THE EFFECTS OF PREFERENTIAL VAT RATES NEAR INTERNATIONAL BORDERS: EVIDENCE FROM MEXICO

Lucas W. Davis

Most goods and services in Mexico are subject to a 16 percent value added tax. However, within 20 kilometers of the border with the United States, the rate is 11 percent. This preferential rate was implemented by the Mexican Department of Revenue to reduce cross-border shopping in the United States. However, the tax differential also creates an unusual distortion within Mexico, encouraging Mexicans to travel to the preferential tax zone for shopping. This paper performs an empirical test of tax avoidance using the Mexican Economic Census, comparing towns on either side of the 20 kilometer threshold using a regression discontinuity design. The analysis provides evidence of a modest but statistically significant distortion in economic activity toward the preferential tax zone.

Keywords: value added tax, cross-border shopping, U.S.-Mexico border

JEL Codes: H73, H87, R12

I. INTRODUCTION

Over the last 50 years the value added tax, or VAT, has become a central form of taxation in the world and is used by 32 out of 33 countries in the Organisation for Economic Co-operation and Development (OECD) and over 140 countries worldwide (OECD, 2008). Relative to other forms of taxation the VAT is believed to increase incentives for saving and investment and reduce distortions between different forms of investment. Moreover, because it is levied at each stage of production the VAT is easier to enforce than the retail sales tax, especially at high tax rates.

The conventional wisdom is that the VAT should be levied as broadly as possible on all consumption goods with a minimum of alternative rates and exemptions. This argument, along with concerns about complexity and enforcement, provides a powerful rationale for using a single national VAT rate in all regions of a country (Ebrill et al., 2001). However, optimal tax policy is less clear when there are different tax rates across countries. In theory, with a conventional destination-based VAT, buyers returning home after making cross-border purchases abroad are subject to the tax rate

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in the home country. There are real questions, however, about whether these rules can be cost-effectively enforced, particularly along borders where traffic volume is high. Another alternative is to use a geographically-differentiated tax rate which reduces the severity of the tax differential, mitigating the incentive for cross-border shopping.

This paper examines, in particular, the effects of the VAT along the Mexican border with the United States. Most goods and services in Mexico are subject to a 16 percent value added tax. However, within 20 kilometers of the border with the United States the rate is 11 percent. This preferential tax zone was established by the Mexican Department of Revenue in 1980 when the VAT was first introduced in an effort to reduce cross-border shopping to the United States where retail sales tax rates typically range from 5–7 percent. Although the zone reduces the tax differential at the U.S.-Mexico border, it also introduces a new tax differential within Mexico, distorting economic activity toward the preferential tax zone as households and tax-exempt firms travel to the border zone for shopping.

This paper tests empirically for such tax avoidance using data from the 2004 Mexican Economic Census. The main empirical challenge is to disentangle the causal impact of the preferential tax rate from the other factors that have led to a large concentration of economic activity along the Mexican side of the U.S. border. This paper adopts a regression discontinuity (RD) design, using the highly discontinuous definition of the preferential tax zone in the Mexican tax code. Within a narrow interval along the edge of the preferential tax zone, unobserved factors are likely to be similar, so that locations just outside the preferential tax zone provide a reasonable comparison group for locations in the preferential tax zone.

The RD estimates indicate a discontinuous increase in economic activity at the edge of the 20 kilometer threshold. Results are similar for several measures of economic activity including value added, total sales, and fixed assets, indicating approximately a 15 percent increase in economic activity just inside the preferential tax zone. Moreover, the pattern of estimates across sectors is broadly consistent with expectations about the types of activities most likely to be affected. Whereas estimates for agriculture and mining are small and not statistically significant, estimates for wholesale sales, retail sales, media services, real estate and furniture, and food/beverages/hotels are larger and statistically significant.

