Industrial Structure and Economic Complementarities in City Pairs on the Texas-Mexico Border

Robert W. Gilmer
and
Jesus Cañas

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Robert W. Gilmer
Federal Reserve Bank of Dallas–El Paso Branch
(915) 521-8288
301 E. Main St.
El Paso, TX 79901

bill.gilmer@dal.frb.org

Jesus Cañas
Federal Reserve Bank of Dallas–El Paso Branch
(915) 521-8233
301 E. Main St.
El Paso, TX 79901

jesus.canas@dal.frb.org

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Abstract: The U.S.-Mexico border provides a number of examples of pairs of neighboring cities, one in the U.S. and the other in Mexico. The advent of the North American Industrial Classification System provides a new opportunity to look at these cities using a common industrial classification system. Using U.S. data from the Bureau of Labor Statistics and Bureau of Economic Analysis, and comparable information from the 1999 Mexican economic census, we were able to compare employment by industry sector in city pairs that are located along the Texas-Mexico border: El Paso-Juarez, Laredo-Nuevo Laredo, Brownsville-Matamoros, and McAllen-Reynosa.

This paper focuses on the distribution of employment in border city pairs. It is primarily descriptive in nature, but looks at industrial structure from several perspectives. First, we look at each city as part of its own national economy, then as part of the combined U.S.-Mexico economy. Second, we demonstrate that each city-pair has a distribution of employment by industry that complements the sister city. Different wage levels, distinct legal and regulatory systems and unlike stages of development provide each city with unique opportunities to specialize in the local marketplace. Finally, we interpret the role of these cities as part of a combined US-Mexico economy. The chief economic role played by all city-pairs is that of a manufacturing center, driven largely by maquiladora activity and its support industries.

JEL classification: F14, F15, F16, R12, R11

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Industrial Structure and Economic Complementarities in City Pairs on the Texas-Mexico Border

This paper examines the industrial structure of four pairs of cities, with each pair located adjacent to each other but on opposite sides of the Texas-Mexico border. The cities, shown in the map in Figure 1, are El Paso-Juárez, Laredo-Nuevo Laredo, McAllen-Reynosa, and Brownsville-Matamoros. Because an international border divides each pair, data for the U.S. cities are reported by U.S. statistical agencies, and on the opposite side of the Rio Grande the data source is Mexican authorities. The statistical history of the two countries has been one of marked differences in the availability of economic data, and conflicting definitions where common concepts are measured. The result has been an incomplete understanding of the economy of the U.S.-Mexico border region, including these city pairs.

The introduction of the North American Industry Classification System (NAICS) in the U.S., Mexico and Canada offers a new opportunity to see the industrial structure of these eight cities under a comparable industry classification scheme and similar employment definitions. By industrial structure, we mean the distribution of employment in each city by industry sector. The distribution of economic activity by industry is important in defining the economic role played by these cities in the North American urban hierarchy. It can identify local specialization where the city has developed the capacity to export widely to other regions (oil in Houston, autos in Detroit), or concentrations of activity in such areas as transportation, wholesaling or finance that could label it as a gateway city such as Dallas or St. Louis.

There is strong economic interaction between these border city pairs, apparent from a count of auto, truck, and pedestrian traffic crossing the bridges that connect them,

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from the number of Mexican license plates on autos parked in U.S. malls, or the many service and goods suppliers in U.S. border cities that support manufacturing located in Mexico. If this interaction is strong enough, it should be reflected in local industrial structures that indicate a complementary role, i.e., where one city is strong in specific industries, the other should be weak. In this case, we need to add the city-pairs together to interpret their role in the broader economy, treating them as a single economic unit. NAICS and a comparable employment definition will now allow us to sum the cities by industry.

This paper places all eight cities on a comparable basis in terms of defining local industrial structure. We find complementarities between adjacent cities strong enough to indicate that they may indeed act as a single urban area. Once added together, we assess the role of these cities as part of the larger U.S.-Mexico economy.

The Cities

Table 1 shows the population and employment of the eight border cities in 2002. Neighboring El Paso and Juárez are both the largest of the four border cities in their respective countries, together having a population of 2.2 million. The smallest pair is Laredo and Nuevo Laredo, with a combined 584,000 inhabitants. The Mexican employment figures shown are for formal employment only, or jobs having employment security and pension protections guaranteed by the government. The concept is discussed further below, but formal employment accounts for only about half of all jobs in these northern Mexico cities.

From a Texas perspective, the four U.S. border cities are on the periphery of the economy. The Texas Triangle metro areas of Dallas-Fort Worth, Houston, San Antonio

and Austin are the state's largest and most successful economies, and in recent years these cities have driven the state's growth in personal income, accounting for most of the state's convergence toward U.S. income levels (Gilmer, 2004). The Texas Triangle cities had 62.5 percent of the state's population in 2002, but accounted for 66.3 percent of its jobs and 71.4 percent of personal income. In contrast, the four border cities had 8.6 percent of the state population, but generated only 6.4 percent of jobs and 5.1 percent of income.

The Texas border cities enjoyed strong employment growth in the 1990s, slightly outperforming even the rapid growth of the state economy.[1] This job growth exerted little upward pull on border income levels, however, providing these cities with little or no convergence to U.S. or statewide income levels. The average per capita income of the four cities in 2002 was only $17,222, compared to $29,039 in Texas and $33,178 in the four large Texas Triangle metros. Poverty remains a hallmark of the economy of all these border cities.

In contrast, the cities of northern Mexico are regarded as among the most dynamic in the nation (Díaz-Bautista, Aviles, and Rosas, 2003). Offshore manufacturing has been the primary driver of economic expansion in recent years, as the Mexican maquiladora has raised wages and attracted workers from the interior of the country. Although poverty is a pervasive part of the economy of all the Mexican border cities, it is less pronounced than in the interior of Mexico.

