Factors Associated to Performance in Mexican Water Utilities

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Abstract

Factors associated to performance in Mexican water utilities are investigated by analyzing the correlation structure of the most important indicators for a sample of 106 water utilities. A classification of these utilities using Clustering on Principal Components was made to identify patterns of efficiency related to contextual variables, such as GDP per capita, precipitation and size of the network. Results indicate that non revenue water is higher in utilities with a high number of staff per thousand connections. Non revenue water is also correlated to low production costs and high precipitation rates. Water and sewerage coverage is positively correlated to GDP per capita and number of connections, which indicates that larger and more developed cities have better access to water; however, high population growth rates seem to be associated to lower coverage ratios. Collection ratio and average revenue per cubic meter are greater in localities with higher metering level and these utilities have also the larger operating Revenue/Cost ratio.

Keywords

Mexican cities, urban water administration, water utilities, performance indicators, multivariate analysis

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Introduction

Urban water in Mexico has become an issue of major concern because of the increasing demand of water and sanitation services related to population growth and the rapid urbanization of Mexico during the last decades (Aboites, 2009). In 1930 urban population was only 33% of the total; in 2010 it increased to 78%. Today approximately 87 million people live in urban localities (National Institute of Geography and Statistics, INEGI, 2010), and it is projected that Mexican population will reach more than 121 million people by 2050 (National Population Council, CONAPO, 2006), and most of them will be living in even more concentrated and complex metropolis. Thus, water utilities in Mexico face the challenge of providing water to an increasing population, especially in the arid lands in the north of the country (Pineda and Salazar, 2010).

Urban water in Mexico is provided mostly by local government owned utilities, and only a few utilities managed by private investors. According to Tortajada (2000), Mexico has reached some important goals in supplying urban water and sanitation services, and coverage percentages are higher than in other large Latin American countries (International Benchmarking Network for Water and Sanitation Utilities, Ibnet, 2011). However, there are still large differences between municipalities within the country. While some municipalities have been able to provide water to almost all inhabitants, many still lag behind, since there are stillsome municipalities where a large proportion of its inhabitants are not connected to the water network. Not only coverage is a problem. As cities grow, water becomes scarcer and more costly to produce because it has to be transported from further locations or pumped from deeper water tables. However, despite the population growth and ever scarcer water resources, almost half of the water produced is lost in the networks, mainly due to leakages (Salazar and Lutz, 2012). Water losses imply other problems such as financial insolvency of utilities, health risks due to contamination of water through leaks, and environmental deterioration due to the overexploitation of water resources. Another problem is the low revenue collection, which along with low water prices, discourages water conservation and affects the financial sustainability of utilities.

Despite this dismal picture, there are some examples of good management that have been documented in case studies and global evaluations (Lutz and Salazar, 2011; Caldera, 2006;

Pineda and Briseño, 2012) that show that while many utilities have massive water losses, noteworthy deficiencies in revenue collection and are financially unsustainable, there are some utilities with indicators that are similar to those of developed countries, where water losses are less than 10% and almost all water provided is being paid for. This raises the question: why do some utilities perform better than others? González-Gómez and García-Rubio (2008) explain that some factors affecting management can be effectively controlled by managers whereas other variables can be partially affected by policies and some others cannot be controlled at all. Some of the uncontrollable factors for managers in relation to water management efficiency are: precipitation, population size, and income. Higher levels of precipitation would be associated to lower production costs and thus to a lesser pressure to reduce water losses. Growing populations increase the total demand for water within a city, put more pressure on water availability, and thus increase the marginal cost of the water, which is thought to increase the urgency for loss reduction and water demand management through measurement and price increases. A larger population also puts a greater pressure on the coverage of water and sewage services. Increasing incomes also raise the demand for water, so efficiency enhancement in utilities would provide the additional water required, therefore it is expected that water use efficiency correlates positively with income.

The cost of water production and per capita consumption are variables located in the middle of the controllable-uncontrollable spectrum. The first one has some components out of the control of managers such as the cost of chemicals and energy for water production, but the size of staff and some operational aspects that affect total costs can still be managed. In a scenario of scarcity, water losses (both physical and commercial) are also financial losses for utilities, so it would be desirable to reduce them as much as possible, as long as the cost of the water lost is greater than the cost of avoiding losses. It is expected that utilities with higher production costs favor water conservation and look for more efficient use of resources (Agthe et al., 2003). Consumption depends on the price of water, income, and discretional uses of consumers that can be altered by means of policy instruments. Consumption can be considered a proxy for demand, and water demand in general terms is expected to correlate negatively to water loss (Park, 2006).

