scale (in the view of the improbability that technologies operate under constant returns

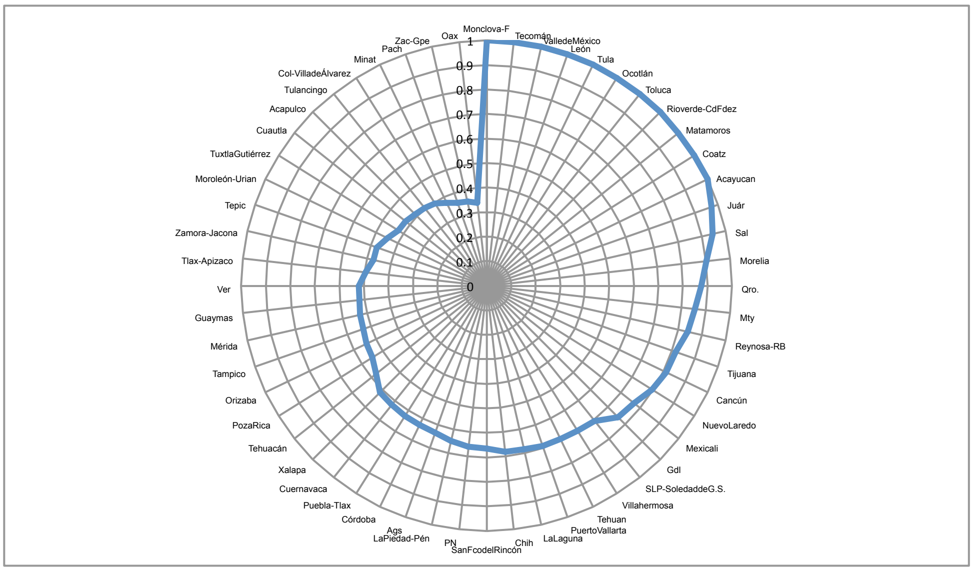
[2] Excluding most primary activities.

to scale) and that the objective of DMU´s is to maximize output given their input endowments (from the policy point of view it seems more reasonable to expect increases in material surpluses than decreases in capital accumulation and employment).

a) Technical efficiency

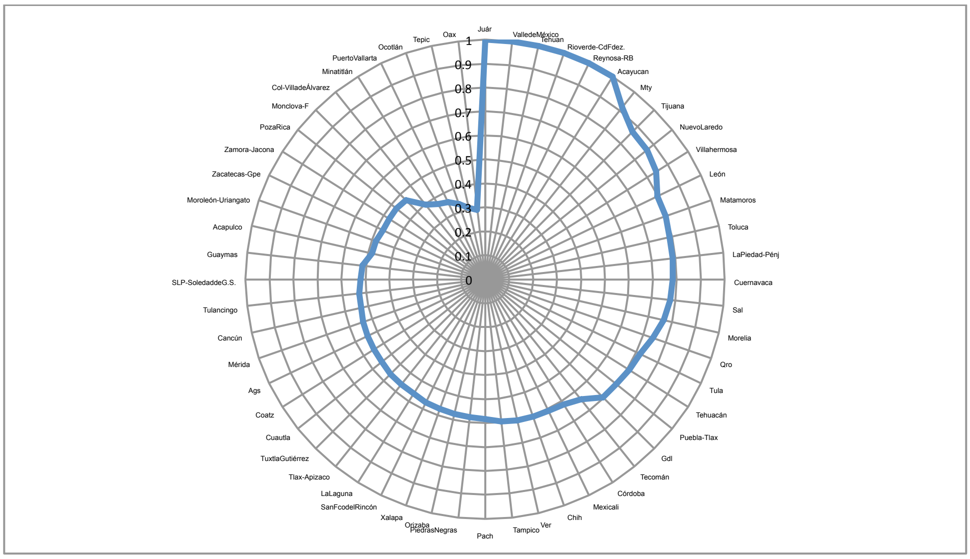
In the year 1998 almost one fifth of metropolises were efficient, while 45 of them showed some degree of technical inefficiency. This is a sign of the poor relative performance of most of MZ´s economic structures. Furthermore, by looking at figures 6 to 8 one can observe that the number of inefficient units increase over time. Supposing that the external circumference in each graph is the efficient frontier, only six metropolises reach full efficiency in 2003 and only four in 2008.