Gilmer, Gurch and Wang (2001) have examined the industrial structure of Texas border cities. Although the analysis used the Standard Industrial Classification, it sets expectations for what we will find using NAICS. The dominant economic features of

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Texas border cities were found to be (1) a large transportation and distribution sector serving international traffic, (2) a U.S. retail sector inflated by serving two cities, and (3) a government sector swollen by border enforcement and by public programs that address high poverty levels.

The high concentration of trucking and transportation services is due to international bridges and checkpoints that cause delays and require special handling of goods moving across the border. Laredo has by far the largest concentration of transportation activity, a product of its strategic location on the shortest truck route from the United States to Monterrey, Mexico's major industrial center.

The strength of border retail sales results from Mexican shoppers who prefer the U.S. side for many items. Brownsville and El Paso have large neighboring cities in Mexico. Laredo draws shoppers from Nuevo Laredo, but is best known as a destination for shoppers from the Mexican interior, especially Monterrey. Some of this shopping from the interior also spills into McAllen and Brownsville. The result is exportable retail sales that vary from 20 percent of total sales in Laredo to six percent in El Paso (Phillips and Manzanares). Zamora and Lecuanda show how retail sales in neighboring Tijuana and San Diego respond to and interact differently with changes in the exchange rate and disposable income.

Various sources contribute to the high concentration of government employment. El Paso is home to a major military installation, providing both civilian and military jobs. The border itself generates jobs in customs, immigration, naturalization, and border security. Finally, state and local governments provide unusually high levels of public assistance for income maintenance, medical care, education and training, and housing.

We don't have a comparable study for the Mexican side, but residents of U.S. border cities also find many reasons to shop or do business in Mexico: pharmaceuticals, medical clinics (for reasons from delivering a baby to plastic surgery), dentists, auto repair and upholstery, general groceries, ethnic foods, bottled liquor, barber and beauty services, clubs, and fine restaurants. Low price, a different culture, or a shortcut of U.S. regulation is behind most of the demand for these goods and services.

The dominant factor that has affected the growth and industrial structure of Mexican border cities in recent years has been offshore manufacturing, largely operating under Mexico's maquiladora program. The maquiladora industry began in 1965, and experienced slow but steady growth under the Border Industrialization Program (Hansen, 2003). The cancelled Bracero Program had used Mexican labor in agriculture, and the replacement maquiladora was designed to relieve the resulting high unemployment rates in the north of Mexico. The new program used low-wage Mexican labor as a lure to draw U.S. manufacturing to the region, allowing companies to move production machinery and unassembled parts into Mexico without tariff consequences, as long as the assembled final product was returned to the U.S. for final sale. Figure 2 shows the 10-fold increase in maquiladora employment between 1980 and its peak in 2000, from 120,000 workers to 1.2 million.

In 1980, about 94 percent of the maquiladora employment was in the border states of northern Mexico.[2] Today, the share has slipped to 78 percent, but the northern states still dominate. In 2003, 2,860 operating plants accounted for about nine percent of formal employment in Mexico, or three percent of total labor force. The companies

operating under the maquiladora program are a who's who of U.S. industry, including Delphi, Mattel, Tyco, General Electric, and ITT.

Maquiladora employment growth in Mexico also has important implications for the U.S. border cities (Patrick 1990, Sprinkle 1986, Silvers and Pavlakovich 1994). It reinforces the need for transportation services, finance, legal, and administrative support needed to move goods across the border. New and more prosperous maquiladora workers also shop in the U.S. And a relatively recent trend has been the development of manufacturing in U.S. border cities, with new plants acting as suppliers to the maquiladora industry. The primary supplier links to the maquiladoras remain in the traditional Midwestern U.S. manufacturing states such as Ohio, Michigan and Indiana, but in recent years just-in-time inventory needs have pushed many suppliers to the U.S. border. Plastic injection molding and metal stamping are among the most common of the new Texas-based suppliers to maquiladoras (Cañas, Coronado, and Gilmer 2004a).

Gordon Hanson has estimated that a ten percent increase in maquiladora output in a Mexican border city generates an increase in employment the neighboring U.S city of 1.1 to 2.0 percent. He further estimates that this 10 percent increase in output would increase wholesale trade employment in the U.S. by 2.1 to 2.7 percent, transportation services by 1.7 to 2.7 percent, manufacturing by 1.2 to 2.1 percent, and retail trade by 1.0 to 1.8 percent.

Mexican Data

The Mexican data used in this paper are from the 1999 *Censos Económicos*, conducted by Mexico's chief statistical agency, the Instituto Nacional de Estadística, Geografía e Informática (INEGI). This census serves as the backbone of all Mexican

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economic data collection, and it is currently carried out on a five-year cycle. The 2004 Census just concluded its data collection phase in June, and 16 censuses now have been completed since 1930.

The census covers all industry, services, and commerce important to understand the economic structure of Mexico.[3] A complete census is carried out in urban areas, industrial parks, important rural areas, and prominent tourist destinations. The rest of the country is sampled. The effort is huge: 1.2 million blocks canvassed by 35,000 census takers, along with 23.0 million homes visited and 3.3 million small businesses contacted. Data are tabulated for 974 NAICS sectors and 2,516 variables. The largest group not covered by the census is "ambulatory" or street sales, as some physical structure (including private homes) must be associated with the business to be included in the census.