The aim of this paper is, first, to investigate the factors associated to performance in Mexican water utilities by analyzing the correlation structure of the most important indicators of a sample of 106 water utilities. Secondly, to classify these utilities according to these factors to identify patterns of efficiency related to contextual variables, such as GDP per capita, precipitation and population. This paper is divided in sections. In the first section, the indicators selected for the analysis are described and the methods and procedures for analyzing data and classifying utilities are presented. In the second section, a review of the summary statistics for indicators is carried out and the results of the principal component and cluster analysis are discussed; finally, in the third section the conclusions of the study are summarized.

Methods and procedures

In order to describe the current situation of water utilities in Mexico, indicators for a sample of 106 utilities located in cities with population greater than 50,000. Although it is not a random sample, but a convenience sample based on data availability, it includes many of the most important cities in the country and can be considered as fairly representative of water utilities in medium and large sized municipalities. These indicators were obtained from official sources the National Water Commission (CONAGUA, 2010). The indicators used were:

i) Physical Efficiency. An indicator of water loss, which is calculated as follows:

$$Physical\ Efficiency = \frac{Total\ Quantity\ of\ Water\ Billed}{Total\ Quantity\ of\ Water\ Produced}$$

ii) Commercial Efficiency. It is the indicator used for measuring revenue collection and is calculated as follows:

$$Commercial\ Efficiency = \frac{Total\ Quantity\ of\ Water\ Paid\ for}{Total\ \ Quantity\ of\ Water\ Billed}$$

iii) Revenue/Cost ratio.The financial viability of utilities can be measured by:

$$Revenue/Cost\ ratio = \frac{Total\ Revenue}{Total\ \ Operation\ Cost}$$

iv) Price. It is the average price which is calculated as:

$$Price = \frac{Total\ Revenue}{Total\ \ quantity\ of\ water\ billed}$$

v) Production Cost. It is the average production cost which is calculated as:

$$Production\ Cost = \frac{Total\ Operation\ Cost}{Total\ Quantity\ of\ Water\ Produced}$$

vi) Staff per thousand connections. It indicates how large is the staff in a utility relative to the size of that utility.

$$Staff\ per\ thousand\ connections = \frac{Total\ Staff}{Total\ number\ of\ connections} \times 1000$$

vii) Consumption is the average per capita consumption estimated by dividing the total quantity of water billed by the population.

$$Consumption = \frac{Total\ \ quantity\ of\ water\ billed}{Population}$$

viii) Measurement. It is the percentage of customers that have a meter, so that the quantity of water consumed can be measured.

$$Measurement = \frac{Connections\ that\ have\ a\ meter}{Total\ \ number\ of\ connections} \times 100$$

ix) Water Coverage. It is the percentage of households that have a water connection.

x) Sewage Coverage. It is the percentage of households that have a sewage connection.

Three additional variables provide the context of the utilities in the sample: Precipitation average of the municipality (IMTA, 2007), Number of connections (CONAGUA, 2010) and GDP per capita (CONAPO, 2001).

In order to investigate the factors that are inherent to the main performance indicators, a principal component analysis was carried out. Principal components were obtained from the indicators and the three contextual variables that are associated to these indicators. Principal component extraction was carried out and the components providing at least 60% of cumulative variance were retained. An Orthogonal Varimax rotation of components was carried out in order to maximize the correlation of variables to the least number of factors (Hair, 1999) and to facilitate the grouping of indicators. Then variables were grouped according to its loading to each component. The cutoff point used for this grouping was 0.25.

After principal components were obtained and rotated, individual scores for each city were obtained and a clustering procedure was carried out based on these scores. Hierarchical clustering was carried out by applying Ward´s method in order to minimize the total within-cluster variance (Ward, 1963). Squared Euclidean distance (L2) was used as dissimilarity measure. The number of clusters to be formed was selected according to the first Calinsky-Harabasz pseudo-F local maximum obtained (Calinski and Harabasz, 1974). According to Milligan and Cooper (1985) the Calinski-Harabasz statistic provides a better stop rule for cluster number determination compared to other rules. After hierarchical clustering, a K-means procedure using L2 as dissimilarity measure was used to fine tune the assignment of utilities into clusters. The means of the indicators for each of these clusters were obtained in order to analyze and compare the performance profiles for utilities.

