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Analyzing the Export Flow from Texas to Mexico

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Abstract

From 1997 to 2008, Texas shipped 40 percent of its manufacturing exports to Mexico. This puts Texas–Mexico among the largest state–country trading relationships. But this share has been declining recently. A gravity equation cannot account for either of these facts, even though Texas and Mexico share a border. This positive contiguity effect is not unique in state export data. I study the features of the Texas–Mexico relationship to try to account for the size of the export flow and the recent decline in share. Data limitations prevent a full accounting, but the most likely feature is the changing source of maquiladora inputs from the United States to Asia.

JEL codes: F14, R11
Keywords: Texas, Mexico, exports, gravity, border, consolidation, maquiladoras

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Texas was the largest U.S. state in terms of the real value of exported manufactured goods from 1997 to 2008. Fifteen percent of U.S. exports originated in Texas. Nearly 40 percent of these exports were shipped to Mexico. However, the share of Texas' exports to Mexico has been falling over time. A standard gravity equation can neither account for the size of this export relationship nor the recent decrease. This lack of knowledge is an important problem because economic forecasts and policy predictions (frequently based on the gravity equation) will not be accurate without understanding Texas' economic relationship to its southern neighbor.

I begin by documenting two facts about Texas' manufacturing exports to Mexico that cannot be accounted for in a standard gravity equation. First, the Texas–Mexico export relationship is the largest state–country export relationship in terms of value but only eighth in terms of export share. However, with 39.5 percent of Texas' total exports, Mexico receives a large share of exports compared with the share received by the average country. Second, though real manufacturing exports from Texas to Mexico are increasing in value over time, the share of Texas exports to Mexico is decreasing. This finding conflicts with Coughlin (2004), who argues that proximity is increasingly important for U.S. state exports.

After establishing these facts, I estimate the parameters of a gravity equation using export data from all U.S. states to 175 countries. I apply these estimated parameters to Texas and Mexico to see how well the gravity equation accounts for this relationship. Though the gravity equation accounts for 70 percent of U.S. state export data, it underpredicts manufacturing exports from Texas to Mexico by a factor of three.

I use the gravity equation to reinterpret the unaccounted-for exports. Instead of trying to find variables that increase exports, I calculate the geographic distance required to make Texas' exports to Mexico match those predicted by the equation. By this calculation, Texas needs to be three times closer to Mexico in geographic distance than it actually is, measured by the great circle route from its population centroid to Mexico City. Therefore, the failure of gravity to account for contiguity trade such as Texas–Mexico (even with the inclusion of a border dummy variable) can be interpreted as poor modeling of economic and physical distance.

Thinking that the gravity equation's underestimation of Texas–Mexico trade is a failure to correctly model and measure distance yields an insight. McCallum (1995) estimates a sizable international border hindrance effect by comparing trade between economies of similar size and distance with and without an international border separating them. Though Anderson and van Wincoop (2003) greatly revise McCallum's international border hindrance effect downward, they support its existence. Coughlin and Novy (2009) find a larger hindrance effect for state borders.[1]

I find an unaccounted-for boost to trade from being contiguous rather than noncontiguous with a foreign partner in a state–country relationship of otherwise equal size and distance. There is a conceptual difference between McCallum's border effect and the contiguity effect I document. The border effect in the literature is the decrease in exports observed in international trade data rather than domestic trade data for equally sized and distanced partners. The contiguity effect I document is the enhancement of international trade from contiguous partners over equally sized and distanced noncontiguous partners. This positive contiguity effect has been documented before, often offhandedly, whenever a border dummy for an international trade regression is significantly positive. Here I take that frequently dismissed estimate seriously as a failure to model distance correctly.

I study features of the Texas–Mexico relationship to account for the documented facts about Texas manufacturing exports to Mexico and the enhancing contiguity effect. The features I consider are 1) the existence of idiosyncratic industrial subsectors that are driving the aggregate data, 2) the existence of Texas' one-and-only trade office in Mexico City, 3) the existence of Mexican maquiladoras along the Texas border, and 4) possible measurement errors in the export data due to the attribution of other states' Mexico-bound exports to Texas as a result of consolidation at Texas ports. I consider these features from the viewpoint that they need to decrease the economic distance for the gravity equation to predict the amount of exports in the data. I use data on state exports from Texas to Mexico as well as other states and countries for comparison and controls.

I find that three of these four features are unlikely to account for either Texas' large share of exports to Mexico or the decrease in that share over time. The pattern of exports from the auto and oil industries is not largely different from that in the overall economy. The full estimation with a variable for the existence of an overseas office leads to a prediction that Texas will export to Mexico less than the original gravity equation predicts. And though there is evidence of exports to Mexico being overattributed to Texas, the likely error is not enough to significantly change the gravity prediction.

[1] Hillberry and Hummels (2008) argue that the border deterrence effect is an illusion based on trade in intermediate inputs, aggregate data, and political boundaries at distance from economic activity.

I find evidence, admittedly unquantified, that the existence of maquiladoras may partially account for both of the facts. First, maquiladoras used to be concentrated on the border but are increasingly located throughout Mexico, and second, maquiladoras used to buy essentially all their inputs from the United States but increasingly get them from other countries. These trends are likely important in explaining Texas' high share of exports to Mexico and the decline in that share over time.

Texas' export relationship with Mexico is not the largest trade relationship among U.S. states. It is the eighth largest in terms of share. Texas–Mexico receives my attention because it is the largest trade relationship in terms of value. Though I study how unique features such as maquiladoras impact the trade flow between the regions, the lessons learned may apply to other contiguous relationships. For example, a change in Canadian intermediate input purchases away from the United States (possibly combined with a consolidation of Great Lakes states exports in Michigan) may partially account for Michigan's high share of exports to Canada and the recent decline in that share.

1. THE EXPORT DATA

Before documenting the Texas–Mexico export facts, I describe the data used to establish the facts. I use state export data from the Census Bureau, available through the third-party World Institute for Strategic Economic Research (WISER, various years). I also use country gross domestic product (GDP) data from the International Monetary Fund (2009) and state GDP data from the Bureau of Economic Analysis.[2]

State export data are the f.a.s. (free alongside ship) sales value measured at the port of exit. These data were collected by recording information on the Shipper's Export Declaration (filled out by the shipper) but are now collected electronically. The data are then compiled by the U.S. Census Bureau and released to the public through WISER. These are the only state export data with information on the destination country. They also specify whether the exported good was shipped by sea or air.

The state export data are known as origin of movement (OM) data because the collection method means exports are attributed to the state in which the shipment began its journey abroad and not necessarily the state in which the shipment was produced. Cassey (2009b) describes the data collection process in detail and estimates the discrepancy between the origin of movement of state exports and the origin of production. He finds that this discrepancy is not large for manufactured goods, provided the data are aggregated to the state level. But Cassey finds that the export data for unprocessed agricultural and mining goods are not credible. Therefore, only manufacturing data will be used in this analysis. Furthermore, Cassey finds Texas has the second-largest discrepancy (behind Florida) between the OM data and destination-less manufacturing export data from the Annual Survey of Manufactures. This is one feature of the Texas–Mexico relationship that will be considered: that the large share of exports from Texas to Mexico is due to consolidation of other states' Mexico-bound exports at Texas ports, resulting in mismeasurement.