Figure 6. Metropolitan efficiency in 1998



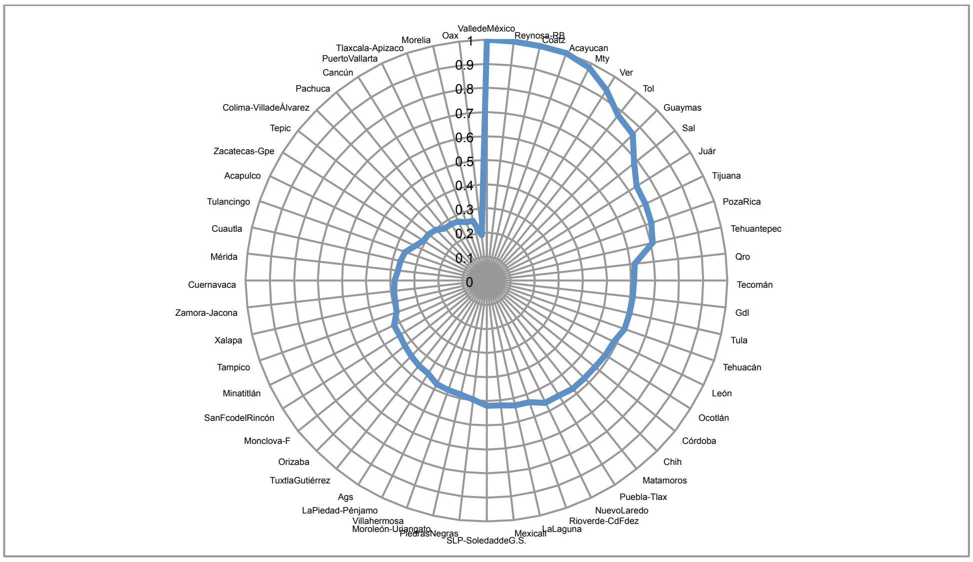
Source: Author´s elaboration with information from INEGI economic census 1998.

Figure 7. Metropolitan efficiency in 2003



Source: Author´s elaboration with information from INEGI economic census 1998.

Figure 8. Metropolitan efficiency in 2008



Source: Author´s elaboration with information from INEGI economic census 1998.

Table 2 contains the efficient metropolises in the periods under scrutiny and the total average efficiency. The efficient units in 1998 are Mexico City; Monclova and Matamoros (both located in the north of the country and endowed with an industrial base); Leon and Toluca (medium sized important industrialised metropolises in central Mexico); and a group of six small DMU´s. In 2003 two emerging industrial metropolises located at the border with the US, Juarez and Reynosa-Rio Bravo, reach the efficient frontier whereas only Mexico City and Acayucan remain efficient with respect to the previous period. Tehuantepec is another efficient unit in that year; Tehuantepec is one of the metropolises that have some oil-based activities. Mexico City, Acayucan, Reynosa and Coatzacoalcos are the efficient units in 2008. That is, only Mexico City and Acayucan are efficient in the three years; Reynosa remains efficient from 2003.

Even though estimates are no fully comparable between periods on the unit by unit basis, the mean efficiency demonstrates a decreasing metropolitan performance.

With respect to the other two biggest Metro Zones, Monterrey improves its performance over time and occupies the 16th, 7th and 5th place in the efficiency ranking with comparatively low levels of inefficiency. Guadalajara, on the other hand, has an above average efficiency but always in the middle of the ranking.

Despite its efficient position in 1998, Monclova suffers a significant decline in its efficiency. This city enjoyed the benefits of having a huge steel industry but became extremely dependent on its specialised economic base; however the industry has experienced important contractions due to increasing imports. To a less extent, Juarez and Tijuana decreased their relative performance between 2003 and 2008; this can be associated with criminality increases in these metropolises bordering the US.