These results are relevant for pending fiscal reform in Mexico, where revenue from Pemex, the national oil monopoly, has fallen substantially in recent years creating a budgetary shortfall. Although many would like to see Mexico increase its reliance on the VAT, it is important to note that Mexico is much less efficient at collecting revenue than other countries with similar VAT rates. Among OECD countries with a VAT, the average revenue ratio is 0.58, meaning that these countries on average collect 58 percent of the revenue that theoretically could be raised if the VAT was applied at the standard rate to all final consumption. In contrast, Mexico has a revenue ratio of 0.33, ranking it

at the bottom among all OECD countries.[1] This unusually low revenue ratio primarily reflects the large number of reduced rates available in the Mexican tax code.

This paper is germane to a substantial literature on cross-border shopping. Several studies have examined cross-border shopping in response to sales tax differentials in the United States.[2] Other studies have examined cross-border shopping between the United States and Canada in response to Canada's relatively high-rate value-added tax.[3] Cross-border shopping in response to differences in alcohol and cigarette excise taxes has also received attention.[4] Relative to most previous studies, an attractive feature of this analysis is that the change in tax rates at the edge of Mexico's preferential tax zone does not coincide with state or international boundaries. This feature corresponds well with the key identifying assumption for RD and increases the credibility of the estimates.

The econometric methodology in the analysis is closely related to a literature on the effect of local taxation on firm location decisions. Following Holmes (1998), a major empirical strategy in this literature has been to examine the concentration of different types of firms at boundaries where tax rates change.[5] In these studies, discontinuous changes in the concentration of firms at borders is attributed to tax differences across states. Of course, it is typically difficult to distinguish the effect of state tax rates from other state policies that affect firm location decisions. Again, it is important to emphasize that the 20 kilometer threshold along Mexico's preferential tax zone is an arbitrary boundary that does not correspond to state borders, mitigating concerns about unobserved differences across locations.

The paper proceeds as follows. Section II provides background about the U.S.-Mexico border and the Mexican VAT. Sections III and IV describe the data and empirical strategy. Section V presents results and Section VI offers concluding remarks.

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[1] Only six other OECD countries have revenue ratios below 50 percent; Hungary (0.49), United Kingdom (0.49), Poland (0.48), Portugal (0.48), Greece (0.46), and Italy (0.41) (OECD, 2008).

[2] Mikesell (1970) examines sales tax differentials in a cross-section of 173 central cities, finding that a one percentage point increase in sales tax differential is associated with a 2–11 percent decrease in per capita sales. Similarly, Fox (1986) examines sales tax changes in three metropolitan areas along the Tennessee state border, finding that sales levels vary predictably given sales taxes in neighboring Kentucky, Virginia, and Georgia. See also Walsh and Jones (1988) and Tosun and Skidmore (2007) who focus on sales taxes on food in West Virginia.

[3] Di Matteo (1993) and Ferris (2000) examine border crossings by Canadian residents into the United States, finding that excise taxes on liquor and tobacco and the Canadian VAT have significant effects on the volume of border crossings.

[4] Asplund, Friberg, and Wilander (2007) use evidence from Swedish municipalities to estimate the responsiveness of alcohol sales to prices across the border in Denmark. Lovenheim (2008) documents extensive cross-border smuggling of cigarettes in the United States, estimating that between 13–25 percent of consumers purchase cigarettes in border localities.

[5] In related work, Duranton, Gobillon, and Overman (forthcoming) use variation in tax levels both across jurisdiction borders and over time to examine the effect of local taxation on employment growth and firm entry in England.

II. BACKGROUND

A. The Mexican VAT

Consumption taxes are used on both sides of the U.S.-Mexico border. The state retail sales tax rates in California, Arizona, New Mexico, and Texas are 7.25, 5.6, 5.0, and 6.25 percent, respectively, with local sales taxes increasing this rate by an additional 1–2 percent in some communities (federation of .[6] Consumption is taxed in Mexico using a European-style invoice-credit VAT with a base rate of 16 percent. As explained in the introduction, there is also a preferential rate of 11 percent in towns near the border.[7] This preferential tax zone includes the northern border with the United States and the southern border with Guatemala, though this analysis focuses exclusively on the U.S.-Mexico border.