Results and discussion

In spite of population growth and ever harder to obtain water supplies, water managers have not addressed the problem posed by the high levels of water losses. Table 1 shows that, on average, *Physical Efficiency* in major Mexican cities is about 52.7%. That is, 47.3% of water is not being accounted for, and most of it is lost mainly due to leakages in the water distribution networks. This indicator also shows a large variability: the maximum is 92.4% (within the range of developed countries) and the minimum is 15.2 (almost 85% of water goes unaccounted for).

Table 1. Summary of indicators and contextual variables for a sample of 106 water utilities

	Mean	Std. Dev.	Min	Max
Physical efficiency (%)	52.7	16.3	15.2	92.4
Commercial efficiency (%)	76.3	16.6	24.8	100.0
Revenue/Cost ratio	0.8	0.3	0.2	1.9
Price ($\$/m^3$)	8.0	3.9	1.2	19.7
Production cost ($\$/m^3$)	5.4	3.1	0.7	19.4
Staff per thousand connections	5.0	2.3	2.0	19.8
Measurement (%)	63.3	30.5	2.0	100.0
Consumption (m^3/person/year)	54.7	30.0	8.0	197.6
Water coverage (%)	88.8	8.9	40.7	96.8
Sewage coverage (%)	87.4	9.6	33.6	97.3
Number of connections	125,154	245,289	10,955	2,001,194
Precipitation (mm)	740	515	31	3,041
GDP per capita (US$)	8,390	3,860	2,200	27,695

Source: CONAGUA, IMTA and INEGI.

Not only water losses affect utilities, but also financial losses. Table 1 shows that, on average, Commercial Efficiency in the sample is about 76.3%. That is, 23.7% of the water billed is not being paid for, which discourages conservation and affects the financial viability of water utilities. On average, water utilities are not self-sufficient in terms of financing their operations. Table 1 indicates that the average of this indicator in the sample is 0.8, which means that revenue from water services in Mexican utilities amount to only 80% of the total operation costs. These costs do not include the investments that are necessary for improving the network and enhancing efficiency. So, about 20% of the operational costs of water utilities in Mexico has to be financed either by debt or government subsidies. However, there are some utilities that are self-sufficient, since the maximum of this indicator is 1.9, which indicates that this utility has revenue that amounts to twice its operational costs. There are also utilities that are being almost totally subsidized, since the minimum of the indicator is 0.2, which means that this utility has a revenue equivalent to only 20% of its operation costs.

Another variable that adds pressure on the finances of utilities is the *price* of water. Since almost all utilities are regulated, they are not allowed to establish the price for water without the approval of local governments. Low prices not only affect utilities because they reduce their potential revenue, but they also discourage water conservation, as customers do not perceive the scarcity of water through a price signal. Average price in the sample is 8 pesos per m^3, but there is also a large variation in this indicator: the minimum is 1.2 pesos per m^3 and the maximum is 19.8 pesos per m^3. Prices of water are usually set by local governments and these prices are usually set in order to reflect the production costs of water. The average production cost in the sample is 5.4, and the minimum is 3.1 and the maximum is 19.4, which reflects the great variability in water availability through the country.

Staff per thousand connections affect the cost structure of the utilities, when this indicator is too high it means that its workforce is too large compared to the size of the network and thus it is operating inefficiently. The sample has an average of 5, a minimum of 2 and a maximum of 19.8 Thus, the most inefficient utility has 10 times as many staff per thousand connections as the most efficient one.

Measurement is necessary for water conservation and bill collection based on the quantity consumed by customers. In the sample, measurement has an average of 63%, a minimum of 2 and a maximum of 100%. Thus while there are some utilities that do not measure water consumption at all, some are measuring each connection in the network. On average, the people in these cities consume 54.7 m3 per person per year. The variability in consumption in the country is large, since the maximum consumption goes up to 127 and the minimum is 8, although the latter is probably due to an under estimation of the total water billed, which is in turn a result of deficiencies in measurement.