2. TWO FACTS

Fact 1: Share of Exports to Leading Destinations Is Large

From 1997 to 2008, Texas shipped 39.5 percent of its manufacturing exports to Mexico. This is the lion's share because Texas sent 10 percent to Canada, the second-biggest receiver. Though the average state shipped 28 percent of its exports to the biggest receiving country, the Texas–Mexico relationship is not the most prominent. The largest is Michigan, which sent 57 percent of its exports to Canada, followed by Ohio–Canada with 51 percent and Indiana–Canada with 45 percent. Texas does ship more of its exports to Mexico than the other states bordering Mexico. Arizona ships 27 percent, California 15 percent, and New Mexico only 7 percent.[3]

Figure 1 compares the Texas–Mexico export share with the amount other states export to their largest receiving partners. Texas sends a smaller share of total exports to the third-, fourth-, and fifth-largest receivers than other states do. Also, though Texas–Mexico is the largest export relationship among state–country pairs in value, it is unexceptional in terms of export share to leading recipients. The main fact learned from Figure 1 is that the share of exports Texas sends to its leading destination, though not exceptional, is greater than the average and several times more than other leading exporting states such as California and Florida send to their top recipient.

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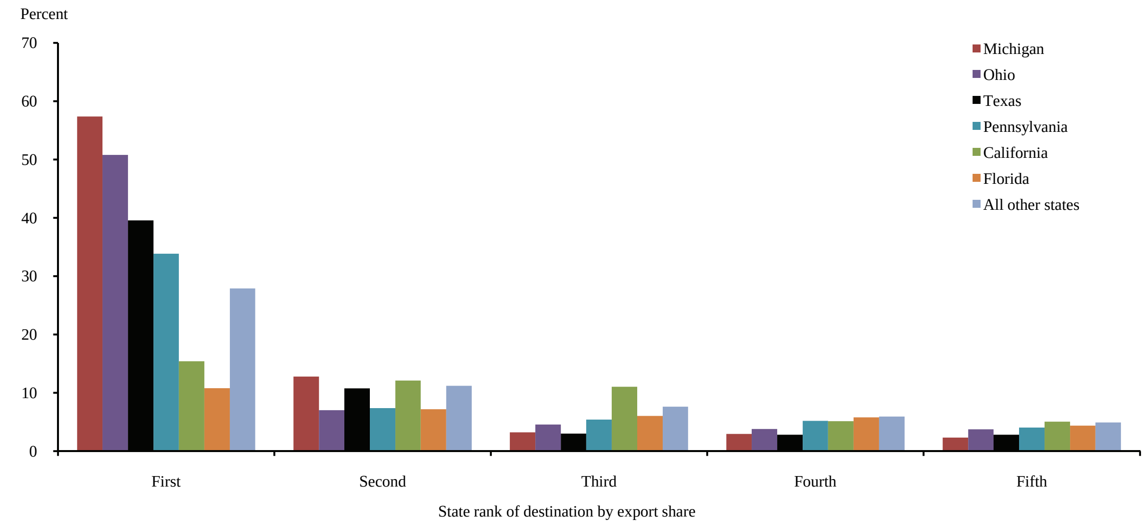
[2]See www.bea.gov/regional, accessed June 12, 2010.

[3]Mexico is California's largest destination, but Arizona exports more to Canada than Mexico. Mexico is the fifth-largest receiver of New Mexico exports after the Philippines, Malaysia, China, and South Korea.

Figure 1: Share of Exports from U.S. States to Leading Destinations, 1997–2008



NOTE: For each state, "First" is the country that receives the largest share of exports, "Second" is the country that receives the second-largest share of exports, and so on. The largest receiving country depends on the state. For Texas and California, the largest recipient is Mexico. For Michigan, Ohio, and Pennsylvania, the largest recipient is Canada. For Florida, the largest recipient is Brazil.

SOURCE: Author's calculations using WISER state export data.

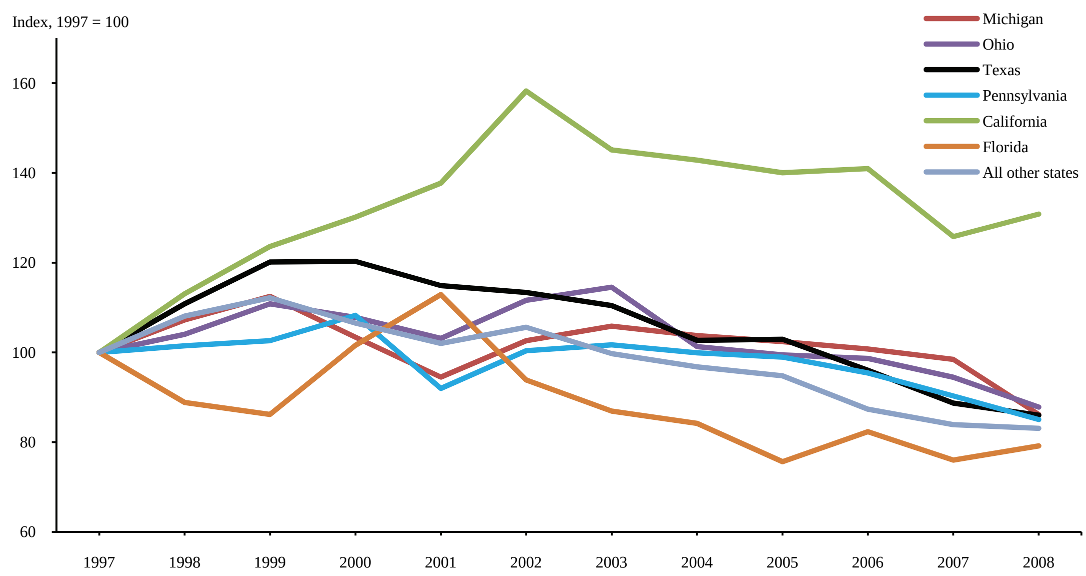
Fact 2: Share of Exports to Leading Destinations Is Decreasing

Figure 2 shows how the share of exports to leading destinations has changed over time. For example, Texas sent 38 percent of its exports to Mexico in 1997 but 46 percent in 2000. Rather than show the shares in levels, Figure 2 indexes each state to be 100 in 1997 so that changes from 1997 can be seen in comparison with other states.

For Texas, the export share to Mexico increased immediately after 1997 but began a steady decline from its 1999–2000 peak. The fact learned in Figure 2 is that Mexico is not as important a destination for Texas exports as it used to be.