The preferential tax zone was established by the Mexican Department of Revenue because of concerns that the VAT would encourage cross-border shopping in the United States. Millions of Mexicans live along the U.S.-Mexico border and over one million people cross the border every day. Cross-border shopping has real costs. Not only are there private costs in the form of time and transportation costs, but there are also social costs in the form of longer wait times at the border, traffic congestion and other externalities associated with driving. Cross-border shopping also implies less revenue for the home country. Whether or not a preferential tax rate near the border will increase revenue or not depends on whether or not the increased revenue from deterring cross-border shopping is large enough to offset the lost revenue from the lower rate.[8]

In theory, tax adjustments at the international border would eliminate any incentives for cross-border shopping because the Mexican VAT would be levied at the border for goods entering Mexico, and Mexican VAT would be reimbursed for goods entering the United States. In practice, however, the magnitude of border crossings makes this kind of border enforcement infeasible. This is, to some extent, already recognized by Mexican law and Mexicans arriving by plane are legally allowed to bring up to USD $300 worth of goods tax free. Individuals arriving by land may bring goods with a total value up to USD $50. These rules are seldom enforced.[9]

Originally the preferential tax zone was defined as all towns within 20 kilometers of the border. Over time, however, the zone has been expanded to include the entire

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[6] Federation of Tax Administrators, "State Sales Tax Rates for January 1, 2007," http://www.taxadmin.org/fta/rate/tax_stru.html. In all four states food, prescription drugs, and goods sold for export are exempt.

[7] The use of a geographically-differentiated VAT is unusual, but not unique to Mexico. According to OECD (2008), Austria, Canada, France, Greece, Portugal, and Spain all have VAT rates that vary across geographic regions. Another important example is India, where VAT rates vary by state.

[8] An extensive theoretical literature considers the effect of international integration on tax structure, including Kanbur and Keen (1993), Ohsawa (1999) and Ohsawa (2003). It would be interesting to formalize the Hotelling spatial competition model described in these studies to allow for geographically-differentiated rates within countries.

[9] An important exception is vehicles. As discussed by Davis and Kahn (2010), because vehicles must be licensed it is impossible to avoid the VAT when bringing vehicles into Mexico.

state of Baja California Norte, the entire state of Baja California Sur, the entire state of Quintana Roo (next to Belize), and three municipalities in the state of Sonora (next to Arizona) that would not otherwise have been included.[10] These non-conforming areas represent less than 10 percent of the total area within 20 kilometers of the U.S.-Mexican border. Nonetheless, these changes raise endogeneity concerns because these regions lobbied for and were granted inclusion in the zone and thus may be different from other regions in Mexico. The main empirical analysis excludes these non-conforming areas in order to focus specifically on areas that are subject to the 20 kilometer rule. Later in the paper these non-conforming areas are examined individually and the findings are very similar to the results from the main analysis.

Mexico has maintained a preferential tax zone along the border since 1980 when a national VAT was first introduced, though both the standard rate and the preferential rate have changed over time.[11] Most recently, President Felipe Calderon increased both rates by one percentage point on January 1, 2010, as the standard rate was increased from 15 percent to 16 percent, and the preferential rate was increased from 10 percent to 11 percent.[12]

B. Implications

Following standard practice, the Mexican VAT is administered using the credit-invoice method. Whenever transactions occur, the seller charges the buyer VAT and the seller gives the buyer an invoice indicating the amount of VAT paid. Periodically, firms remit any amount due to the Mexican Department of Revenue. Value added is calculated as the difference between total sales and intermediate purchases of goods including investment but excluding labor. Because firms deduct the tax paid on intermediate good purchases from total VAT liability, they have a strong incentive to collect invoices on all intermediate purchases. Mexican tax treatment of international exports and imports is also standard. Following the destination principle, exports are "zero-rated" meaning that tax is not paid on exports and an exporting firm can obtain refunds for tax paid and invoiced on purchases of intermediate goods used to produce the exports. Imported goods are subject to the VAT and, at least in principle, tax is supposed to be levied on all goods brought into the country.

