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Price and Distance Effects on Mexican Cross-Border Shopping: Implications for a Borderlands Economy

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1. Introduction

After generations of discounting the value of proximity to their Mexican neighbors, retail merchants in southwestern border region of the United States have become openly enthusiastic about their economic links with nearby Mexico. The growing maquiladora trade, brisk sales to cross-border Mexican shoppers, and now the passage of the North American Free Trade Agreement (NAFTA) have transformed these attitudes.

But expectations may have become exaggerated as many merchants have given public expression to their individual experiences. For example, newspapers in Tucson, Arizona have quoted shopping center owners who proclaim that the Mexican market accounts for one-fourth of that city's retail sales (Hawkins, 1991). This seems surprising since Nogales in the Mexican state of Sonora, which is Tucson's leading market in Mexico, is located sixty miles (96 km.) away; its population is only a fifth the size of Tucson and its mean income is only one seventh that of Tucson. Tucson's next most important Mexican market, Hermosillo, is several times more populous than Nogales, but is also several times more distant. Obviously, these retailers discount the economist's rule that distance acts as a price-like deterrent, and they pay no homage to the geographer's gravity model.

At the same time, many merchants in large U.S. border cities such as Tucson see NAFTA as a bonanza by effectively lowering prices to Mexican shoppers. Obviously, these sellers put a lot of faith in price effects, even though sales bonanzas do not typically follow a price cut of perhaps ten percent, which is the average tariff that NAFTA will eliminate.

Clearly, there is some logical inconsistency in these two popular views concerning implicit price elasticities of demand by Mexican shoppers for U.S. goods. This paper provides estimates of these price elasticities, and shows economic implications for one border-region economy.

2. Estimation Strategy and Data Sources

By imposing a cost that is associated

with the effort to purchase a good, travel distance has a negative price effect on demand. This relation has long been considered in the location theory literature (Hotelling, 1929; Hoover, 1948; Isard, 1956) and in econometric analyses of distance as a price proxy in the demand for non-priced goods (Clawson and Knetch, 1966; Gum, 1986). Following this "travel cost method" of demand analysis, distance from the residential origin of Mexican visitors to shopping destinations in U. S. border cities can be included in cross-sectional regression analyses with either the number of Mexican shoppers or spending per shopper being the dependent variable. However, sources of bias due to the aggregated nature of available data must be considered. Alternatively, the demand for cross-border shopping can be estimated using the real exchange rate as a price proxy[1]. Data on the real exchange rate of pesos for dollars can be included in a time series regression using a measure of retail export sales to Mexican consumers as the dependent variable. However, no attempt is made to correct these real exchange rates for non-traded goods; nor are the effects considered of such non-tariff barriers as upper limits on purchases by Mexican cross-border shoppers, or other customs rules and practices.

Data on purchases of U.S. goods by Mexican shoppers disaggregated by origin location of residence are available from field surveys of Mexican visitors to Arizona conducted by de Gennaro and Ritchey (1978) in 1978 and by Hopkins (1992) in 1991. However, the former source does not further disaggregate these shoppers by municipality (*municipio*) of residence and by travel mode, so that those who fly from distant Mexican cities to large Arizona cities to purchase high-price goods are not distinguished from Mexican pedestrians who cross the border daily to buy food in border supermarkets. Nor does it further disaggregate these shoppers by Arizona city of destination. These disaggregations are available, however, in the more recent, 1991 survey data (Hopkins, 1992). Figure 1 shows the distribution of 10 origin cities in Sonora, Mexico and 9 destination cities in Arizona.