But it is not just Texas–Mexico that is seeing a decrease in export share to its leading destination. As Figure 2 shows, this trend is occurring for almost all states except California (which increased its export

Figure 2: Export Share to Largest Destination, 1997–2008



NOTE: Changes to the export share to the leading destination indexed so that each state's share is 100 in 1997.

SOURCE: Author's calculations using WISER state export data.

share to its largest destination, Mexico). Because the nearest country is most frequently the largest recipient of a state's exports, the trend is seemingly in conflict with Coughlin (2004).

Coughlin reports that trade has intensified with geographically close partners, and, in particular, that state export shares to Mexico have increased. His calculations show that the geographic distance traveled by the average state export is decreasing. But that can occur even if the export share to the leading destination is falling if the state increases its export share to other nearby countries. Furthermore, Coughlin's data are through 2002, so he misses the subsequent decline in share (in all states including California).[4]

3. GRAVITY EQUATION CANNOT FULLY ACCOUNT FOR TEXAS–MEXICO

The gravity equation accounts for trade flows between two countries using the economic size of the trading partners and their economic distance, including observed and unobserved barriers to trade. The equation was introduced by Tinbergen (1962) and is named for its similarity to Newton's description of the gravity felt by massive objects. In the equation's simplest form, real GDP is used for size, and great-circle-route mileage is used for distance. Even in this simplest form, the gravity equation is empirically successful as measured by a large R^2.

I apply the OM state export data, state and country GDP, and physical distance between states and countries to a gravity equation. Though the vast majority of the gravity literature uses the equation on bilateral country data, derivations of the equation by Anderson (1979) and Chaney (2008), among others, show there is no conceptual difference between the gravity equation applied to country–country data and state–country data. Cassey (2008) and Coughlin and Novy (2009) applied state–country data to a gravity equation, justifying its use in this application.

To see how much of the Texas–Mexico export relationship is accounted for by the simplest version of the gravity equation, I first use the ordinary least squares (OLS) estimator on pooled data across time and the sample of 175 countries. I regress the logarithm of exports on the logarithms of real GDP and great-circle-route mileage without the Texas–Mexico observations.[5] Then I apply these estimates to Texas and Mexico to compare exports predicted by the gravity equation with exports in the data:

$$\log X_{ijt} = -\underset{(0.106)^*}{3.912} + \underset{(0.006)^*}{1.352} \log Y_{it} + \underset{(0.003)^*}{1.092} \log Y_{jt} - \underset{(0.012)^*}{1.407} \log D_{ij} + \varepsilon_{ijt}. \tag{1}$$

$$N = 84,334 \quad R^2 = .70 \quad RMSE = 1.74.$$

In (1), i is an index for the exporting U.S. state, j is an index for the importing country, and t is for year. The standard errors in parentheses are robust to heteroskedasticity. An asterisk on the standard error denotes that the corresponding coefficient estimate is significantly different from zero with 99 percent confidence. The pooled data without Texas–Mexico have 86,078 positive observations on exports—82 percent of all possible state–country trade combinations. (The number of possible observations is $104,988 = 50$ states $\times$ 175 countries $\times$ 12 years $-$ 12 Texas–Mexico observations.) The observations with zero exports are dropped from the regression. Also dropped are observations with missing country GDP information. This reduces the number of observations to 84,334. The $R^2 = .70$, indicating the simple gravity equation accounts for 70 percent of the data.

When the parameter estimates obtained from (1) are applied to the Texas–Mexico GDP and physical distance data, the gravity equation predicts yearly aggregate exports to be $7.5 billion in 1982–84 dollars. The datum for Texas–Mexico exports is $28 billion. Therefore, the gravity equation accounts for about 25 percent of Texas' exports to Mexico, compared with 70 percent of the actual data.

The corresponding share of Texas exports to Mexico is only 25.5 percent as calculated by the gravity equation, instead of near 40 percent in reality. Furthermore, given the data on state and country GDP by year, (1) predicts this share increases from 1997 to 2002, declines until 2004, and is roughly constant from then on. Figure 3 shows this and compares Texas' share of exports to Mexico with that predicted by (1). The gravity equation does not match the Texas–Mexico data very well in any year and lags behind the trend in decreasing share.

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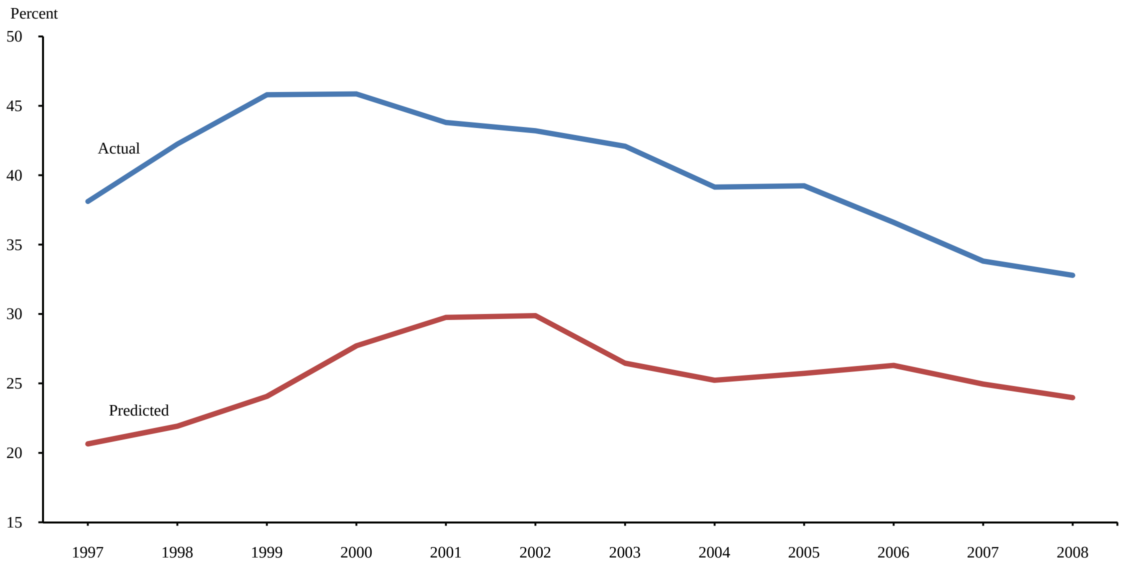
[4] Carrère and Schiff (2005) agree with Coughlin that distance is becoming more important for world trade, but they note the opposite is happening in the United States.

[5] State GDP data are from the Bureau of Economic Analysis, www.bea.gov/regional, and country GDP data are from the International Monetary Fund (2009). Distance is the author's calculation, using geographic coordinates of each country's capital and the population centroid of U.S. states.

Figure 3: Texas' Actual and Predicted Export Share to Mexico, 1997–2008



SOURCE: Author's calculations using WISER state export data.