As previously stated, there are large variations in water and sewage coverage. Water coverage has an average of 88.8, but the minimum goes as low as 40.7%, while the maximum is as high as 96.8%. In sewage, the average is 87.4% and the minimum is as low as 33% while the maximum is 97%.

The last three variables provide the context of the utilities in the sample. Their number of connections range from about 11,000 connections to around 2 million, with an average of 125,000. Precipitation ranges from 31 mm to 3041, from deserts to rainforests, which indicates the great variability of water availability in Mexico. Finally, GDP per capita goes from 2,200 US$ per year to 27,695 US$, which reflects the variability of development of regions in the country.

Principal Components extraction

Principal components extraction was carried out and the four components with the highest sum of squares were retained. These components explain 62% of the variance in the data. Then Varimax rotation was carried out. In table 2, the rotated components are shown as well as the correlations between variables and each component.

Table 2. Rotated Principal Components

	Rotated components			
Variables	PC1	PC2	PC3	PC4
Commercial efficiency	0.0332	0.1121	-0.0531	**0.5286**
Physical efficiency	**0.2530**	-0.0967	**0.5021**	0.0106
Staff per thousand connections	0.2198	0.0664	**-0.3272**	**-0.2607**
Measurement	0.2412	-0.1448	0.0070	**0.3900**
Production cost	**0.6531**	-0.0341	0.1221	-0.1102
Revenue/Cost ratio	-0.1307	-0.0228	0.0347	**0.6136**
Price	**0.4444**	0.0346	-0.2310	**0.2896**
Consumption	-0.0607	0.2270	**0.4626**	-0.0760
Water coverage	-0.2352	**0.4256**	0.1961	0.1385
Sewage coverage	-0.0442	**0.6333**	-0.1287	-0.0153
log(Number of Connections)	**0.3137**	**0.4165**	0.0446	0.0058
Precipitation	-0.0316	0.1051	**-0.5422**	-0.0045
GDP Per capita	0.1642	**0.3627**	0.0595	-0.0502

The variables with higher factor loadings on **PC1 (Cost)** are *Physical Efficiency, Production cost*, *Price* and *Number of connections*. This is an indication of the relation between the size of the population and the cost of providing water to a city, since population growth affect the total demand of water in a city and further, deeper and more expensive water sources must be incorporated to the water supply system. This increase in production cost affects water prices, which utilities try to keep in a level where costs can be met (as stated in the water laws of some states) so that the utility can remain financially viable. The inclusion of Physical efficiency in this component indicates the negative relation between water loss and production cost, that indicates that water utilities reduce the amount of water losses in the presence of higher production costs (Park, 2008; Salazar and Lutz, 2012)

The variables with higher factor loadings on **PC2 (Availability)** are *Water Coverage, Sewage Coverage, Number of Connections* and *GDP per capita*. These variables are indicators of water availability, and their inclusion in this component, as well as the fact that all these variables have a positive sign suggests that water coverage and availability is correlated to the size of the city and economic development.

The variables with larger factor loadings on **PC3 (Conservation)** are *Phisical Efficiency, Staff per Thousand Connections, Consumption* and *Precipitation*. This component is related to the causes of higher water losses and thus low Physical Efficiency. Cities with lower precipitation usually have higher water consumption, so that is why the sign for Precipitation is negative, and the sign for Consumption is positive. It has been found also that higher a staff per thousand connections is a sign of lower performance and efficiency, and is negatively correlated to Physical Efficiency, so that is why we observe a negative sign for the former variable and a positive sign for the latter. Consumption and Physical efficiency are usually found to be positively correlated since as water consumption increases in a city, utilities must provide an additional quantity of water to the system, which increases the marginal cost to the utility and must therefore reduce water loses.

The variables with higher factor loadings on **PC4 (Profitability)** are *Commercial Efficiency, Staff per thousand connections, Measurement, Revenue/Cost Ratio* and *Price*. These variables are related to collection, so this component can be thought as a factor of profitability, or how the utility increases its revenue. All variables have a positive sign, except Staff per thousand connections, which means that a higher measurement and a higher price are associated to a higher collection, and thus to a higher Revenue/Cost ratio. Higher measurement indicates that the utility has a policy of effectively collecting water bills, and higher prices are an incentive to carry out the collection, bills not being collected represent an opportunity cost to the utility. The negative sign of Staff per thousand connections indicates that having too much staff is associated to lower performance and it also induces higher staff costs.