The importance of the *Censos Económicos* is that Mexico lacks a comprehensive registry to record total employment. In the U.S., for example, unemployment insurance records provide an administrative basis to track wage and salary employment in great detail. In Mexico, however, a majority of workers are found in the "informal" sector, outside the protection of social or employment security.[4] A recent study by one of Mexico's largest banks estimated that 63.3 percent of all Mexican employment in 2003 was informal (BANAMEX, 2003). The northern states that include the four Mexican border cities have the smallest fraction of informal employment of any region in Mexico, but 40-55 percent of all jobs in these states are still in the informal sector according to this report. The informal jobs could be professional accounting or computer services, a restaurant or café, or a corner bakery operated from home or a small business, and they

may or may not pay taxes. INEGI estimates that these jobs accounted for only 10.1

percent of Mexican gross product in 2001.[5]

Table 2 shows location quotients (LQ_{ij}) for Mexican border cities defined as:

$$LQ_{ij} \; = \; \frac{\text{Percent share of industry (i) in city j}}{\text{Percent share of industry (i) in the Mexican economy}}$$

These calculations show where the concentration of local employment is typical of the

Mexican economy (LQ=1), less than typical (LQ<1), or highly concentrated (LQ>1).

Displayed in the table is any industry with a concentration 5 percent or more above

normal, or LQ>1.05.[6] It is assumed that a large LQ reflects "excess employment," and

perhaps the presence of a local export industry. The shortcomings of location quotients

as a means of indicating local exports is well known (Andrews, 1953-55), including

issues associated with local differences in taste, economics of scale, and technology. For

this reason, we have gone to substantial lengths to motivate our results with specific

descriptions of border economic condition and the factual basis of likely exports.

As expected, we see a strong concentration of manufacturing in all cities due to

maquiladoras, with both Matamoros and Reynosa doubling the national norm. There is a

very strong concentration of transportation in Nuevo Laredo, though not the other

Mexican cities. The Rio Grande valley is a farming region, explaining Matamoros

concentration in agriculture. Mexican development of the Burgos Basin gas fields is the

reason for the large LQ for mining in Reynosa. The concentration of information

industries in Juárez results from service maquiladoras processing coupons and other

routine paperwork.

U.S. Data

The broad definition of employment used in the Mexican Census requires that the U.S. data be similarly comprehensive. The most inclusive definition in the U.S. would be that used by the *Census of Population*: private and public wage and salary workers, the self-employed, plus unpaid family members. Table 3 shows the distribution of these categories of workers in Texas and the four U.S. border cities according to the 2000 *Census of Population*. We were able to approximate a broad definition of employment in 1998 by using the sum of wage and salary workers and the self-employed. This omits unpaid family members, but they constitute less than one percent of total jobs in all four cities.

Data on the self-employed is based on the number of proprietors and individual partners, and is estimated by the Bureau of Economic Analysis (BEA) from a sample of individual tax records.[7] BEA has distributed these proprietors under NAICS only in 2001 and 2002, and data are not available to match the earlier Mexican census year of 1998. To approximate the earlier year, we used the 1998 total number of proprietors by city and distributed them across industries at the NAICS sector level by assuming that the 2001 sector shares were unchanged. The top four industries receiving proprietors in all cities (although the order varied by city) were construction, retail, real estate, and other services (except public administration). Together these four industries accounted for a low of 47 percent of the self-employed in Brownsville to a high of 52 percent in Laredo.

The self-employment data were added to figures from the Quarterly Census of Employment and Wages Program at the Bureau of Labor Statistics. This is a comprehensive tabulation of wage and salary workers covered by state and federal

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unemployment programs. Table 4 shows the result at the NAICS sector level. Because

we were unable to match the 1998 Mexican and U.S. agriculture and public

administration sector definitions well, only private, non-agricultural employment is

compared in this paper. Once again, location quotients are computed, but now using the

U.S. economy as a base. Again, only LQ>1.05 is shown, presumably an indication of

excess employment.

$$LQ_{ij} \; = \; \frac{\text{Percent share of industry (i) in city j}}{\text{Percent share of industry (i) in the U.S economy}}$$

As expected the U.S. border cities show significant concentrations of retail trade

and transportation. The mining activity in Laredo and McAllen results from the South

Texas natural gas fields; utilities in McAllen and Brownsville are pipelines to move

natural gas out of the region, plus large electric generators in both cities. The strength of

construction in El Paso and McAllen partly reflects the strength of the local business

cycle in 1998. Accommodation and food service support the large number of truckers

moving through the area, retail visitors, and some winter tourism. Administrative

services and support in El Paso is information processing, legal, and other support

services for the largest concentration of maquiladoras on the U.S.-Mexico border, located

in neighboring Juárez. El Paso is the only one of the four U.S. border cities to have a

history of manufacturing, a large concentration of low-wage textile, apparel, and leather

industries that has rapidly been lost in recent years to off-shore competition. The

remaining strength in manufacturing in El Paso is partly a residual of low-wage industry,

and partly the new industries that have moved to the border to support maquiladoras in

Juárez.

The strength in education comes from a variety of sources. It is partly due to large family size in a mostly Hispanic and Catholic population, ranging from 14 percent larger than the U.S average in El Paso to 29 percent in Laredo. An English-language education is prized in Mexico, and many upper- and middle-class Mexican families send their children to private (often Catholic) primary and secondary schools in the U.S. cities. Many other Mexican families, unable to afford private tuition, but with a relative that can provide a U.S. address, will also send their children to U.S. public schools. This is illegal, but a "don't ask, don't tell" policy generally prevails along the border. Finally, every city is home to a state university, each of which allows Mexican students from neighboring states to attend at in-state tuition rates. Taken together, the U.S. border cities become significant exporters of education to both the U.S and Mexico.

In Tables 2 and 4, we looked at the industrial structure of the Mexican border cities as part of the Mexican economy, and at the U.S. cities as part of the U.S. economy. To compare the city pairs, which effectively operate on both sides of the border, we computed location quotients that have a combined U.S.-Mexico economy as a base.

$$LQ_{ij} = \frac{\text{Percent share of industry (i) in city j}}{\text{Percent share of industry (i) in the U.S and Mexican economy}}$$

Table 5 shows location quotients with a 5 percent or higher than normal concentration of activity in these cities.