One possible reason for gravity's failure to predict Texas–Mexico trade is simple randomness. The equation has an error term, and perhaps Texas–Mexico observations just happen to be different from average. But this does not seem likely because the discrepancy between data and prediction is roughly constant for all years. Another possible reason for gravity's failure could be that (1) is misspecified. And though a Ramsey Regression Equation Specification Error Test (RESET) offers evidence supporting misspecification $(F(3, 84327) = 802)$, the fact that (1) has a relatively high R^2 means that it accounts for most of the non-Texas–Mexico observations. Nonetheless, I now consider an alternative gravity equation model.

Theoretic and econometric advances have corrected the simple gravity equation (1) for bias from heteroskedasticity when variables are subject to logarithmic transformation (Santos Silva and Tenreyro 2006), selection (Helpman, Melitz, and Rubinstein 2008), and missing variables (Anderson and van Wincoop 2003). When fixed effects (Egger 2000) and the Poisson quasi-maximum likelihood estimator (Santos Silva and Tenreyro) are used, the estimates are:

$$X_{ijt} = -\underset{(0.785)^*}{3.995} + \underset{(0.258)^*}{0.752} \log Y_{it} + \underset{(0.052)^*}{0.705} \log Y_{jt} - \underset{(0.037)^*}{0.904} \log D_{ij}$$

$$+ \sum_{i=2}^{50} \delta_i S_i + \sum_{j=2}^{175} \gamma_j C_j + \sum_{t=1998}^{2008} \tau_t T_t + \varepsilon_{ijt}. \quad (2)$$

$$N = 103,838 \qquad \hat{R}^2 = .61 \qquad RMSE = 7.12.$$

Here, S_i, C_j, and T_t are binary fixed effects to control for time invariant state, country, and year characteristics. Again, the asterisk denotes the estimate is significantly different from zero with 99 percent confidence.

Equation (2) predicts yearly Texas exports to Mexico will be $10.8 billion, or still only 38 percent of the datum. Though exporter-year and importer-year interactions are recommended by Feenstra (2003, p. 161), I do not include any time-varying interaction terms because of computational limitations. There would be 2,453 interaction coefficients to estimate. For robustness, I do run a variant of (2) with country dummies and state–year interaction (and without $\log Y_{it}$), but the results are not qualitatively different.

Notice that the estimated coefficient on distance in (1) is greater than in (2) in absolute value. A greater distance coefficient means distance is more of a hindrance to exports and, with all else equal, results in more exports to closer destinations. The reason the estimated coefficient in (2) is smaller than in (1), yet the predicted exports are no greater, is that the estimated coefficients on GDP have changed and the presence of the fixed effects.

The fact that Texas' export share to Mexico is decreasing but the level of exports is not may be explained by an increase in the GDP of other countries relative to Mexico (this hypothesis cannot account for fact 1). But if this were true, California would have a decreasing share of exports to Mexico. Figure 2 shows California's share of exports to Mexico is increasing. Furthermore, (1) explicitly accounts for GDP in other countries. As Figure 3 shows, gravity's predicted Texas export share to Mexico lags behind the data and does not decrease as much. Though the GDP growth of China, for example, does account for some of fact 2, a lot remains to be accounted for.

To formally consider the possibility of country GDP growth, I take first differences of (1) and apply it to the state export data. Only the GDP growth of other countries matters and not the GDP growth of Texas because that applies equally to all destinations. The results, reported in the appendix, indicate that growth in country GDP has very low explanatory power for the changes in state exports.

Another possibility is that the U.S.–Mexico exchange rate relative to the U.S.–other countries exchange rate accounts for the decrease in Texas–Mexico export share but not fact 1. However, the evidence is against this because the world's major currencies, except the South Korean won, appreciated versus the Mexican peso relative to the U.S. dollar. Fact 2 cannot be accounted for from South Korea because it was the destination for less than 3 percent of Texas' exports from 1997 to 2008. In the appendix, see the chart showing relative exchange rate movements against the peso.

I have ruled out the typical gravity variables for explaining the two facts about Texas–Mexico. To get gravity to match the data, the equation needs a variable that increases Texas–Mexico exports and does not increase Texas exports to more distant destinations (which would decrease Texas' share of exports to Mexico).

4. RECASTING DISTANCE

The discrepancy between the gravity equation and the data means there is a missing or mismeasured variable that will increase the equation's predicted exports from Texas to Mexico (and potentially those in other large relationships such as Michigan–Canada) but not increase exports to other destinations. One way to specify this variable is with a more precise measure of economic distance that decreases distance by lowering economic barriers to trade without diminishing the importance of physical distance. This way, the great-circle-route distance from population centroid to capital is a component of a more complete economic distance particular to Texas–Mexico relative to similarly sized and distanced trade partners.

For example, the great circle distance from Texas' population centroid to Mexico City (the capital and most populous city) is 804 miles. By using the parameter estimates from (1) and the data on Texas–Mexico exports, the gravity equation implies that the distance needed to generate the data is 304 miles, or about 40 percent of 804. The distance needed for (2) to match the data is 276 miles.

Perhaps the discrepancy is because Texas and Mexico share a border. The gravity literature struggles with how to handle contiguous partners. One standard method is to insert a bilateral binary variable into (1) that takes the value of 1 for partners sharing a border. Doing this gives an estimate of 0.618* (0.096) on the binary border variable without changing the other estimates much, indicating contiguous partners have on average 85 percent ($= \exp(.618) - 1 \times 100$) more exports than noncontiguous partners. (Again, the asterisk denotes the estimate is significantly different from zero with 99 percent confidence.) With the border binary variable included, predicted Texas exports to Mexico increase to \$13.5 billion, and the geographic distance needed for the gravity equation to match the data becomes 464 miles.

Fact 1 suggests there is a contiguity bonus in the data. As noted earlier, this contiguity effect may be thought of as an atheoretic coefficient on a border dummy. An atheoretic coefficient is not satisfactory, in part because it accounts for only some of the missing exports and in part because fact 2 (the share of Texas exports to Mexico has been decreasing) implies this ad hoc contiguity dummy also has to change over time for an ad hoc reason.

In the next section, I study four unique features of the Texas–Mexico relationship to determine if they can partially account for the gravity equation's estimated short distance: idiosyncratic industries such as petroleum or automobiles, Texas' trade office in Mexico City, maquiladoras, and mismeasurement of the state export data due to consolidation of other states' shipments at the border. The common theme is the possibility that these can shorten Texas' economic distance with Mexico without shortening the economic distance to other countries.

The gravity literature has pursued a similar approach in that it has added to the equation barriers-to-trade variables such as tariffs and nontariff barriers, exchange rates, language, and colonial history. In this case, these variables have no explanatory power because the export data are from U.S. states that all face these same barriers. I have to find a variable unique to Texas and Mexico that still may be informative for other contiguous trade relationships such as Michigan–Canada.