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[10] Estados Unidos Mexicanos (2006) provides a detailed description of the preferential tax zone.

[11] Pagán and Tijerina-Guajardo (2000) and Págan, Soydemir and Tijerina-Guajardo (2001) describe in detail the history of the Mexican VAT. Aportela and Werner (2002) study a change in the Mexican VAT rate in 1995 to examine its incidence across commodities, exploiting the fact that in that year the VAT rate changed in the interior of Mexican but not in the border region.

[12] The VAT was increased in part to offset falling oil revenues from Pemex, the state-owned petroleum company. Once the second-largest oil field in the world, production from Mexico's *Cantarell* oil field has fallen from 2.1 million barrels a day in 2005 to only 500,000 barrels a day in 2009 (Luhnow, 2009). Despite recent increases in crude oil prices, Secretaría de Hacienda y Crédito Público (2010) reports that total oil-related revenues in Mexico fell from 37 percent of total government revenue in 2005 to 32 percent in 2009.

The destination principle is also used for determining whether or not a transaction qualifies for the preferential border rate. In theory, buyers from the preferential tax zone pay an 11 percent rate regardless of the location of origin of the seller. Similarly, buyers from the rest of Mexico should pay a 16 percent rate regardless of the location of origin of the seller. According to the destination principle, the physical location where the transaction takes place does not matter; what matters is the location of origin of the buyer. Therefore in theory there would be no incentive for cross-border shopping within Mexico, just as in theory there is no incentive for international cross-border shopping. In practice, however, there is no "border" enforcement at the 20 kilometer edge of the preferential tax zone and thus little other than time and transportation cost to prevent intra-Mexico cross-border shopping. Although one could imagine a system in which border residents were required to demonstrate residency at the point of sale, this would impose considerable administrative costs and be relatively easy to evade.

Thus the preferential tax zone creates an incentive for transactions to occur in the preferential tax zone. Depending on the incidence of the tax, consumers of final goods living in the interior of Mexico can save up to 5 percent of the sales price by making purchases in the preferential tax zone. Sellers also benefit and, depending on tax incidence, can charge up to 5 percent more by locating in the preferential tax zone. The zone may also facilitate tax evasion. Firms can save 5 percent by misclassifying sales as happening to buyers from the preferential tax zone. Final buyers do not submit invoices on their purchases so this form of evasion is substantially harder to detect than evasion with intermediate goods. Thus in the short-run, one would expect to see more total sales and more value added in the preferential tax zone. In the long-run, one would expect to see more households and more firms locating in the zone in order to take advantage of the lower rate.

In general, buyers of intermediate goods are less concerned about what rate they face because any tax paid on intermediate goods can be deducted against their total VAT liability. The same goes for firms that produce entirely for export. It is important to point out, however, that many small Mexican firms are tax-exempt. Even though these firms do not remit VAT directly, they do pay VAT on many of the intermediate goods they use and by making purchase in the preferential tax zone they can avoid the standard VAT rate on these goods. Nonetheless, one would expect the impact of the preferential tax zone to differ systematically across sectors depending on whether the sector produces final or intermediate goods. Such classifications are not perfect because most sectors produce both final and intermediate goods. Still, comparisons across sectors provide a valuable test of whether or not the results are plausible.

III. DATA

The empirical analysis uses the 2004 Mexican Economic Census, a national census of Mexican firms conducted every five years by Mexico's National Statistics

Institute.[13] The census provides municipality-level measures of economic activity, including the number of establishments, value added, employment, wages, fixed assets, and total sales.[14] The census includes the complete universe of firms in Mexico, including all sizes and types of firms. According to the National Statistics Institute, the participation rate for the 2004 census was 99 percent.