Among the U.S. cities, we see that utilities and retail trade are now significantly weaker, and accommodation and food service are no longer above normal. All of these industries are significantly more labor-intensive in Mexico than the U.S. If we had measures of total retail sales, for example, we could probably show continued strength in

retailing in the U.S.[8] Comparisons that use employment, however, show strength on the

Mexican side because full-service remains a tradition in many large stores, plus the

number of small, low-revenue stores in the informal sector. Food service is similar.

Also, state-owned Mexican utilities remain heavily unionized, giving them high levels of

employment per unit of service compared to the U.S.

Transportation remains strong in all cities except McAllen, and Laredo is very

strong. Construction stays above normal in the U.S., and real estate strengthens. There is

no market in Mexico for real estate that is comparable to the U.S. in terms of financing,

liquidity, or sales, and part of the U.S. strength here is simply the unique institutions that

don't exist in Mexico. However, U.S. real estate companies bring finance, development

and market skills to the Mexican market. U.S. manufacturers searching industrial land or

buildings typically will turn to U.S.-based brokers who then work with the Mexican

government. Land, residential, and commercial development in Mexico often rely on

U.S. advisors and capital. Finally, many Mexicans, seeking to hedge against the peso,

seek residential or commercial property in the U.S., expanding the local market for U.S.

border cities. Education continues to be strong. Some part of the LQ may continue to be

large family size, but strong exports of educational services are still indicated. Local

universities, private and public schools are providing educational services well beyond

the boundary of the two cities, and exporting them into the interior of two countries.

The strengths in the industrial structure of the Mexican cities are not changed

much by changing the base of the location quotient. Mining is still concentrated in

Reynosa, manufacturing looks evens stronger in all cities, and transportation retains its

strength in Nuevo Laredo. The difference in labor-intensity between the two countries

allows utilities, food and accommodations, and retail to emerge in Nuevo Laredo. All of these are tied to cross-border trucking and shoppers. The strength in "other services" in Reynosa and Nuevo Laredo is the result of U.S. shoppers in Mexico. This is where we find barber, beauty and personal care services, auto repair, paint and upholstery, and other services that draw U.S. shoppers across the border.

Economic Interaction and Integration

In the past, differing industrial classifications made it impossible to assess the interaction between border-city pairs. We could assess urban exports in the sense of identifying excess employment as defined by the LQ's, but were left unable to determine whether exports were to the adjacent city or beyond. Without understanding local interaction, and unable to separate it from exports to other regions, it was difficult to define the role of the border region in the U.S.-Mexico economy.

Interaction between the border cities – as we have indicated -- is extensive. The simple fact is that differences between the two sides of the border, differences in wage levels, regulatory schemes, legal system, and culture, offer many opportunities for the border cities to specialize in specific economic niches. Economics of localization, of the type first described by Alfred Marshall, cement these tendencies into place, resulting in distinct intraurban districts serving both sides of the border (Krugman 1993 and Mills, 1992). We have seen, for example, how low-wages in Mexico have created an "off-shore" manufacturing belt a few miles from the U.S. border; how a higher U.S. standard of living provides high-end retail for Mexican shoppers; and how U.S. border city residents shop or do business in Mexico seeking low-wage bargains or to circumvent U.S regulation or taxes.

Do these anecdotes add up to a force sufficient to affect industrial structure of the two cities? Another way to ask this is whether the variance of location quotients of the combined pair of cities declines significantly when compared to the variances of the LQs of the two uncombined cities. If exports from one twin to the other are shaping the industrial structure, the location quotients of many combined sectors should return to levels near one if they serve only the city pair. Strength on one side of the international border is offset by weakness on the other. What remains of the variance should reflect only exports to other regions.

To test the hypothesis that the industrial structures of the city pairs are complements, we computed the variance of the natural logarithm of the LQ for each city in Table 5 across 18 sectors. The variances of the log LQs are shown across the bottom of the table. Because they are computed on a common U.S.-Mexico base, we could combine the city pairs into a single city and recompute the location quotients for the combination, as shown in Table 6. The variance of the log LQs of the combination is shown at the bottom of Table 6. To test the hypothesis of complementary industrial structure, we used the standard F-test for the difference in two variances, comparing an employment-weighted average of the variance of the two cities alone versus the variance of the combined cities. (See the appendix that describes this test further.)

Table 7 summarizes the results and the critical values for the F-test. The results show a high but not conclusive probability of a significant decline in LQ variance, with only El Paso-Juárez and Brownsville-Matamoros meeting a 90 percent probability standard. McAllen-Reynosa is quite close to that standard, and the Laredo-Nuevo Laredo combination falls short. We might offer some institutional reasons for the finding, but

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probably the level of industry summary at the NAICS sector level is too broad to pick up the trade that often occurs at more detailed levels.

We have much more detailed data at the sub-sector and industry group level from both the Mexican census and from U.S. wage and salary information. However, BEA only distributes proprietors and partners at the sector level, making detailed comparisons impossible in sectors where proprietors are important. There were nine NAICS sectors, common to all four cities, where proprietors made up 5 percent or less of the employment. For these sectors, we could do sector-by-sector F-tests, with internal detail providing the necessary degrees of freedom. Table 9 summarizes the results for eight sectors (utilities and mining are combined), and shows the results of the tests by level of significance.

Mining and utilities are complementary in the cities where those industries were important. As expected, manufacturing is highly complementary in all cities. Wholesale trade, educational services, and arts, entertainment and recreation are complementary in three of the four city pairs. Accommodation and food services are complementary in two cities. The information sector is not complementary in any of the cities, perhaps reflecting language differences in TV, radio and newspaper offerings. Unfortunately, we can't reliably test some sectors where anecdotally we expect the strongest complementarities to exist, such as retail and other services.