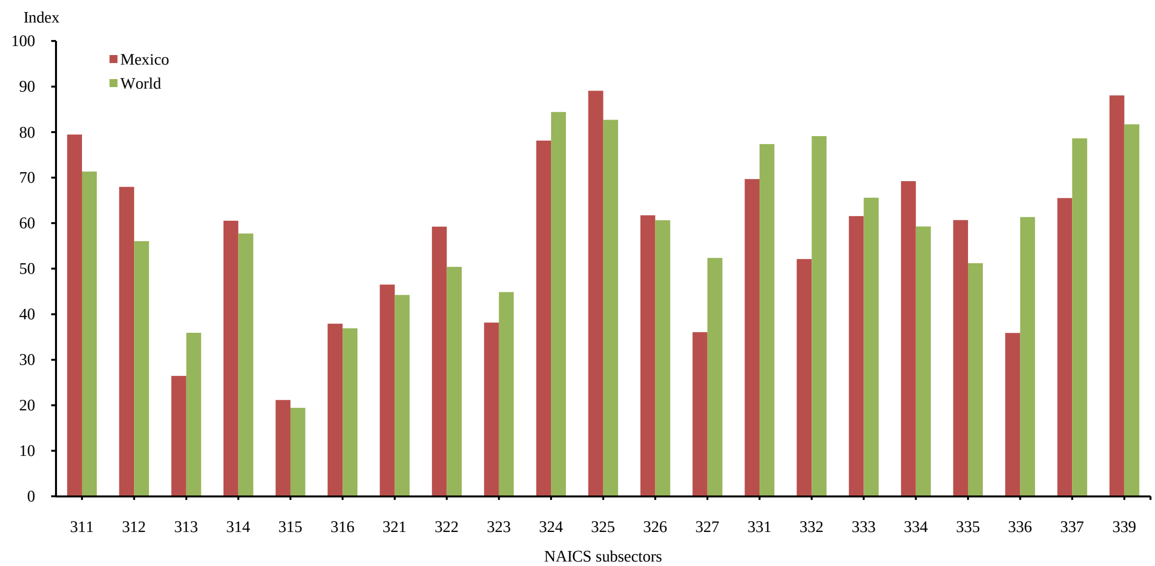
5. CANDIDATES FOR SHORTENING ECONOMIC DISTANCE

Idiosyncratic Industries

It is possible that the two facts are attributable to unique features of a particular industry in Texas and that industry's relationship with Mexico relative to the world. To see this, I disaggregate Texas' exports by the 21 North American Industry Classification System (NAICS) manufacturing subsectors. A list of these subsectors is in the appendix. Texas' top five world export sectors are 1) computer and electronic products (NAICS 334) at 26.1 percent, 2) chemicals (325) at 18.6 percent, 3) machinery, except electrical (333) at 14.2 percent, 4) transportation equipment (336) at 11.4 percent, and 5) petroleum and coal products (324) at 6.7 percent.

Figure 4 compares the change in exports to Mexico and the world over time for the 21 subsectors using a diffusion index. The index is constructed so that the size of the industry does not matter. For each sector, if the bar is exactly 50, that sector did not increase real export value in 1997–2008. But if the bar is above 50, that sector increased real export value. Each year is weighted by its share of total Texas subsector exports. Given that Texas' exports to the world and Mexico are both increasing in real value, in order for any particular subsector to be responsible for the recent decrease in the Texas–Mexico export share, that subsector would need an increase in exports to the world (a green bar over 50) but a decrease in exports to Mexico (a red bar under 50).

Figure 4: Manufacturing Exports Diffusion Index



NOTE: Red bars are exports to Mexico, and green bars are exports to the world. If there is no change in export growth in the sector from 1997 to 2008, the diffusion index is 50. If a manufacturing subsector increases its exports every year from 1997 to 2008, the index is 100. Each year is weighted by its share of total Texas subsector exports.

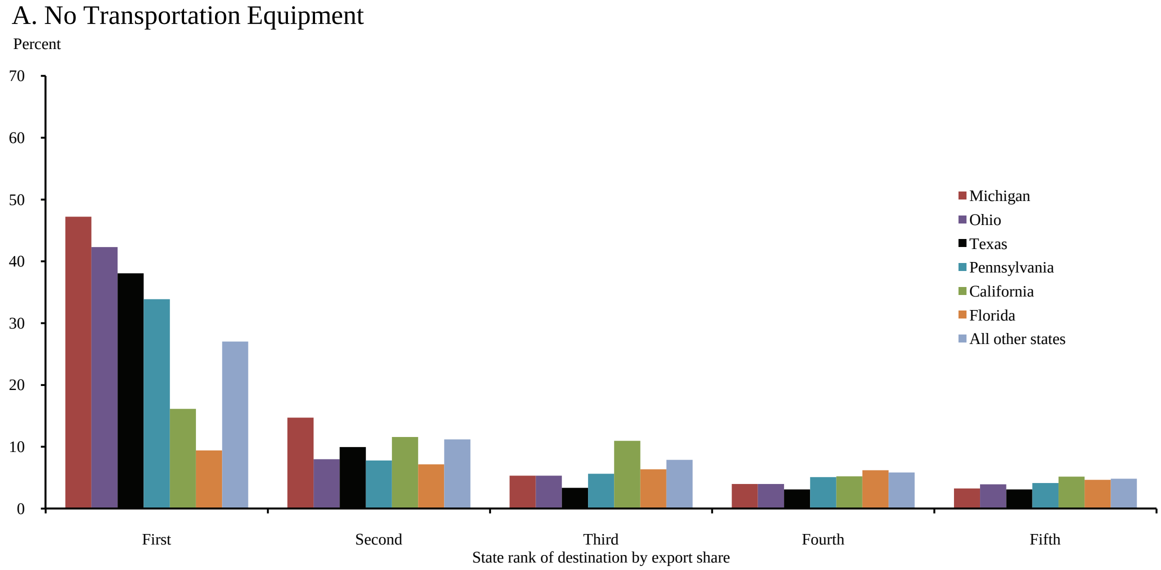
SOURCE: Author's calculations using WISER state export data.