There are 2,453 municipalities in Mexico in 2004, ranging in size from less than one square kilometer to 54,820 square kilometers, with an average area of 772 square kilometers, and ranging in population from 149 residents to 1.6 million residents, with an average population of 31,842. There are some municipalities that are partially in the preferential tax zone, so that within these municipalities some firms face the preferential tax rate and others do not. Ideally one would like to examine the within-municipality distribution of industrial activity, but data at this level of disaggregation are not available. The Mexican Statistics Institute divides the country into states, municipalities, and then what are called "localidades" or towns.[15] The 2004 Mexican Population Census describes town-level population and other demographic information.[16] In order to create a town-level dataset, industrial activity was allocated to towns according to the proportion of the municipality population living in each town. This assumption is conservative in that it will tend to cause the magnitude of the distortion to be understated. In addition, later in the paper similar results are reported separately for the "non-conforming areas" where the edge of the preferential tax zone corresponds exactly with municipality borders.

Finally, distance to the U.S. border was calculated for each town using the town's geographic center. To ensure accuracy the U.S. border was characterized using thousands of equidistant points, and then the closest point to each town centroid was found using a highly-accurate ellipsoidal model of the earth. Vincenty-style calculations were compared with Haversine and Law-of-Cosines-based calculations and all yielded virtually identical distances. Of course for large towns the geographic center may not be an accurate measure of the location of economic activity. However, this is unlikely

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[13] The Mexican Economic Census (*Censos Económicos*) has been conducted approximately every five years since 1930, though records prior to the 1980s are not available. Records for 1989, 1994, 1999 and 2004 are available from the website of the National Statistics Institute, *Instituto Nacional de Estadísticas, Geografía, e Información*. Comparable data for 1981 and 1986 are available in hard copy.

[14] An alternative to the Mexican Economic Census is the Annual Industrial Survey (*Encuesta Industrial Annual*), also administered by the National Statistics Institute. This is an annual, non-random survey of large firms that is used to calculate Mexican GDP. However, only a subset of geographic areas are represented in the survey and records are available to the public only at the national level. See Verhoogen (2008) for details. The only surveys in Mexico that are available at the municipality level are the Mexican Economic Census and the Mexican Population Census.

[15] The definition of town ("*localidad*") according to Mexico's National Statistics Institute is any inhabited place known by law or custom by a particular name. Towns are much smaller than municipalities ("*municipios*"). For example, in the 2004 Mexican Census of Population there are 187,900 towns but only 2,453 municipalities.

[16] Mexican National Statistics Institute, Mexican Census of Population, Geographic Detail Files, 2004. This dataset provides the geographic coordinates and population, as of 2004, for 187,900 towns in Mexico.

to substantially bias the estimates because most towns near the 20 kilometer threshold are relatively small.

Table 1 presents summary statistics. Population and economic characteristics are presented for (1) all of Mexico, (2) the preferential tax zone, and (3) the RD comparison group. The preferential tax zone includes all establishments located in towns within 20 kilometers of the international border. The RD comparison group includes all establishments located between 20 and 100 kilometers of the international border. The table excludes towns in the parts of the preferential tax zone that do not conform to the 20 kilometer rule; these non-conforming areas are examined separately below.

The summary statistics illustrate the highly non-uniform geographic distribution of population and economic activity within Mexico. Compare, for example, population density across regions. The high population density in the preferential tax zone reflects the fact that there are several large cities located on the U.S. border including Ciudad Juarez, Tijuana, and Mexicali. Also striking is the extremely low population density in the RD comparison group. Whereas 3.4 million people live within 20 kilometers of the border, only 500,000 people live between 20 and 100 kilometers. Economic activity is also skewed toward the preferential tax zone. Value added per square kilometer is $280,000 in the preferential tax zone, compared to $120,000 in all of Mexico, and only $10,000 in the RD comparison group. The preferential tax zone represents only 2 percent of the total land area in Mexico, but is responsible for 5 percent of total value added.