Table 2. Efficient Metro zones and average efficiency 1998, 2003 and 2008

	1998		2003		2008	
1	Monclova-F	1	Juarez	1	Mexico City	1
2	Tecomán	1	Mexico City	1	Reynosa-RB	1
3	Mexico City	1	Tehuantepec	1	Coatzacoalcos	1
4	León	1	Rioverde-CdFdez	1	Acayucan	1
5	Tula	1	Reynosa-RB	1		
6	Ocotlán	1	Acayucan	1		
7	Toluca	1				
8	Rioverde-Cd. Fdez	1				
9	Matamoros	1				
10	Coatzacoalcos	1				
11	Acayucan	1				
Average Total MZ´s		0.692		0.643		0.545

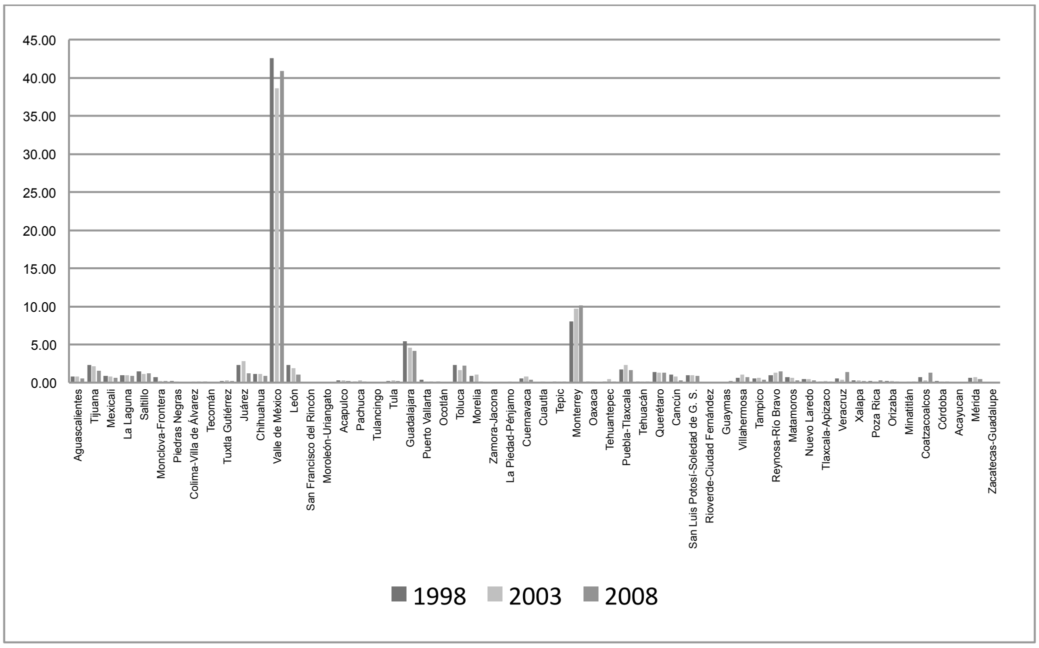
Source: Author´s elaboration with information from INEGI economic census 1998, 2003 and 2008.

A detailed analysis of DEA results lead to the consideration of the estimates about output targets (projected values) or the distance from the Metropolitan Zone´s actual position to the efficient practices. These targets or distances would give the elements for policy decisions in order to improve the economic position and performance of inefficient metropolises; nevertheless that requires individual attention of inefficient units.

b) Metropolitan distribution of technical inefficiency

Weighting the efficiency scores by the relative economic size of each metropolis (share in total metropolitan GDP) gives us its percentage contribution to metropolitan efficiency; that is to say, the sum of all weighted indices can be interpreted as a measure of the technical efficiency in the Mexican metropolitan system. As we have pointed out metropolitan efficiency is reducing; according to the weighted scores global efficiency fluctuates between 86.9 % and 79.8 %. Figure 9 shows the obvious importance of the five biggest metropolitan economies- and to a lesser extent Leon, Tijuana and Juarez- in accounting for the metropolitan system performance. Tijuana and Juarez with a fall in 2008 due to a lower shares in total GDP and also increasing inefficiencies.

Figure 9. Metropolitan distribution of the system efficiency 1998, 2003 and 2008



Source: Author´s elaboration with information from INEGI economic census 1998, 2003 and 2008.

V. Final comments and research agenda

In this paper, the efficiency of the Mexican metropolitan systems has been assessed. The relevance and strategic character of metropolis as units of observation and economic entities has been discussed. Efficiency aspects of the metropolitan functioning are also strategic in boosting metropolitan and national competitiveness.

The heterogeneity of the metropolitan units in demographic (population sizes and densities) and economic aspects might reflect in technical efficiency's spatial distribution and in global efficiency of the system. Results show that, in the first place, most of metropolitan economies are becoming more inefficient, leading to decreasing average simple and weighted efficiency. Mexico City is not only the biggest concentration of population and activity, but also the best practice in terms of productive processes. In different periods, other metropolises have reached full efficiency. Monterrey is another big metropolis which has relatively high performance. With few exceptions inefficient DMU's are small metropolises.