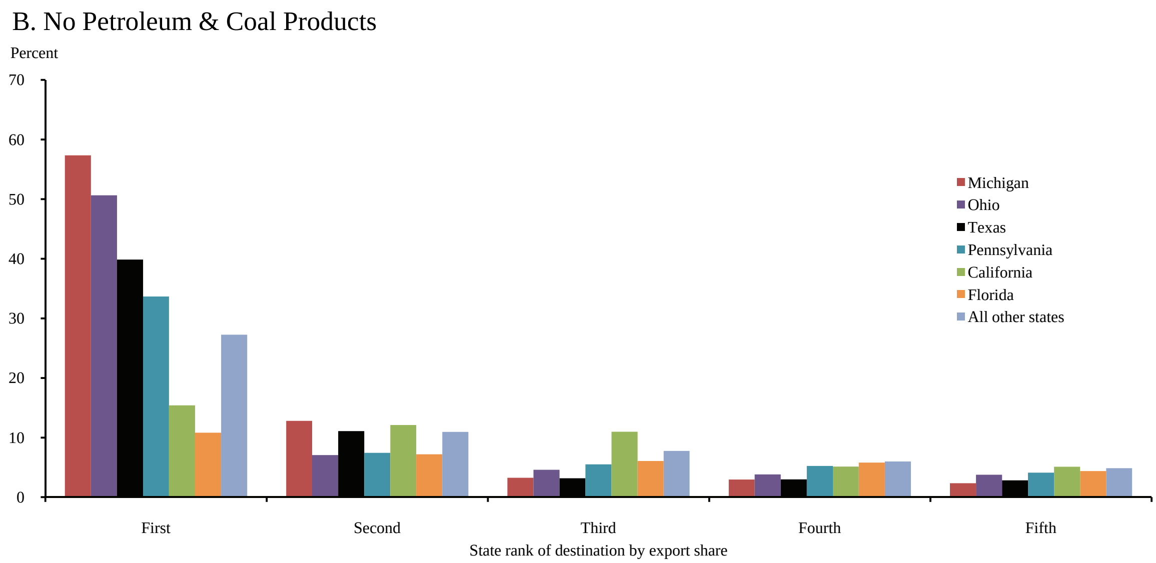
Figure 4 shows that nearly all subsectors' change in exports moved in the same direction (up or down) to both Mexico and the world. But two subsectors increased exports to the world while simultaneously decreasing exports to Mexico. These are nonmetallic mineral products (NAICS 327) and transportation equipment (336). Nonmetallic mineral products is not a large Texas export subsector. With exports of only $4.7 billion for 1997–2008, or 0.5 percent of Texas' total, nometallic mineral products cannot account for the two facts. But transportation equipment is the fourth-largest subsector for Texas, with exports of $97 billion (11.4 percent). It gets special attention later.

Figure 4 also shows that the largest gains in exports, both to Mexico and the world, belong to chemicals (NAICS 325), miscellaneous manufacturing (339), and petroleum and coal products (324). However, exports from both the chemical and miscellaneous manufacturing subsectors to Mexico outgrew those to the world. So these subsectors cannot account for the decline in export share to Mexico. Petroleum and coal products, a historically important subsector for the Texas economy, will also get special attention.

Transportation Equipment. No reference is needed to know that the automotive industry is largely responsible for the trade between Great Lakes states such as Michigan, and Canada. However, the automobile industry is also important in the Texas–Mexico relationship because the maquiladoras located near the Texas

Figure 5: Export Share to Largest Destination, Without Transportation Equipment and Petroleum and Coal Products, 1997–2008





NOTE: For each state, "First" is the country that receives the largest share of exports, "Second" is the country that receives the second-largest share of exports, and so on. The largest receiving country depends on the state. For Texas and California, the largest recipient is Mexico. For Michigan, Ohio, and Pennsylvania, the largest recipient is Canada. For Florida, the largest recipient is Brazil.

SOURCE: Author's calculations using WISER state export data.

border largely manufacture cars and car parts (Cañas and Gilmer 2009).[6] It is possible that the two facts—border relationships have large export shares and that these shares have been decreasing in recent years—can be accounted for by the transportation equipment subsector, NAICS 336.

Figure 5a is a remake of Figure 1, except that transportation equipment has been removed from the rest of the data. Mexico receives 38 percent of Texas' exports without transportation equipment and 39.5 percent with it. Therefore, cars and car parts traded along the border cannot account for the facts. Interestingly, removing transportation equipment does not dramatically change the share of exports to leading destinations for other states, either. Canada receives 47 percent of Michigan's exports without cars despite the anecdotal belief that Michigan–Canada trade is dominated by cars and car parts.

Petroleum and Coal Products. The oil industry is historically important for the Texas economy. Furthermore, the years 1997–2008 were good to the oil industry. There were large increases in the prices of

[6] I consider the role of maquiladoras later in this article.

crude oil and refined gasoline.[7] Though petroleum and coal products is Texas' fifth-largest export sector to the world, Texas exported only \$20 billion to Mexico, 6 percent of its total exports during that time.

Figure 5b shows states' export share to their top destinations without petroleum and coal products. The export shares of Michigan and Ohio to Canada are the same as in Figure 1 when all data are used. Texas' share to Mexico increases slightly, to 39.8 percent. Therefore, the oil industry cannot account for Texas' large export share to Mexico.

Though it is true that Texas exported five times more petroleum and coal products to Mexico in 2008 than in 1997, the state increased its petroleum and coal products exports to the world by more than six times. The increased exports to the world are not enough to reduce the state export share to Mexico by the amount shown in Figure 2. In fact, the share of nonpetroleum exports to Mexico mimics the share with all exports, decreasing from a high of 45.5 percent in 2000 to 34 percent in 2008.

The two aggregate facts from section 2 cannot be attributed to the particulars of any idiosyncratic Texas industry, even autos and oil.

Texas' Trade Office in Mexico City

Every U.S. state has a department of commerce to promote business. Most states also promote exports. Though the form of this export promotion varies, one popular method is to fund an overseas trade office. An overseas office is physically located in the foreign country and helps domestic firms export to that country by providing market information, arranging meetings with potential partners, and offering limited legal services. One view of these overseas offices is that they reduce the informational barriers to trade.

Texas operates only one overseas trade office. But that office is located in Mexico City and is an ideal candidate to decrease the economic distance without decreasing the importance of physical distance.

Consider the following modeling change to gravity: Economic distance D_{ij} is composed of geographic distance $\hat{D}_{ij}$, the existence of an overseas office O_{ij}, and the ad hoc contiguity binary variable $CONT_{ij}$. Then

$$D_{ij}^{\beta_d} = \hat{D}_{ij}^{\beta_{\hat{d}}} \exp(\beta_o O_{ij} + \beta_c CONT_{ij}), \tag{3}$$

where β_d equals -1.407 or -0.904. All of these distance variables, including the office, are time-invariant.

I use the Cassey (2009a) data set with information on the location of overseas offices to reestimate (2) after substituting in (3):

$$\begin{aligned} X_{ijt} = &- \underset{(0.722)^*}{5.238} + \underset{(0.227)^*}{0.749} \log Y_{it} + \underset{(0.050)^*}{0.705} \log Y_{jt} - \underset{(0.034)^*}{0.762} \log \hat{D}_{ij} + \underset{(0.023)^*}{0.359} O_{ij} \\ &+ \underset{(0.063)}{0.106} CONT_{ij} + \sum_{i=2}^{50} \delta_i S_i + \sum_{j=2}^{175} \gamma_j C_j + \sum_{t=1998}^{2008} \tau_t T_t + \varepsilon_{ijt}. \end{aligned} \tag{4}$$

$$N = 103,838 \qquad \hat{R}^2 = .61 \qquad RMSE = 7.06.$$

The coefficient on physical distance $\hat{D}_{ij}$ is less (in absolute value) than the generalized distance in (2), meaning that physical distance is less important for export value than generalized distance. This acts to increase exports to distant countries in the equation and is not helpful in trying to account for why Texas exports more to Mexico than predicted. The estimated coefficient on the office variable O_{ij} is positive and significantly different from zero. The estimated coefficient on the contiguity variable is not statistically different from zero in this specification, although it is when included in (1). The reasons for its loss of significance in (4) are the different modeling and estimation and a degree of collinearity with the office term.