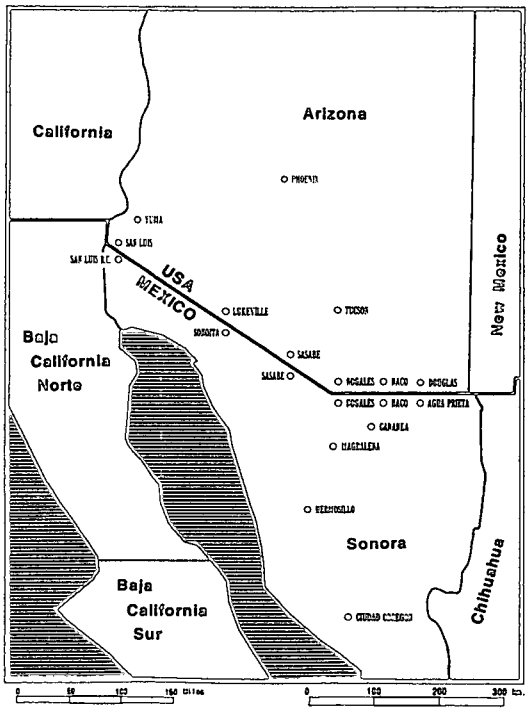

Figure 1. Distribution of origin cities in Sonora, Mexico and destination cities in Arizona

There is no source of time series data on retail exports from U.S. border region cities to Mexican shoppers. But using a regression-analytic technique that reflects the minimum requirements method, a time series has been estimated for Santa Cruz County retail employment attributable to direct exports to Mexican shoppers (Silvers and Pavlakovich, 1991).

3. Distance Effects on Shopping Trips

According to a gravity model specification (Isard, 1960, chapter 11; Krueckeberg and Silvers, 1974, chapter 9), the number of shoppers, VISITS, from origin city i in Mexico to destination city j in Arizona increases with the population of the origin city, POP_i, (measured by *municipio* population) and also with the population of the destination city, POP_j, (measured by county population), but declines with the distance, DIST, between the two cities. Distance between cities is measured in highway kilometers.

Two functional specifications are used; one is multiplicative in all variables with exponents as coefficients, a "gravity" model form:

$$VISITS_{ij} = a\ POP_i^{b1}\ POP_j^{b2}\ DIST_{ij}^{-g}; \quad (1)$$

and the other is multiplicative in population with exponents as coefficients, as before, but exponential in distance, an "exponential" model form:

$$VISITSi_{ij} = a\ POP_i^{b1}\ POP_j^{b2}\ EXP[-g\ DIST_{ij}]. \quad (2)$$

In both cases, natural logarithms of the functions are taken to linearize the regression forms. Of particular interest is the coefficient to distance, $-g$, in the gravity model form since, with all variables expressed in natural logs, the coefficients can be interpreted as elasticities. The results are shown in Table 1.

Table 1. Estimation of Shopping VISITS to Arizona from Mexico, 1991(all transport modes, n=57)

	Gravity Model		Exponential Model	
Variable	Coeff.	t-value	Coeff.	t-value
POPi (Origin)	0.493	4.67	0.586	3.99
POPj(Destination)	0.184	2.62	0.062	0.73
DIST(Distance)	-1.128	9.94	-0.007	-6.44
Constant	0.340	0.28	-3.006	-1.79
R^2, adjusted	0.64		0.42	

All three variables are shown as statistically significant in the gravity model equation, which yields an adjusted R^2 of 0.64. The number of VISITS from Mexico is estimated to have a distance elasticity of -1.128, slightly more than unit elastic.

The exponential form of this relation is less robust, with an adjusted R^2 of 0.42, and the coefficient for destination city population is not significant.

4. Comparison of 1978 and 1991 Distance Elasticities

Of interest is whether the structure of travel demand by Mexican shoppers has changed over time. Using a data set collected in 1978, some comparisons with travel demand in 1991 are possible. However, the 1978 data set was partially ag-

gregated. Data for 1978 VISITS identify the origin city or the destination city of Mexican shoppers, but not both. The specification for 1978 data, therefore, aggregates VISITS over Arizona cities to control for size of the "at risk" population. Data for municipio population in 1980 measures Mexican origin city population. Consequently, the 1978 regressions will not include the "destination city population" variable (POP_j). To make the regression equations comparable, the 1991 estimates will be rerun with "destination city population" also excluded. However, the possibility of specification bias in parameter estimation arises, and this issue will be examined. The results for the 1978 regressions are shown in Table 2.