Clustering

The clustering of utilities resulted into five clusters. The list of the utilities within each cluster is shown in Appendix I. Table 3 shows the mean of each indicator for every cluster. Figures in bold-and-underlined script indicate the highest value and figures in bold-only script indicate that the lowest value for the indicator and. For example, the highest value for commercial efficiency is **<u>90.5</u>** which corresponds to the mean of **Cluster 1**, while the lowest value is **66.4**, which corresponds to **Cluster 4.**

Table 3. Average indicators by cluster

	Cluster				
	1	2	3	4	5
Commercial efficiency	**<u>90.5</u>**	88.7	75.3	**66.4**	68.5
Physical efficiency	**<u>85.0</u>**	60.5	45.5	54.6	**32.2**
Staff per thousand connections	4.6	**4.4**	4.8	4.6	**<u>8.4</u>**
Measurement	**<u>96.9</u>**	82.2	65.9	**42.3**	54.9
Production cost	**<u>16.3</u>**	5.8	**3.4**	5.1	5.7
Revenue/Cost ratio	0.73	**<u>1.08</u>**	0.76	**0.64**	0.70
Price	**<u>15.2</u>**	9.6	5.9	**5.8**	11.6
Consumption	60.1	60.34	34.73	**<u>72.9</u>**	**31.66**
Water coverage	**83.3**	91.9	**83.1**	**<u>91.8</u>**	86.9
Sewage coverage	80.8	90.1	**80.1**	89.9	**<u>91.5</u>**
Connections	**<u>244,561</u>**	189,134	**21,526**	148,518	80,338
Precipitation	**185.1**	605.2	861.3	590.4	**<u>1429.149</u>**
GDP Per capita	8,451	**<u>9,662</u>**	**5,384**	9,545	8,417

Cluster 1 comprises 4 utilities, all of them located in the State of Baja California in northern Mexico. All of these utilities are managed by one state level office (Pineda y Briseño, 2012). Utilities in this cluster have particularly high levels of Physical Efficiency and Commercial Efficiency. Indeed, the average of these indicators in this cluster is higher than in any other cluster. Utilities in this cluster are also the ones with higher measurement in the sample. These utilities have the higher number of connections on average, compared to other clusters. In this cluster we also observe the lowest precipitation level (186 mm), the highest production costs and the highest price as well, which are probably set in order to meet the high production costs. However, despite having a high average price, it is lower than the average cost, which affects the Revenue/Cost ratio, which is less than 1 (0.73). Despite the outstanding indicators on Physical and Commercial Efficiency, this cluster is among the ones with the lowest water and sewage coverage, which could be related to the high population (765,598) and high population growth rate of these cities (3%), which is higher than the average of other clusters, thus the population grows at a rate that cannot be matched by the water utilities in terms of the additional water connections being required.

Cluster 2 comprises utilities with an average of 189,134 connections and are located in municipalities with an average population of 784,989. This cluster includes the second and third largest metropolitan zones of the country (Guadalajara and Monterrey). This cluster also includes the three only utilities with private ownership in the country (Aguascalientes, Cancún y Saltillo). In this group there are 15 utilities located in Central Mexico, 12 in the North and 4 in the South. This group has the highest revenue/cost ratio (1.08) which can be attributed to its relatively high levels of Commercial Efficiency and Measurement (88.7%) as well as to thir low production costs (5.8 $/m3) and prices that are way higher than its production cost (9.6 $/m3). These utilities do not have a very high Physical Efficiency (60.5%), which is above the national average but well below Cluster 1, probably because due to the low costs and relative financial viability they have not had any pressure to reduce water losses. These utilities have the lowest number of Staff per thousand connections (4.4), although it is not very different from the average of most other clusters. Finally, the cities in this group have the highest GDP per capita, since most of them are industrial cities and some of them are important international tourist destinations.