As done before, observations on Texas exports to Mexico are removed and the resulting coefficient estimates are applied. The resulting implied exports are only \$8 billion, and the implied geographic distance needed to match the export data is 152 miles. Breaking down distance to include the overseas office and contiguity term leads to worse predictions than in (2) because the increased exports from the office are roughly offset by the decreased coefficient on distance. Therefore, if Texas' overseas office in Mexico City is as effective as the average of other states' overseas offices, the existence of the office does not account for the seemingly reduced trade barrier between Texas and Mexico. Of course, if Texas' office is superior to those in other states, this method is not correct. But the office would have to be much more effective at decreasing

[7] See U.S Energy Information Administration (2010), Petroleum Navigator: Weekly United States Spot Price FOB Weighted by Estimated Import Volumes, www.eia.gov, acessed July 26, 2010.

the barriers to trade to account for the gap between gravity's prediction of Texas' exports to Mexico and the data.

Maquiladoras

Perhaps the most unique feature of the Texas–Mexico border economy is the maquiladora. Maquiladoras are manufacturing establishments that import materials for further assembly and then export the output. Maquiladoras import 97 percent of their materials, mostly from the United States (Vargas 2001). The Mexican government established the first maquiladoras in 1965. Near the end of the period under study (2007), maquiladoras, which are owned or operated by U.S. or other foreign firms, were combined with a program for homegrown exporters to form Maquiladora Manufacturing Industry and Export Services, or IMMEX.

The way maquiladoras can diminish economic distance without decreasing the importance of physical distance is if maquiladoras are physically located closer to Texas than Mexico City. This would decrease the shipping distance for Texas–Mexico without changing the estimated coefficient on distance in (2) derived from other states' exports to all countries in the world. And until the 1970s, maquiladoras had to be within 20 kilometers of the border. As of 2000, 40 percent of maquiladora production ocurred within the Texas border region (Vargas 2001).

Suppose all of Texas' manufacturing exports to Mexico were for maquiladoras on the exact border. Laredo is the largest inland port in the United States and Nuevo Laredo is the largest inland port in Mexico, so I use this gateway as "the border."[8] Hanson (2001) finds evidence that a 10 percent increase in maquiladora production increases employment in U.S. border cities by 1 to 2 percent and that this employment is in manufacturing in the larger border cities. However, any increase in manufacturing jobs may be for final goods for U.S. consumption and not intermediate output to be used by maquiladoras. Cañas, Coronado, and Gilmer (2005) argue that the "twin plant" idea was never realized along the border. I assume Texas' exports continue to come from the population centroid, which is 13 miles southeast of Temple.[9] The distance is 205 miles as the crow flies and 303 miles down Interstate 35, almost identical to the physical distance predicted by (1).

This example shows maquiladoras can reduce the distance between Texas and Mexico to match that predicted by gravity if all of Texas' exports to Mexico are destined for maquiladoras in Nuevo Laredo. To what extent is it true? All of Texas' exports would have to be intermediate goods because, until 2008, maquiladoras did not sell assembled goods to Mexicans. So how much of Texas' exports to Mexico are intermediates?

Earlier, I showed that exports of transportation equipment to Mexico cannot account for the decrease in distance. The maquiladoras on the Texas border are concentrated in transportation equipment and electronics associated with the auto industry (Cañas and Gilmer 2009). It is farfetched that all of Texas' exports to Mexico are intermediate goods for use in the 40 percent of maquiladoras on the border. At this point, however, it seems data are not available to quantify Texas' exports used as maquiladora inputs. Therefore, it is likely that maquiladoras along Texas' border do partially account for fact 1. But I cannot say by how much.

What is known is the share of maquiladora inputs from the United States. Maquiladoras imported 90 percent of their inputs from the United States in 2000, but by 2004, that fraction fell to 60 percent (Cañas, Coronado, and Gilmer 2005). The evidence suggests that Texas' falling export share is due to maquiladoras shifting their imported inputs from the United States to Asia. It is also known that maquiladora employment is shifting away from the border. Employment in maquiladoras bordering Texas as a share of the maquiladora industry decreased from 45 percent in 1990 to 38 percent in 2006 (Cañas and Gilmer 2009). These facts are consistent with the previous finding that transportation equipment was one manufacturing subsector that increased exports to the world but decreased exports to Mexico. Thus, though I am not able to precisely quantify it, the changing source of maquiladora imports and plant location are partially responsible for fact 2.

Until data are obtainable on U.S. exports by state, destination, and end-use category, the claim that maquiladoras are heavily responsible for Texas' large but declining share of exports to Mexico will remain speculation. Further clouding the picture are the findings of Cañas and Gilmer (2009) that maquiladoras'

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[8]Though Laredo is the largest port, accounting for 40 percent of all U.S.–Mexico shipments (Orrenius, Phillips, and Blackburn 2001), by far the city in Mexico with the most maquiladora production is Ciudad Juárez, across from El Paso, Texas. Orrenius, Phillips, and Blackburn report that 80 percent of the traffic through Laredo goes on to the Mexican interior. But I want the scenario in the text to be the best case for maquiladoras and see how far it goes in accounting for the facts.

[9]In the case where the logarithm of distance is zero, (2) predicts exports to Mexico will be $4.6 trillion.

imported inputs largely do not come from Texas but are concentrated in states such as Illinois, Michigan, and Ohio. In this case, Texas' large share of exports to Mexico may be due to the attribution of other states' exports to Texas because it is the state of origin of movement rather than production.

Mismeasurement of State Export Data

The evidence from Cañas and Gilmer (2009) that maquiladora inputs are mostly from midwestern U.S. states, and the evidence from Cassey (2009b) that Texas has the second-highest discrepancy between the origin of movement and production of aggregate exports implies that the consolidation in Texas of Mexico-bound shipments from other U.S. states may partially account for the large share of Texas exports to Mexico. Strictly speaking, this would not be mismeasurement of the state export data because the data intentionally document the state of origin of movement and not the state of production or the state(s) that add value to the export. The export declaration form's instructions say to indicate the state of shipment consolidation if repackaging takes place.

Figure 6 shows the volume of freight with origins elsewhere in the United States that is shipped through Texas by road and rail. The figure, from Palacios (2005), shows that geographic constraints force most land-based U.S. shipments to Mexico through Texas. Due to Mexican regulations, southbound shipments are usually unpacked, stored for a few days in a customs broker's warehouse, and transferred to short-haul trucks to cross the border (Orrenius, Phillips, and Blackburn 2001). This increases the likelihood that shipments from other states are consolidated in Texas.