Table 2. Estimation of Shopping VISITS to Arizona from Mexico, 1978 (all transport modes, n=18)

	Gravity Model		Exponential Model	
Variable	Coeff.	t-value	Coeff.	t-value
POP_i(Origin)	0.526	2.66	0.783	2.95
DIST(Distance)	-0.737	-6.35	-0.007	-4.85
Constant	0.658	0.34	-3.477	-1.32
R^2, adjusted	0.69		0.56	

The coefficients for both variables in both the gravity model and the exponential model forms are statistically significant at the 0.01 level, and with the expected sign. Adjusted R^2's are 0.69 and 0.56 respectively. The elasticity of the number of Mexican shoppers to Arizona in 1978 with respect to distance was -0.737.

These results can be compared with results from the 1991 survey of Mexican shoppers visiting Arizona. Using the same level of disaggregation as for the 1978 data, regression results are obtained and shown in Table 3. However, given the weaker results for the exponential model in both Tables 1 and 2, only the gravity model form is tested.

Table 3. Estimation of Shopping VISITS with Destination Excluded, 1991 (Gravity Model only, n=14)

	All transport modes		Automobile Trip Only	
Variable	Coeff.	t-value	Coeff.	t-value
POP_i(Origin)	0.572	3.68	0.580	3.99
DIST(Distance)	-0.536	-4.30	-0.550	-4.48
Constant	0.238	0.15	0.178	0.13
R^2, adjusted	0.63		0.66	

The strength of explanation is somewhat less for 1991 data compared with the 1978 findings, but more interesting is that distance became less elastic over the thirteen year period from -0.737 to -0.536. This shows that Mexican shoppers were more willing to travel the same distance in 1991 to shop for goods in Arizona's border cities than they were in 1978.

The source of this change in distance elasticity, however, is not clear. It may be either that larger but more distant Arizona cities grew, and offered more attractive goods relative to offerings of more nearby cities, or that mean incomes of Mexican shoppers rose, allowing transport costs to be more affordable, or that income distribution shifted so that there were more higher income shoppers using air transport to fly to more distant destinations, or that Mexican investment in

highway development increased, thereby lowering the cost of distance to Arizona.

The 1991 data allows two of these sources of the reduction in distance elasticity to be considered. If large, more distant cities offering more attractive goods affected the distance elasticity, then controlling for size of destination city should increase the distance coefficient. Also, if increased use of air travel to more distant destinations affected distance elasticity, then disaggregating the VISITS by mode should yield a reduced elasticity for non-air travel visits.

The first of these two comparisons was shown in the first regression results in Table 1. When destination population is included in the regression, and VISITS via all modes are included in the regression, then the distance coefficient falls to −1.128, or double the elasticities obtained when not controlling for size of destination city. With destination city population excluded from both the 1978 and 1991 equations, distance elasticity estimates were biased upward.

Instead, disaggregating by mode to consider only trips by automobile, but not controlling for destination city population, the coefficient estimates are nearly identical with those obtained in Table 2 above. Excluding air travel results in a distance coefficient only 0.014 points higher; that is, air travel does have a lower distance elasticity, as would be obvious, but its effect on the overall coefficient estimate is very small.

It is noted that another regression was run in which the data were disaggregated by mode and destination city size was included as a regressor. The results, however, were nearly identical with those shown for the first regression shown for all modes in Table 1, although the distance coefficient was 0.042 points lower, the same proportionate effect shown for the second regression in Table 3. Evidently, it is the exclusion of destination city size, not travel mode, that strongly biases the distance elasticity estimate. The weakened effect of distance on Mexican shopping visits to the Arizona border region over the 1979 to 1991 period is now shown to be, at least in part, the consequence of the growth of distant but large Arizona city shopping offerings. Further, it may be that a change in Mexican income patterns together with improved transportation access also explains the decline in the distance effect on Mexican shopping VISITS over the decade. However, it is evident that the elasticity of VISITS with respect to distance costs is negative unity.