The Role of Border Cities

How do the border cities relate to the rest of the world? By combining the cities in Table 6, we should have cancelled out the interaction between them, i.e., the cobined cities are more self-sufficient. The remaining concentrations of excess employment

should reflect only exports that move beyond the city pair and into the rest of the world. Retail trade, for example, remains significant only in Laredo-Nuevo Laredo and McAllen-Reynosa, cities that draw large numbers of shoppers from the interior of Mexico. Only McAllen-Reynosa sells personal and repair services beyond the local area. Real estate remains an important border export. Some part of the LQ for educational services may continue to be large family size, but strong exports of educational services are still indicated. Local universities, private and public schools are providing educational services well beyond the boundary of the two cities, and into the interior of two countries.

Mining is still strong in Table 6, with oil and gas extraction on both sides of the border. This leaves us with the traditional border industries of maquila-led manufacturing, and the border transportation and warehousing in Laredo. The shared features in all the twin-city combinations are education, real estate, and manufacturing. In terms of the size of these sectors, measured excess employment in all eight cities in education at 53,597 and at 6,437 in real estate. Manufacturing dominates, however, with virtually all of 435,891 manufacturing jobs are probably tied to exports.[9] The simplest characterization of the entire border region is that it is an important manufacturing region. In terms of the stages of development moving from primary extraction and agriculture to industry, and then to services and information, the Texas-Mexico border remains at the secondary stage of industrialization.

Conclusions

For the first time, we have a consistent picture from official data of major cities located on both sides of the Texas-Mexico border. Using location quotients to identify

excess employment proved a useful tool to identify potential exports, highlighting sectors known to the border city strengths. The U.S. border cities primarily engage in oil and gas extraction, retailing, transportation and warehousing, educational services, and real estate services. Key exports from the Mexican side are maquiladora manufacturing, oil and gas extraction, and personal and repair services.

When local exports from one adjacent city to the other are eliminated, the regional exports that best characterize the border cities are those of the maquiladora plants and their suppliers, telling us that the border is essentially a manufacturing belt. Mining persists, along with real estate and transportation that both have significant ties to the maquiladoras. Educational services are exported both to the U.S. and Mexico, with a strong component of English-language exports via Mexican students. However, if we compare border's economy to the common classification of the stages of development – extraction, industrialization, services– the border remains firmly in the second stage of industrialization, with few service exports.

We found strong, if less than conclusive evidence of complementary industrial structures in neighboring border cities. Three of the city pairs were quite close to or above a 90 percent probability of being complements when compared at the NAICS sector level. A lack of industrial detail probably hurt these broad comparisons, but examination of detail within industrial sectors, where the data was appropriate to do so, showed city-pair complementarities between manufacturing, mining and utilities, wholesale trade, educational services, and arts and entertainment. Because of data limitations, we were unable to test important sectors such as retail trade or personal services.

[1] Job growth in Texas from 1990 to 2000 averaged 2.9 percent per year, well ahead of 1.8 percent in the U.S. Only El Paso lagged the state economy among the four largest U.S. border cities: El Paso, 2.1 percent; Laredo, 4.1; Brownsville, 3.7; and McAllen, 4.6.

[2] Mexican border states here include Baja California, Sonora, Chihuahua, Coahuila and Tamaulipas, excluding Nuevo León.

[3] Presentation by Gerardo Leyva Parra, Director General Adjunta de Estadísticas Económicas, titled *Censos Económicos: 2004, Panorama General*, August 2004 in El Paso, Texas.

[4] The usual dividing line between formal and informal is whether or not the worker is covered by the Instituto Nacional de Seguro Social (IMSS), which provides employment, medical and pension protection. IMSS coverage provides the closest approximation to an employment registry.

[5] Valor bruto de producción del subsector informal at www.inegi.gob.mx

[6] The data in Table 3 are distributed under NAICS at the sector level. The original 1998 Census was conducted using the Mexican Industrial Classification System, and converted to by INEGI to NAICS using bridge tables.

[7] Data on the distribution of proprietors at the sector level for our cities, and a summary of how the data is derived, was received by correspondence with David Lenze, economist and chief methodologist at BEA.

[8] INEGI publishes indexes of retail sales growth, but levels are not available.

[9] The definition of excess employment for services such as real estate or education is the percentage of total employment in that sector multiplier by ((LQ-1)/LQ))*100 where LQ>1. Manufacturing and mining are usually assumed to be near 100 percent exports, with only a few exceptions such as local food processing.

Appendix
A Test for Complementarity in City Pairs

We can use computed location quotients to test for complementary industrial structure in city pairs. The premise is that if exports from one city are matched by imports from the other, the cities are economic complements. If the cities produced similar exports, they would be rivals. If we combine complementary cities and recompute the location quotients on the same common base used for the individual cities, the variance of the LQ's for the combination should fall, i.e., the variance of the combination should be smaller than an appropriately weighted average of the two cities when they stand alone.

To show how this works, consider a region that has j=1,…,n places, with i=1,…,m industries. There are two kinds of industries, basic and non basic. Basic industries export widely.

b_{ij} = basic industry in place j, with i = 1,…, k

$b_{\bullet j}$ = basic industry in place j in all industries

$$= \sum_{i=1}^{k} b_{ij} \text{ , j=1 ,…, n}$$

$b_{i\bullet}$ = total industry i region-wide, i = 1,…, k

$$b_{\bullet\bullet} = \sum_{j=1}^{k} b_{\bullet j} = \text{region wide basic industry}$$

Assume basic industry is measured by industry employment, and that non basic employment develops in each place in proportion to total local basic employment $(b_{\bullet j})$

$n_{ij} = a_i b_{\bullet j}$ i = k+1, …, m

$$n_{\bullet j} = \sum_{i=k+1}^{m} n_{ij} = b_{\bullet j} \sum_{i=k+1}^{m} a_i$$

$$n_{i\bullet} = \sum_{j=1}^{n} n_{ij} = a_i \sum_{j=1}^{n} b_{\bullet j} = a_i b_{\bullet\bullet}$$