IV. EMPIRICAL STRATEGY

The preferential tax rate provides one possible explanation for the large concentration of economic activity along the U.S. border. However, there are many alternative explanations. First, the border is an important direct source of jobs. For example, the Mexican government employs workers as immigration officers and customs agents and workers are employed in the private sector as lawyers and customs consultants. Second, much of the border is delineated by the Rio Grande, a major water source for the entire region and an important input to economic activity. Third, the border is close to U.S. markets, providing an advantage for firms that export to the United States, produce goods using U.S. inputs or cater to U.S. tourists. Thus, even in the absence of the preferential tax rate one would expect to see a large concentration of economic activity along the U.S. border. The empirical challenge is to disentangle the causal effect of the tax from these other factors that make the preferential tax zone unlike other areas in Mexico.

This paper adopts a regression discontinuity approach, measuring the effect of the preferential tax zone by exploiting the highly discontinuous nature of the Mexican tax code. The RD analysis is based on the fact that the assignment of towns to the preferential tax zone is a deterministic and discontinuous function of distance to the U.S. border. The regressor of interest, *1(<20 kilometers)*, is an indicator variable equal to one for towns within 20 kilometers of the border. Within a narrow interval along the edge of the preferential tax zone, other factors are likely to be similar, so that locations just outside the preferential tax zone provide a comparison group for locations in the preferential tax zone.

Table 1

Summary Statistics

	All of Mexico	Preferential Tax Zone	RD Comparison Group
Population Characteristics:			
Total Population (1,000,000s)	103.3	3.4	0.5
Percentage Completed High School	0.216	0.198	0.208
Percentage with Health Coverage	0.47	0.61	0.71
Percentage with Health Coverage in Public System	0.31	0.51	0.51
Percentage of Households Below Poverty Line	0.07	0.04	0.11
Area in Square Kilometers (10,000s)	192.3	4.0	16.1
Population Density (per square kilometer)	53.7	84.9	3.0
Economic Characteristics:			
Number of Establishments			
Total (1000s)	2,834	82	13
Per Capita	0.027	0.024	0.027
Per Square Kilometer	1.47	2.03	0.08
Annual Value Added			
Total ($Billions)	222.88	11.40	0.95
Per Capita ($Thousands)	2.16	3.33	1.98
Per Square Kilometer ($Millions)	0.12	0.28	0.01
Annual Total Production			
Total ($Billions)	444.26	17.71	1.48
Per Capita ($Thousands)	4.30	5.18	3.08
Per Square Kilometer ($Millions)	0.23	0.44	0.01
Total Employment			
Total (1000s)	13,593	764	82
Per Capita	0.13	0.22	0.17
Per Square Kilometer	7.1	19.0	0.5
Annual Wages			
Total ($Billions)	55.40	4.06	0.31
Per Capita	536	1,187	646
Per Square Kilometer ($Millions)	0.03	0.10	0.00
Fixed Assets			
Total ($Billions)	224.39	6.84	0.94
Per Capita ($Thousands)	2.17	2.00	1.95
Per Square Kilometer ($Millions)	0.12	0.17	0.01

Notes: Demographic data are from the Mexican Census of Population, 2004. Economic characteristics are from the 2004 Mexican Economic Census. All dollar amounts are in 2004 U.S. Dollars. The preferential tax zone includes all establishments located in towns within 20 kilometers of the U.S.-Mexico border, excluding establishments in towns in certain additional exempt areas as described in the text. The RD comparison group includes establishments in towns located between 20 and 100 kilometers of the U.S.-Mexico border.