Figure 6: Texas at Center of U.S. Freight Traffic, 2005

NOTE: Veins show the volume of freight shipped through Texas with origins in the United States. Thicker veins are heavier volumes.

SOURCE: Palacios (2005) from Federal Highway Administration data.

To see if consolidation of other states' shipments in Texas may account for the large share of Texas exports to Mexico, I use the fact that the state export data can be disaggregated by mode of transportation: air and sea. "Other" is the difference from the total and represents truck and rail transportation. Figure 6 shows sizable volumes of "other" transportation from all states.

I calculate the share of exports sent by the other 49 states to Mexico via land-based transportation. There will be evidence of consolidation if the share of land-based exports from Texas is larger than for other states. This is because if exports from other states are consolidated in Texas, the share of exports by truck and rail will go up for Texas but down for the other states.

The mean share of exports by truck and rail to Mexico is 83 percent across all 50 states over the years 1997–2008.[10] Texas shipped 90 percent of its exports to Mexico by land over those 12 years. The 99 percent confidence interval is ± 1.865. On this basis, I reject that Texas' truck and rail export share is the same as it is for the average state. Thus, there is evidence of consolidation and mismeasurement at the Texas border.

This consolidation error, however, is only about 7 percent of total Texas exports, which is not large enough to account for the facts. To see this, suppose Texas exports the average land-based share of the other states and the rest is mismeasurement. Texas exports would then average \$26 billion, down from \$28 billion in the data. Plugging \$26 billion into (1) yields 326 miles, but it is twice that in the data.

Furthermore, consolidation and mismeasurement cannot account for fact 2 unless the increased use of electronic shipping documents since 1997 decreases the amount of exports credited to Texas or there is a

[10] In comparison, the United States sends an average of 87 percent of its exports to Canada by "other" transportation. The share of "other" to both Mexico and Canada is relatively stable over the 12 years under consideration.

change in the mode of transportation. There seems to be no indication in the data that a widespread change in mode of transportation is occurring.

6. CONCLUSION

I establish two facts about Texas' exports to Mexico. First, the share of exports is large compared with the average state–country trade share. Second, this share has been declining since the early 2000s. These facts are qualitatively the same for other state–country contiguous partners such as Michigan–Canada. However, these facts are not consistent with a standard gravity equation.

I interpret the failure of gravity to predict Texas' exports to Mexico over time as a failure to measure economic distance correctly. I study unique features of the Texas–Mexico relationship that could potentially decrease the economic distance between Texas and Mexico without diminishing the importance of geographic distance for noncontiguous world trade.

The features I study are exports from the transportation equipment and the petroleum and coal products subsectors, the existence of Texas' only overseas office in Mexico, the existence of maquiladoras along the Texas border, and the consolidation of shipments from other states in Texas. The evidence suggests that the auto and oil industries, overseas office, and consolidation of shipments in Texas cannot account for either of the two facts. However, maquiladoras' changing input purchases can partially account for both facts.

The literature of the 1990s and early 2000s talks about the death of distance, implicitly assuming globalization lowers trade costs. Later papers such as Carrère and Schiff (2005) and Coughlin (2004) find evidence that distance is not decreasing in importance. I find exports to neighbors consistent with the importance of proximity to trade, but this importance has been decreasing since the early 2000s. To the extent that Canadian establishments are also decreasing their share of U.S.-manufactured intermediate inputs, the lessons learned from Texas–Mexico are applicable to other state–country border relationships.

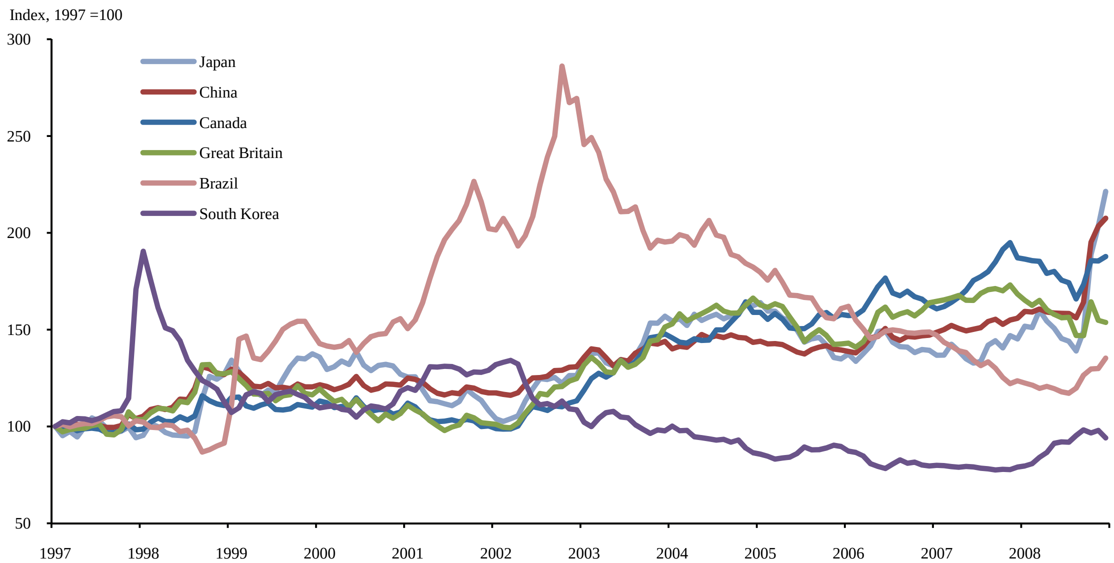
APPENDIX

Regression results for gravity equation with first differences of country GDP

$$\Delta \log X_{ijt,t-1} = -\underset{(0.005)^*}{0.033} + \underset{(0.041)^*}{0.766} \Delta \log Y_{jt,t-1} + \Delta\varepsilon_{ijt,t-1}.$$

$$N = 72,594 \quad R^2 = .006 \quad RMSE = 1.16$$

Relative Mexican Exchange Rate, 1997–2008



NOTE: Changes to the relative exchange rate of the Mexican peso with other countries' currency, indexed so that each country's exchange rate is 100 in 1997.

SOURCE: Author's calculations using data from www.oanda.com, accessed March 18, 2010.

NAICS Manufacturing Subsectors

NAICS	Description	NAICS	Description
311	Food & kindred products	326	Plastics & rubber products
312	Beverages & tobacco products	327	Nonmetallic mineral products
313	Textiles & fabrics	331	Primary metal manufacturing
314	Textile mill products	332	Fabricated metal products, not elsewhere specified
315	Apparel & accessories	333	Machinery, except electrical
316	Leather & allied products	334	Computer & electronic products
321	Wood products	335	Electrical equipment, appliances & components
322	Paper	336	Transportation equipment
323	Printing, publishing & similar products	337	Furniture & fixtures
324	Petroleum & coal products	339	Miscellaneous manufactured commodities
325	Chemicals		

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