5. Distance Effects on Expenditures per Shopper

The effect of distance on expenditures per Mexican shopper can also be considered. The theory of demand for the individual consumer states that, for non-inferior goods, the quantity demanded is inversely related to price. If distance costs are a component of price, then the quantity demanded should fall with greater distance from residential to shopping locations.

Expenditure data for Mexican shoppers is available from the 1978 and 1991 Arizona surveys. The data obtained from these surveys shows total spending in

Arizona, including spending for transportation. Also, spending per shopper includes both quantity purchased as well as price per unit quantity, so the relation between spending and distance does not actually identify a demand relation.

Consider first the change over time in the effect of distance on shopper spending. Table 4 shows that the elasticity of spending per Mexican shopper in 1978 was positive at 0.216 (significant at 0.01). Although this result is contrary to expectation, recall that the spending data includes transport costs, which necessarily rise with distance. Table 4 also shows that this positive elasticity rose to 0.40 (also significant at 0.01) by 1991, an increase relative to 1978 as was observed with the VISITS relation.

It may be that this finding merely represents specification bias due to the exclusion of the kinds of variables considered earlier, or it might merely reflect the inclusion of transport costs in total spending. Accordingly, the same tests considered earlier will be considered again.

Shown in columns 2 and 3 of Table 5 is the regression result for Mexican shoppers in 1991 travelling via all modes, with spending per shopper controlled for destination city population. The elasticity of distance is now much lower than before, and is not significant (assuming a 2-tail test). Evidently, the larger expenditures of shoppers travelling to more distant cities (such as Tucson), especially those who fly, explains much of the positive coefficient previously obtained for the distance variable. To test the effect of air travel on this relation, two regressions for Mexican shoppers travelling by automobile were estimated, and are shown in columns 4 through 7.

Table 4. Estimation of Spending Per Mexican Shopper in Arizona, 1978 and 1991 (all transport modes)

	1978(n=18)		1991(n=14)	
Variable	Coeff	t-value	Coeff.	t-value
POP_i(Origin)	0.346	2.56	0.200	1.89
DIST(Distance)	0.216	2.73	0.400	4.73
Constant	−0.189	0.14	1.418	1.32
R^2, adjusted	0.54		0.72	

The first of these regressions (shown as "Automobile trip 1" in columns 4 and 5) excludes the destination city population, as before, and the second (shown as "Automobile trip 2" in columns 6 and 7) includes this variable. Not controlling for destination city population results in a positive and significant distance elasticity coefficient for automobile travellers, as in Table 4 above, suggestion that those who drive longer distances buy more expensive goods, as is asserted by Tucson's department store managers. However, when the regression for automobile travellers is controlled for destination city population size, the distance coefficient becomes negative (-0.919), significant at 0.01, and very close to the negative unity found earlier for the distance elasticity effect on number of shoppers. That is, with air travellers excluded from the regression, even though travel costs are included in the dependent variable, they are small enough that the effect of travel costs does not obscure the strong negative relation between distance and spending per Mexican shopper.

Table 5. Tests for Destination City and Travel Mode Effects on Spending per Mexican Shopper in Arizona, 1991

	All transport modes (n=57)		Automobile trip 1 (n=14)		Automobile trip 2 (n=55)	
Variable	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
POP_i(Origin)	0.900	0.97	0.188	1.68	0.597	3.92
POP_j(Destination)	0.235	3.84			0.328	3.17
Distance	0.148	1.49	0.353	3.93	−0.919	−5.54
Constant	0.878	0.84	1.710	1.51	1.615	0.93
R^2, adjusted	0.34		0.64		0.38	

6. Travel Costs and Total Cross-Border Demand

The total expenditure, SPEND, by Mexican shoppers from origin i for goods in Arizona destination j is the spending per visitor times the number of visitors from i to j. Multiplying the gravity model equation in Table 1 by the "automobile trip 2" equation in Table 5 gives a "travel cost" estimation of the cross-border demand equation:

$$SPEND = e^{1.955} POP_i^{1.090} POP_j^{0.512} DIST_{ij}^{-2.047}. \quad (3)$$

This result indicates that the distance elasticity of Mexican cross-border spending is approximately -2, much as suggested by the traditional "inverse square of distance" gravity model.