Total employment in place j is:

$$e_{\bullet j} = b_{\bullet j} + n_{\bullet j} = b_{\bullet j}(1+ \sum_{k+1}^{m} a_i)$$

Region-wide employment is then:

$$e_{\bullet\bullet} = \sum_{j=1}^{n} e_{\bullet j} = \sum_{j=1}^{n} (1 + \sum_{k+1}^{m} a_i) \, b_{\bullet j} = (1 + \sum_{i=k+1}^{m} a_i) \, b_{\bullet\bullet}$$

Simple algebra shows that the location quotient for all non basic activity is 1.0 in all industries and in all places.

$$\frac{n_{ij}}{e_{\bullet j}} \bigg/ \frac{n_{i\bullet}}{e_{\bullet\bullet}} = 1.0$$

The location quotient for basic activity is independent of non basic activity.

$$\frac{b_{ij}}{e_{\bullet j}} \bigg/ \frac{b_{i\bullet}}{e_{\bullet\bullet}} = \frac{b_{ij}}{b_{\bullet j}} \bigg/ \frac{b_{i\bullet}}{b_{\bullet\bullet}}$$

Variance in location quotients across industries in all places depend <u>only</u> on differences in basic activity. For twin cities j and j', for example, we expect complementarities to exist in exports. What one city does well, the other does not, and $b_{ij} > 1$ will often imply $b_{ij'} < 1$ and vice-versa.

If we combine the location quotient of these two cities, we have

$$LQ'_{ij} = \frac{b_{ij} + b_{ij'}}{b_{\bullet j} + b_{\bullet j'}} \bigg/ \frac{b_{i\bullet}}{b_{\bullet\bullet}}$$

As we compute the variance of the combined cities, we expect to find many cases where the decline in the numerators will be substantial, and the combined LQ' should move closer to one than either of the original values. As the combined region becomes more self-sufficient, relying less on trade, the result should be a variance of LQ' lower than the variance of the two cities measured individually.

This test can be compared to a similar test used by Keil and Mack (1986) and Gilmer (1990), where variance in location quotients is used to identify basic and non-basic industry. The test uses the variance of location quotients in a single industry across many places to identify export industries. This test, in contrast, uses the variance of LQ's in a single place and across many industries to measure change self-sufficiency.

Figure 1. The Largest City –Pairs Located on the Texas –Mexico Border

Source: Texas Comptroller of Public Accounts; U.S. Census Bureau.
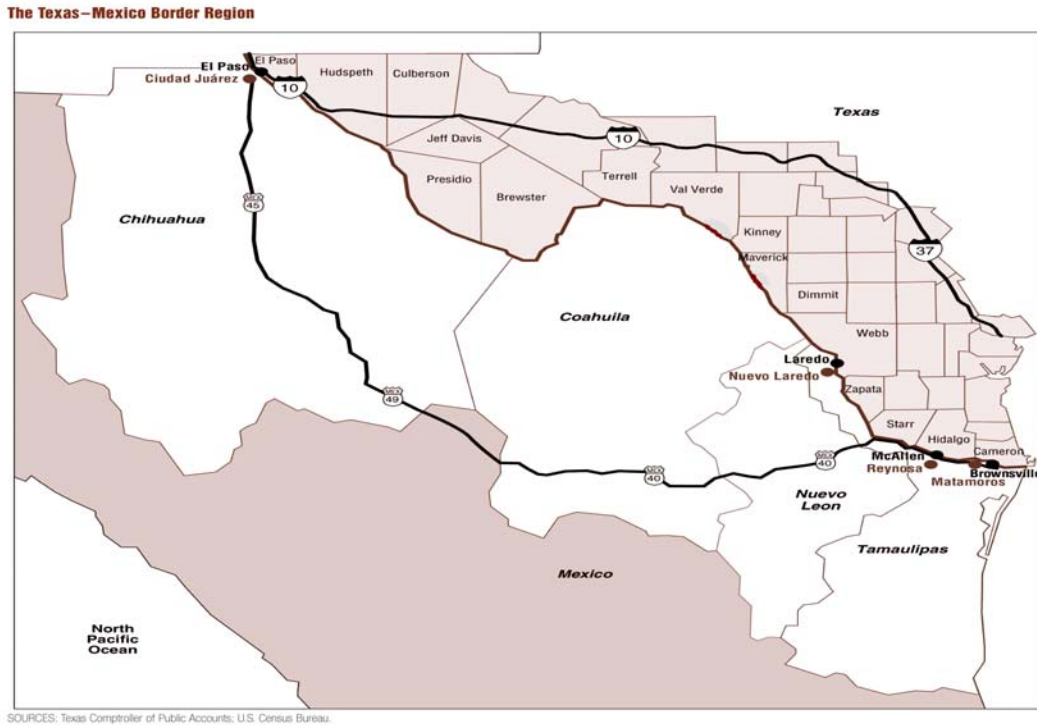
Table 1. Population and Formal Employment in the Largest City –Pairs Located on the Texas –Mexico Border

	Population	Formal Employment
El Paso	732,613	255,700
Ciudad Juárez, Chihuahua	1,420,262	331,623
Laredo	219,760	75,700
Nuevo Laredo, Tamaulipas	363,919	118,561
McAllen	642,776	179,200
Reynosa, Tamaulipas	504,748	175,495
Brownsville	370,268	114,700
Matamoros, Tamaulipas	486,941	167,362

Source: Population for Mexican cities from Consejo Nacional de Población mid year estimates,
2000-2030. Population for U.S. cities from Texas Comptroller of Public Accounts mid year
Texas County Population Projections, 2000-2030. Employment for Mexican cities Chihuahua,
and Tamaulipas State Government Offices. For U.S. cities Federal Reserve Bank of Dallas