What the metropolitan system faces, as a whole and individually, is a deteriorating panorama in terms of its capacity to generate and maximise its material wealth which puts in danger is stability and internal cohesion. This requires, apart from further analysis, some kind of private and public policy approach.

Lastly, a case by case evaluation of inefficiency and economic targets is one way to expand this analysis, with paradigmatic or strategic instances for instance. Other approach consists in searching for the explanations of efficiency in the system or in individual metropolis, even in specific branches of economic activities.

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Annex

Efficiency and scale DEA results by Metropolitan Zone 1998, 2003 and 2008

		1998				2003				2008			
	Metropolitan Zone	crste	vrste	scale		crste	vrste	scale		crste	vrste	scale	
1	Aguascalientes	0.61	0.64	0.963	drs	0.52	0.55	0.95	drs	0.29	0.46	0.63	drs
2	Tijuana	0.79	0.82	0.968	drs	0.87	0.87	1.00	drs	0.57	0.73	0.78	drs
3	Mexicali	0.73	0.77	0.953	drs	0.49	0.61	0.81	drs	0.34	0.52	0.66	drs
4	La Laguna	0.67	0.68	0.981	drs	0.54	0.56	0.95	drs	0.31	0.53	0.59	drs
5	Saltillo	0.94	0.95	0.997	drs	0.48	0.78	0.62	drs	0.51	0.79	0.66	drs
6	Monclova-Frontera	1.00	1.00	1	-	0.47	0.47	0.99	irs	0.42	0.43	0.97	irs
7	Piedras Negras	0.65	0.66	0.991	irs	0.54	0.58	0.94	irs	0.47	0.50	0.95	irs
8	Colima-Villa de Álvarez	0.36	0.40	0.911	irs	0.39	0.40	0.98	irs	0.28	0.30	0.94	irs
9	Tecomán	0.62	1.00	0.622	irs	0.56	0.64	0.88	irs	0.27	0.61	0.44	irs
10	Tuxtla Gutiérrez	0.42	0.42	0.999	drs	0.56	0.56	0.99	irs	0.44	0.45	0.98	irs
11	Juárez	0.78	0.97	0.802	drs	1.00	1.00	1.00	-	0.62	0.74	0.85	drs
12	Chihuahua	0.65	0.68	0.953	drs	0.51	0.61	0.83	drs	0.35	0.57	0.61	drs
13	Valle de México	0.92	1.00	0.92	drs	0.90	1.00	0.90	drs	0.48	1.00	0.48	drs
14	León	1.00	1.00	1	-	0.76	0.80	0.95	drs	0.44	0.59	0.75	drs
15	San Francisco del Rincón	0.63	0.66	0.946	irs	0.57	0.57	0.99	irs	0.38	0.43	0.90	irs
16	Moroleón-Uriangato	0.40	0.45	0.894	irs	0.47	0.48	0.97	irs	0.39	0.48	0.80	irs
17	Acapulco	0.41	0.41	0.999	-	0.48	0.49	0.99	irs	0.33	0.33	0.99	irs
18	Pachuca	0.36	0.36	0.994	irs	0.58	0.58	0.99	irs	0.28	0.28	0.99	irs
19	Tulancingo	0.39	0.41	0.964	irs	0.50	0.53	0.94	irs	0.32	0.36	0.89	irs
20	Tula	0.89	1.00	0.893	irs	0.60	0.72	0.84	drs	0.50	0.61	0.82	irs
21	Guadalajara	0.70	0.76	0.927	drs	0.62	0.70	0.89	drs	0.32	0.61	0.53	drs
22	Puerto Vallarta	0.66	0.69	0.955	irs	0.35	0.36	0.98	irs	0.27	0.27	0.99	irs
23	Ocotlán	0.97	1.00	0.97	irs	0.30	0.33	0.92	irs	0.52	0.58	0.89	irs
24	Toluca	1.00	1.00	1	-	0.67	0.79	0.84	drs	0.46	0.88	0.53	drs
25	Morelia	0.88	0.90	0.977	drs	0.74	0.77	0.97	drs	0.18	0.25	0.72	drs
26	Zamora-Jacona	0.43	0.47	0.917	irs	0.45	0.47	0.96	irs	0.36	0.39	0.93	irs
27	La Piedad-Pénjamo	0.60	0.65	0.921	irs	0.78	0.79	1.00	drs	0.41	0.48	0.87	irs
28	Cuernavaca	0.60	0.62	0.966	drs	0.78	0.78	1.00	irs	0.32	0.38	0.84	drs
29	Cuautla	0.42	0.42	0.989	irs	0.54	0.55	0.97	irs	0.35	0.37	0.96	irs
30	Tepic	0.45	0.47	0.96	irs	0.30	0.31	0.98	drs	0.31	0.31	0.99	irs
31	Monterrey	0.79	0.86	0.922	drs	0.65	0.92	0.71	drs	0.41	0.98	0.42	drs
32	Oaxaca	0.34	0.34	0.996	drs	0.29	0.29	0.99	irs	0.19	0.19	0.99	drs
33	Tehuantepec	0.56	0.69	0.804	irs	1.00	1.00	1.00	-	0.45	0.71	0.64	irs
34	Puebla-Tlaxcala	0.58	0.63	0.93	drs	0.56	0.70	0.80	drs	0.27	0.56	0.47	drs
35	Tehuacán	0.56	0.58	0.979	irs	0.70	0.71	0.99	drs	0.56	0.61	0.92	irs