7. Effect of the Real Exchange Rate on Retail Exports

To test the effect of the real exchange rate, as a price proxy, on the demand by Mexican cross-border shoppers for Arizona retail goods, a time series was constructed measuring border county employment for retail exports to Mexico. To do this, Santa Cruz County in Arizona was chosen because it lies on the border with Mexico, its major city (Nogales) is known to have retail sales to Mexican shoppers as the preponderance of its economic base, and does not have any other sector as a major component of its economic base. Consequently, application of a sectoring method such as the location quotient or the minimum requirements method to estimate export employment will yield an estimate of export employment attributable to retail exports to Mexican shoppers.

Rather than using these sectoring methods, an alternative method was developed that reflects the concept embodied in the minimum requirements approach, but uses regression analysis to estimate the local retail employment actually existing to serve local population needs[2]. The approach identified twenty-one relatively rural counties in the population size range 14,000 to 115,000 located in southwestern U.S. states, but were not located on the U.S.-Mexico border and that had no known major tourist attractions. By not being lo-

cated near other large cities nor serving tourists, the retail sectors of such counties would approximate exclusive service to the county's local population. A simple linear regression was then run with county population, COPOP, as the independent variable and county retail employment, RETEMP, as the dependent variable. The resulting "local-oriented retail employment" equation is:

$$\log \text{RETEMP} = 3.1 + 1.22 \log \text{COPOP} \quad (14.0) \qquad (4)$$

where the t-value of the regression coefficient is in parenthesis, and the R^2 is 0.91.

This equation was then applied to the population of Santa Cruz County to estimate its "local oriented retail employment" for each of fifteen years. This time series was then subtracted from actual Santa Cruz County retail employment to yield an estimated series for retail employment for exports to Mexican shoppers.

The independent variables for explaining retail export employment were the real exchange rate of pesos per dollar, and total employment in the Mexican state of Sonora, which is adjacent to Santa Cruz County, Arizona. The resulting regression equation is:

$$\log \text{RETEMPX} = -9.4 - 1.03 \log \text{REXR} \quad (-3.9) + 1.52 \log \text{SONEMP} \quad (4.1) \qquad (5)$$

where RETEMPX is the estimated annual Santa Cruz retail employment for exports (sales) to Mexican shoppers; REXR is the annual real exchange rate in pesos per dollar, corrected for inflation in Mexico and the U.S.; SONEMP is annual employment in the adjacent border state, Sonora, Mexico; and the R^2 is 0.71.

Since the regression equation is estimated in the logarithms of the variables, the two regression coefficients can be interpreted as the price elasticity of Mexican demand for retail exports from Santa Cruz county, and the Sonoran employment elasticity of demand for retail exports from Santa Cruz county, respectively; both coefficients are significant at the 0.01 level.

The real exchange rate can be interpreted as a price measure since increases in this rate for Mexicans make the price of U.S. goods more expensive. Its estimated elasticity (−1.03) is approximately negative unity. This estimate, however, is lower than the distance elasticity estimate of -2.047 obtained above from the travel cost method. However, the Sonoran employment elasticity of demand of 1.52 is much closer to the analogous "origin population" elasticity of demand of 1.09 shown in the travel cost demand estimator of equation (3). Both can be considered as estimates of the Sonoran income demand elasticity of demand for cross-border shopping.