Figure 2. Maquiladora Employment Growth

Thousands, SA Data
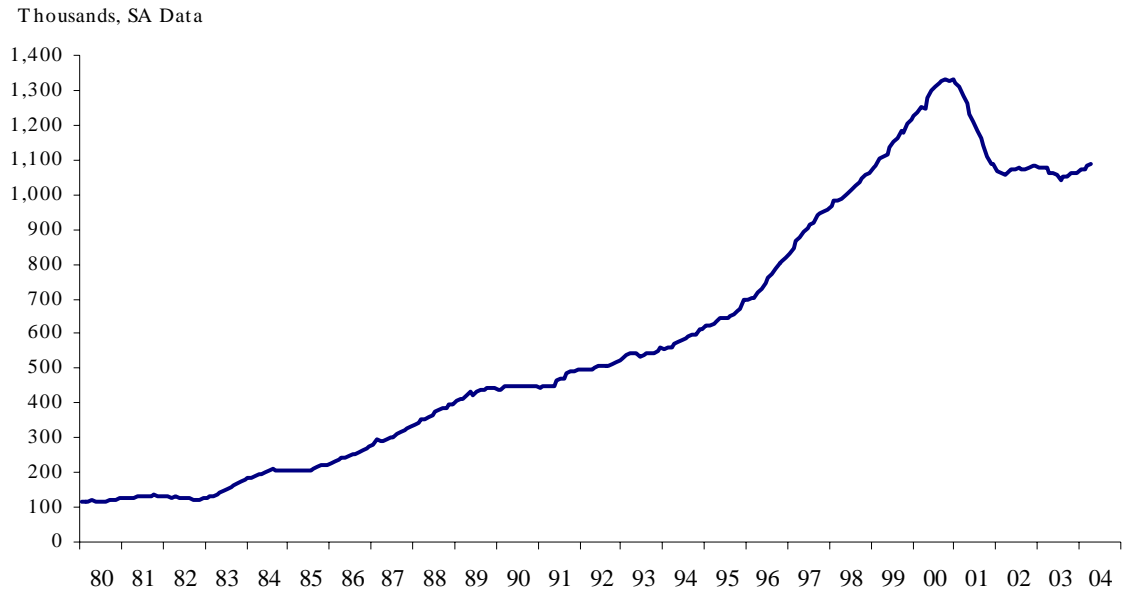
Source: Federal Reserve Bank of Dallas, El Paso Branch with data from INEGI

Table 2. Location Quotients for Mexican Cities Located on the U.S. –Mexico Border (LQ>1.05)

NAICS Code	Sector	Juárez	Nuevo Laredo	Reynosa	Matamoros
11	Agriculture, Forestry, Fishing and Hunting	0.05	0.06	0.01	1.13
21	Mining	0.06	0.03	4.07	0.11
22	Utilities	0.30	0.64	0.38	0.34
23	Construction	0.32	0.45	0.87	0.56
31-33	Manufacturing	2.12	1.28	1.69	1.98
42	Wholesale Trade	0.49	0.56	0.50	0.53
44-45	Retail Trade	0.55	0.83	0.68	0.64
48-49	Transportation Housing	0.55	3.29	0.62	0.62
51	Information	1.89	0.70	0.95	0.69
52	Finance and Insurance	0.08	0.20	0.11	0.14
53	Real Estate and Rental and Leasing	0.68	0.64	0.85	0.50
54	Professional, Scientific, and Technical Services	0.49	0.63	0.72	0.31
55	Management of Companies and Enterprises	0.01	0.00	0.05	0.00
56	Administrative and Support and Waste Management	0.42	0.47	0.35	0.37
61	Educational Services	0.28	0.44	0.47	0.48
62	Health Care and Social Assistence	0.64	0.99	0.75	0.61
71	Arts, Entertainment, and Recreation	0.55	0.73	0.38	0.52
72	Accomodation and Food Services	0.70	1.10	0.83	0.67
81	Other Services(except Public Administration)	0.50	0.99	1.07	0.74
92	Public Administration				

Source: Instituto Nacional de Estadística Geografia e Informática, Censos Económicos 1999 and author's calculations.

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Table 3. Distribution of Employment in Texas and Texas Border Cities By Type of Job, 2000 (Percent)

	Texas	Brownsville	El Paso	Laredo	McAllen
Total Employment	100.0	100.0	100.0	100.0	100.0
Private Wage and Salary Workers	76.7	71.6	73.5	71.3	71.5
Civilian Government Workers	15.2	20.0	19.9	20.5	19.6
Self-Employed	7.6	7.7	6.0	7.6	8.2
Unpaid Family Members	0.5	0.7	0.5	0.6	0.7

Source: U.S. Census of Population

Table 4. Location Quotients for U.S. Cities Located on the Texas –Mexico Border (LQ>1.05)

NAICS Code	Sector	El Paso	Laredo	McAllen	Brownsville
11	Agriculture, Forestry, Fishing and Hunting	0.00	0.00	0.00	0.00
21	Mining	0.05	4.56	2.06	0.05
22	Utilities	0.55	0.91	1.36	1.13
23	Construction	1.12	0.89	1.20	0.82
31-33	Manufacturing	1.19	0.10	0.55	0.82
42	Wholesale Trade	1.02	0.95	0.87	0.76
44-45	Retail Trade	1.17	1.51	1.49	1.30
48-49	Transportation Housing	1.27	4.99	0.81	1.15
51	Information	0.60	0.23	0.38	0.34
52	Finance and Insurance	0.59	0.99	0.66	0.59
53	Real Estate and Rental and Leasing	1.26	0.92	0.86	1.19
54	Professional, Scientific, and Technical Services	0.54	0.46	0.44	0.42
55	Management of Companies and Enterprises	0.03	0.00	0.02	0.01
56	Administrative and Support and Waste Management	1.18	0.77	0.48	0.57
61	Educational Services	6.81	7.89	9.89	8.29
62	Health Care and Social Assistence	0.96	1.10	1.57	1.95
71	Arts, Entertainment, and Recreation	0.80	0.33	0.73	0.79
72	Accomodation and Food Services	1.19	1.18	1.21	1.26
81	Other Services(except Public Administration)	0.78	0.61	0.66	0.72
92	Public Administration				

Source: Bureau of Labor Statistics, Bureau of Economic, and author's calculations.