36	Querétaro	0.83	0.87	0.949	drs	0.72	0.74	0.97	drs	0.44	0.62	0.71	drs
37	Cancún	0.81	0.81	1	-	0.53	0.53	1.00	-	0.23	0.28	0.84	drs
38	San Luis Potosí-Soledad de G. S.	0.67	0.71	0.945	drs	0.48	0.52	0.92	drs	0.30	0.52	0.58	drs
39	Rioverde-Ciudad Fernández	0.39	1.00	0.387	irs	0.59	1.00	0.59	irs	0.32	0.53	0.60	irs
40	Guaymas	0.51	0.52	0.986	irs	0.50	0.52	0.96	irs	0.79	0.86	0.92	irs
41	Villahermosa	0.69	0.70	0.983	drs	0.84	0.84	1.00	irs	0.37	0.48	0.77	drs
42	Tampico	0.53	0.53	0.986	drs	0.38	0.60	0.64	drs	0.29	0.40	0.73	drs
43	Reynosa-Río Bravo	0.83	0.84	0.986	drs	1.00	1.00	1.00	-	0.89	1.00	0.89	drs
44	Matamoros	1.00	1.00	1	-	0.79	0.80	0.99	irs	0.56	0.57	0.98	irs
45	Nuevo Laredo	0.79	0.80	0.991	irs	0.85	0.87	0.98	irs	0.55	0.56	0.97	irs
46	Tlaxcala-Apizaco	0.49	0.50	0.997	irs	0.55	0.56	0.98	irs	0.26	0.26	1.00	-
47	Veracruz	0.52	0.52	0.996	irs	0.29	0.61	0.48	drs	0.65	0.94	0.70	drs
48	Xalapa	0.61	0.61	0.998	drs	0.57	0.57	0.99	irs	0.39	0.39	0.99	irs
49	Poza Rica	0.52	0.55	0.943	irs	0.46	0.47	0.97	irs	0.72	0.72	1.00	irs
50	Orizaba	0.53	0.54	0.967	irs	0.57	0.58	0.99	irs	0.44	0.44	0.98	irs
51	Minatitlán	0.35	0.38	0.937	irs	0.36	0.37	0.98	drs	0.37	0.43	0.86	irs
52	Coatzacoalcos	1.00	1.00	1	-	0.45	0.55	0.81	drs	1.00	1.00	1.00	-
53	Córdoba	0.62	0.63	0.989	irs	0.60	0.62	0.97	irs	0.55	0.58	0.96	irs
54	Acayucan	0.77	1.00	0.772	irs	1.00	1.00	1.00	-	0.57	1.00	0.57	irs
55	Mérida	0.52	0.53	0.991	drs	0.52	0.54	0.97	drs	0.26	0.37	0.72	drs
56	Zacatecas-Guadalupe	0.35	0.35	0.989	irs	0.46	0.47	0.97	irs	0.30	0.31	0.96	irs
	Average	0.645	0.692	0.942		0.59	0.64	0.92		0.42	0.55	0.81	