8. Implications and Conclusions

The statistical analyses presented here provide evidence that the demand by Mexican visitors for cross-border shopping is significantly affected by the size of the Mexican market, with an employment

or population elasticity of demand lying between 1 and 1.5, and by such prices as travel distance and the real exchange rate, with a price elasticity of Mexican demand for U.S. border-region goods lying between -1 and -2.

If we want to compare the likelihood that Mexican shoppers who reside in two Sonoran cities, say Nogales and Hermosillo in Sonora, would travel to a given U.S. border city, say Tucson, we can consider the relative size of the two Mexican cities and the relative distance from each of the two cities to the U.S. border city destination. In the case of Nogales and Hermosillo, Hermosillo is approximately three times the size of Nogales but is located about three times as far from Tucson as is Nogales. Consequently, if the population elasticity of demand is approximately +1 and the distance-elasticity of demand is -2 as in equation (3), then Nogales shoppers would generate about three times as much demand for Tucson goods as would Hermosillo shoppers.

The fact that border-region exports to Mexican shoppers falls off quite rapidly with distance to the Mexican cities of origin necessarily limits the relative importance of cross-border shopping for cities like Tucson, located an hour by car from the border, compared with Nogales, Arizona, located right at the border. Further, although the Mexican state of Sonora has two million people, their average incomes are only one-seventh Arizona household incomes, and they reside in cities sixty to two-hundred miles (96 to 320 km.) distant and more. Given these parameters, it can be understood that 1991 Tucson metropolitan area sales to Mexican shoppers of $108 million accounted for only 1.5 percent of total Tucson retail sales, in contrast to the 20 or 25 percent that some shopping center owners have been claiming (Hopkins, 1992a)[3].

Another implication of these elasticity estimates is that if the effective price of U.S. goods were to fall by, say ten percent and price elasticity of demand is -1 as in equation (5), then sales to Mexican shoppers by U.S. border-region retailers would rise by approximately ten percent over current levels. This, of course, is roughly what is envisioned by passage of NAFTA, and is not a very sizeable impact.

Of perhaps greater potential importance is the likely impact of future economic growth in Mexico's northern region, including the state of Sonora. If this state continues to grow at an annual rate of 3.5 to 4.5 percent over the next five years, NAFTA impacts not included, its population and employment would rise by approximately 20 percent; with the impacts of NAFTA included, the increase would be perhaps 25 percent. Using the estimates of income demand elasticity of 1.1 to 1.5 percent, near-term Sonoran economic growth should generate an increased demand for goods sold by Arizona firms of approximately 27 to 37 percent. Whether this demand for Arizona goods will be served by Arizona firms, however, is another question: with relaxed investment and trade barriers, much of this demand may be served by new firms locating in Sonora.

Notes

1) An analysis of the impact of changes in the peso-

dollar exchange rate on U.S. sectoral exports to Mexico has been provided by Sawyer and Sprinkle (1987).

2) This analysis was developed by Arthur Silvers and Lee Frankel in Silvers and Pavlakovich (1991).

3) Total Arizona sales to Mexican shoppers amounted to $688 million, 69 percent of which were in three small Arizona cities located along the border (Hopkins, 1992a).

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ABSTRACT

Common belief in border regions holds that Mexican cross-border shoppers play a larger role in the regional economic base than they do and that NAFTA will provide a bigger stimulus to the regional economy than it is likely. In the first case, price elasticities are implicitly under-estimated as highly inelastic and in the latter case, overestimated as highly elastic. This paper provides empirical evidence on the effects of distance and real exchange rates as price proxies on both field survey and population-imputed estimates of cross-border shopping. After estimating both distance-based and real exchange rate-based estimates of price elasticities of Mexican shopper demand for U. S. border-region goods, implications are obtained concerning the relative importance for U.S. border-region economies of more distant Mexican markets, and the likely impacts of NAFTA.

Key words: Gravity Model, Price Elasticity, Distance Elasticity, US-Mexico Border, Cross-border Shopping.