Cluster 3 comprises 26 utilities with an average of 21,526 connections serving a population of 151,689 on average, so it is the cluster with the smallest utilities in the sample. This cluster is mainly formed by utilities from central Mexico and some from the south. It has the lowest production costs (3.4 $\$/m^3$) and the average price for water is also the lowest. Commercial efficiency (75.3%) is close to the average of the sample and physical efficiency is lower than the sample global average. Most of them are in deficit, since the Revenue/Cost ratio is lower than 1 (0.76). They have low coverage levels, both for water and sewage, probably due to the relatively high proportion of rural population of these municipalities. These municipalities are the least developed on average and have the lowest consumption. 54% of the utilities in this cluster are located in central Mexico, 19% in the north and 27% in the south.

Cluster 4 is formed by 33 utilities with an average of 148,518 connections that provide water to 573,674 inhabitants on average. Most of the cities are located in the north of the country (70%) and some of them in central region 24%. Only 6% are located in the south. Mexico City, the largest city in the country, is located in this cluster. This group has the lowest average Commercial efficiency (66.4%) and lowest measurement (42.3). It also has the lowest water price ($5.8) but unlike Cluster 3, Cluster 4 has a greater production cost. Due to the low Commercial Efficiency, low measurement, and low price, it is the cluster with the lowest Revenue/Collection ratio. It is also one the cluster with the higher GDP per capita, which in addition to the low commercial efficiency makes it the cluster with the highest consumption. Physical Efficiency (54.6%) is barely higher than the global average. Many of these cities struggle with inadequate water supply, because, although this cluster is not the one with the lowest precipitation, many of the utilities in this cluster have low natural water availability.

Cluster 5 is formed only by utilities located in municipalities from the south (75%), and central regions of the country (25%). They have 80,338 connections on average and provide water to a population of 409,116 on average. Although this group has good sewage coverage and water coverage close to the global average (68%), utilities in this group have the lowest Physical Efficiency (32.2%) and its Commercial Efficiency is the second lowest (68%). It is also the group with the highest staff per thousand connections (8.4) which is almost twice the average of the other clusters. Although the average price (11.2) is almost twice the price, its Collection/revenue ratio is one of the lowest (0.7). This cluster is both the one with the lowest consumption (34.3 m3) and the one with the higher precipitation.

Conclusions

Results indicate that Physical efficiency is lower in utilities with a high number of staff per thousand connections. Physical efficiency is also correlated to high production costs and low precipitation rates, used as a proxy for water availability. Water and sewerage coverage is positively correlated to GDP per capita and number of connections, which indicates that larger and more developed cities have better access to water; however, high population growth rates seem to be associated to lower coverage ratios. Commercial efficiency and average price per cubic meter are greater in localities with higher metering level and these utilities have also the larger Revenue/Cost ratio. Privately managed utilities are located in the cluster which has the lowest staff per connection and highest revenue/cost ratio. Utilities with the overall best performance are located in the north of Mexico, where water is scarce, while the worst performing utilities are usually located in the south of the country, where water is more abundant.

In general, this study provides an understanding of the correlations of performance indicators, and the classification of utilities provides policy makers with an overview of the variety of water utility profiles in order to formulate policies that are consistent with the problems faced by each cluster. Utilities in Cluster 1 must address the problem of high production costs and service extension in order to cope with high population growth. Cluster 2 must address the issue of water losses, since despite their good performance on financial viability, there is still an important gap in physical efficiencies compared to Cluster 1. Utilities in cluster 3 must address the issue of coverage, which is still an issue in these smaller municipalities. Utilities in clusters 4 and 5 have to carry out important improvement measures. Although utilities in Cluster 4 are located in municipalities of similar size and development as Clusters 1 and 2, their performance is lower: they have greater water losses and lower Commercial efficiency, which in addition to low prices results in the cluster with the lowest financial viability. These utilities must focus then on increasing both physical and commercial efficiency, as well as on increasing their prices to a level similar to Cluster 2. Utilities in cluster 5 must address the issue of their large Staff relative to their size, as well as the problem of high water losses. Prices are not an issue in this cluster because they are already the second highest (only cluster 1 has a highest average price) however the weak performance in other areas makes that these prices are not enough to cover the operation costs.

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Appendix I. List of utilities by cluster.