Table 5 Location Quotients for U.S. and Mexican Border Cities Using a Common Base of the U.S. and Mexico (LQ>1.05)

NAICS Code	Sector	El Paso	Laredo	McAllen	Brownsville	Juarez	Nuevo Laredo	Reynosa	Matamoros
21	Mining	0.04	3.68	1.68	0.04	0.10	0.04	6.45	0.17
22	Utilities	0.42	0.68	1.03	0.85	0.63	1.34	0.80	0.72
23	Construction	1.01	0.79	1.09	0.73	0.26	0.36	0.70	0.46
31-33	Manufacturing	0.96	0.08	0.44	0.65	3.64	2.20	2.90	3.45
42	Wholesale Trade	0.89	0.81	0.76	0.65	0.55	0.63	0.56	0.60
44-45	Retail Trade	0.97	1.24	1.24	1.07	0.80	1.21	0.98	0.94
48-49	Transportation Housing	1.11	4.30	0.71	1.00	0.59	3.55	0.67	0.67
51	Information	0.56	0.22	0.36	0.32	0.90	0.33	0.45	0.33
52	Finance and Insurance	0.56	0.93	0.63	0.56	0.03	0.07	0.04	0.05
53	Real Estate and Rental and Leasing	1.18	0.85	0.81	1.11	0.33	0.31	0.41	0.24
54	Professional, Scientific, and Technical Services	0.51	0.42	0.41	0.39	0.24	0.31	0.36	0.16
55	Management of Companies and Enterprises	0.03	0.00	0.02	0.01	0.00	0.00	0.01	0.00
56	Administrative and Support and Waste Management	1.09	0.71	0.44	0.52	0.27	0.30	0.22	0.24
61	Educational Services	5.87	6.71	8.53	7.07	0.34	0.52	0.56	0.58
62	Health Care and Social Assistance	0.94	1.06	1.53	1.88	0.13	0.20	0.15	0.12
71	Arts, Entertainment, and Recreation	0.75	0.30	0.69	0.73	0.29	0.38	0.20	0.27
72	Accomodation and Food Services	1.08	1.06	1.10	1.13	0.54	0.85	0.64	0.53
81	Other Services(except Public Administration)	0.66	0.51	0.56	0.61	0.63	1.25	1.35	0.94
	VARIANCE	**1.15**	**2.34**	**2.14**	**1.61**	**0.65**	**0.8**	**2.30**	**0.59**

Sources: Instituto Nacional de Estadística Geografia e Informática, Censos Económicos 1999 for Mexican cities employment;
Texas Workforce Commission and Bureau of Economic Analysis for U.S. cities employment; and author's calculations.

Table 6. City Pairs Combined: Location Quotients for City Pairs on U.S. –Mexico Base (LQ>1.05)

NAICS Code	Sector	El Paso Juárez	Laredo Nuevo Laredo	McAllen Reynosa	Brownsville Matamoros
21	Mining	0.20	1.80	3.50	0.30
22	Utilities	0.50	1.00	0.80	0.70
23	Construction	0.60	0.70	1.20	0.80
31-33	Manufacturing	2.50	1.10	1.30	1.90
42	Wholesale Trade	0.70	0.70	0.60	0.60
44-45	Retail Trade	0.90	1.20	1.10	1.00
48-49	Transportation Housing	0.80	3.80	0.80	0.90
51	Information	0.70	0.30	0.40	0.30
52	Finance and Insurance	0.30	0.50	0.50	0.40
53	Real Estate and Rental and Leasing	1.10	1.20	1.80	1.30
54	Professional, Scientific, and Technical Services	0.40	0.50	0.50	0.40
55	Management of Companies and Enterprises	0.00	0.00	0.00	0.00
56	Administrative and Support and Waste Management	0.60	0.50	0.50	0.50
61	Educational Services	2.20	3.20	4.30	3.30
62	Health Care and Social Assistence	0.40	0.60	0.90	0.90
71	Arts, Entertainment, and Recreation	0.60	0.40	0.60	0.60
72	Accomodation and Food Services	0.70	0.90	0.80	0.80
81	Other Services(except Public Administration)	0.70	1.00	1.10	0.90
	VARIANCE	**0.39**	**0.94**	**1.18**	**0.56**

Source: author's calculations.

Table 7. F-Test for Complementary Industrial Structures for Adjacent Border Cities

	Variance Ratio		
El Paso – Juárez	**2.10**		
Laredo – Nuevo Laredo	**1.61**		
McAllen – Reynosa	**1.88**		
Brownsville – Matamoros	**2.00**		
	99 %	95 %	90 %
Critical Value[*]	**3.24**	**2.27**	**1.89**

Source: Sources: Author's calculations.
*At 17 degrees of freedom

Table 8. F- Test for Complementary of Individual Sectors in Adjacent Border Cities, by Sector and Level of Significance

Sector	df	El Paso–Juarez			Laredo–Nvo. Laredo			McAllen–Reynosa			Brownsville–Matamoros		
Level of Significance		99 %	95 %	90 %	99 %	95 %	90 %	99 %	95 %	90 %	99 %	95 %	90 %
21-22 Mining & Utilities	8					•			•				
31-33 Manufacturing	84	•			•			•			•		
42 Wholesale Trade	17			•			•					•	
51 Information	11												
55 Management of Companies and Enterprises	18					•							
61 Educational Services	5		•				•						•
71 Arts, Entertainment, and Recreation	8		•							•			•
72 Accomodation and Food Services	6								•			•	

Source: Author's calculations.

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