CLUSTER 1

State	**City**	**Region**
Baja California	Ensenada	North
Baja California	Mexicali	North
Baja California	Tecate	North
Baja California	Tijuana	North

CLUSTER 2

State	**City**	**Region**
Aguascalientes	Aguascalientes	Central
Chihuahua	Chihuahua	North
Chihuahua	Cuauhtémoc	North
Chihuahua	Hidalgo del Parral	North
Chihuahua	Juárez	North
Coahuila	Saltillo	North
Coahuila	Torreón	North
Colima	Manzanillo	Central
Guanajuato	Celaya	Central
Guanajuato	Cortázar	Central
Guanajuato	Irapuato	Central
Guanajuato	León	Central
Guanajuato	San Francisco del Rincón	Central
Hidalgo	Pachuca de Soto	Central
Jalisco	Guadalajara ZM	Central
Jalisco	Puerto Vallarta	Central
Mexico	Tlalnepantla	Central
Nuevo León	Monterrey ZM	North
Querétaro	Querétaro	Central
Querétaro	San Juan del Río	Central
Querétaro	Tequisquiapan	Central
Quintana Roo	Cancún	South
Quintana Roo	Cozumel	South
Quintana Roo	Playa del Carmen	South
San Luis Potosí	San Luis Potosí	Central
Sinaloa	Los Mochis	North
Sinaloa	Culiacán	North
Sonora	San Luis Río Colorado	North
Tamaulipas	Nuevo Laredo	North
Tamaulipas	Victoria	North
Yucatán	Mérida	South

CLUSTER 3

State	City	Region
Aguascalientes	Calvillo	Central
Chiapas	Tapachula	South
Coahuila	Francisco I. Madero	North
Coahuila	San Pedro	North
Guanajuato	Allende	Central
Guanajuato	Dolores Hidalgo	Central
Guanajuato	Purísima del Rincón	Central
Guanajuato	Valle de Santiago	Central
Guerrero	Iguala	South
Hidalgo	Tula	Central
Morelos	Cuautla	Central
Puebla	Atlixco	Central
Puebla	Huauchinango	Central
Puebla	San Martín Texmelucan	Central
Puebla	San Pedro Cholula	Central
Querétaro	Amealco	Central
San Luis Potosí	Ciudad Valles	Central
San Luis Potosí	Matehuala	Central
Sinaloa	Guasave	North
Sonora	Caborca	North
Tamaulipas	El Mante	North
Veracruz	Coatepec	South
Veracruz	Papantla	South
Veracruz	Poza Rica	South
Veracruz	Túxpam	South
Yucatán	Valladolid	South

CLUSTER 4

State	City	Region
Campeche	Campeche	South
Coahuila	Acuña	North
Coahuila	Matamoros	North
Coahuila	Monclova	North
Coahuila	Piedras Negras	North
Coahuila	Ramos Arizpe	North
Coahuila	Sabinas	North
Colima	Colima	Central
D.F.	Mexico City	Central
Durango	Durango	North
Durango	Gómez Palacio	North

CLUSTER 4 (continued)

State	City	Region
Durango	Lerdo	North
Michoacán	Zamora	Central
Morelos	Cuernavaca	Central
Morelos	Jiutepec	Central
Morelos	Temixco	Central
Nayarit	Tepic	Central
Puebla	Puebla	Central
Sinaloa	Mazatlán	North
Sinaloa	Guamuchil	North
Sonora	Agua Prieta	North
Sonora	Cajeme	North
Sonora	Guaymas	North
Sonora	Hermosillo	North
Sonora	Navojoa	North
Sonora	Nogales	North
Sonora	Puerto Peñasco	North
Tamaulipas	Matamoros	North
Tamaulipas	Reynosa	North
Tamaulipas	Tampico	North
Veracruz	Veracruz	South
Zacatecas	Fresnillo	North
Zacatecas	Zacatecas	North

CLUSTER 5

State	City	Region
Campeche	Carmen	South
Chiapas	Tuxtla Gutiérrez	South
Guanajuato	Acámbaro	Central
Guanajuato	Guanajuato	Central
Guerrero	Acapulco	South
Mexico	Naulcalpan	South
Michoacán	Uruapan	Central
Quintana Roo	Chetumal	South
Tabasco	Centro	South
Veracruz	Coatzacoalcos	South
Veracruz	Córdoba	South
Veracruz	Xalapa	South