Suppose that economic activity Y_i can be described by a linear function,

(1) $Y_i = f(x_i) + \beta\,1(<20\ kilometers)_i + \varepsilon_i$

where x_i is the distance in kilometers to the U.S. border. The RD design estimates the causal effect of the preferential tax zone by distinguishing the effect of the discontinuous function $1(<20\ kilometers)$ from the effect of the continuous function $f(x_i)$. The function $f(x_i)$ controls flexibly for distance to the U.S. border, and the effect of the preferential tax zone on Y_i is identified under the assumption that the other factors affecting the concentration of economic activity, ε_i, are not changing discontinuously at the 20 kilometer threshold.[17] This seems particularly reasonable given the type of confounding factors discussed above and the fact that the 20 kilometer threshold does not coincide with state or municipal boundaries.

Conceptually, one would like to compare economic activity within an arbitrarily narrow window around the edge of the preferential tax zone. Increasing the interval around the threshold causes estimates of the effect of the preferential tax zone to be biased. However, if an assumption is made about the functional form of the relationship between economic activity and distance from the U.S. border, $f(x_i)$, then a wider interval can be used to identify the effect of the preferential tax rate. In the following section results are presented from specifications that adopt a variety of different time trends and window widths. Most specifications exclude towns located beyond 100 kilometers from the U.S. border. Towns farther away are sufficiently different from the 20 kilometer threshold that in practice they provide little additional information.

The primary measure of economic activity Y is value added (in logs). Other measures of economic activity will also be considered including number of establishments, total sales, number of workers, total wages, and fixed assets (all in logs). In all regressions the causal effect of interest, β, is the percent change in Y associated with the preferential tax zone. A positive β is evidence of a discontinuous increase in economic activity as one enters the preferential tax zone, consistent with buyers travelling to the preferential tax zone for shopping. An attractive feature of the RD design is that unlike many alternative empirical strategies, it does not hinge upon the availability of control variables. In this context there are so many differences between border and non-border regions in Mexico that it would be unrealistic to think that one could control effectively for all relevant differences using, for example, the demographic characteristics of towns or historical industrial composition. The results that follow include only state indicator variables and a flexible polynomial in town population. These additional control variables help predict Y and thus tend to increase the precision of the estimates.

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[17] Under mild assumptions RD yields consistent estimates in the presence of geographic-varying omitted variables. Hahn, Todd and Van der Klaauw (2001) show that nonparametric identification of a constant treatment effect with a sharp RD design requires that the expectation of the error term be continuous at the edge of the preferential tax zone. Under this assumption there may be unobserved factors that influence economic activity, but their effect cannot change discontinuously at the edge of the preferential tax zone.

These estimates likely understate the total distortionary effect of the preferential tax zone. Many households and firms that have moved over the last several decades to the border region have decided to locate in Tijuana or Ciudad Juarez, both right on the U.S. border. Creating a credible counterfactual for how these cities would have evolved in the absence of the preferential tax rate would be a very challenging empirical exercise given the North American Free Trade Agreement (NAFTA) and other dramatic changes that have occurred over this period. The RD approach provides a compelling strategy for controlling for the factors that make the border different from non-border regions, but the estimates should be interpreted caution. The estimated effects describe the discontinuous change in economic activity at the edge of the zone, *not* the average effect across the zone.

V. RESULTS

A. Main Results

Table 2 reports RD estimates of the effect of the preferential tax zone for the six measures of economic activity. The table reports estimates corresponding to β in (1) from 18 separate regressions. The regressions are a stacked specification that includes all fourteen industrial sectors and allows all parameters except for β to vary across sectors. Three alternative specifications are considered, including quadratic, cubic and quartic polynomials in distance to the U.S. border. In addition, all specifications include a quartic polynomial in town population and state indicator variables. The sample used for all 18 regressions includes 7,303 towns within 100 kilometers of the U.S. border.

All 18 coefficients are positive, indicating that controlling flexibly for distance to the border there is a positive and discontinuous increase in economic activity at the edge of the preferential tax zone. For value added the coefficient estimates range from 0.12 to 0.15, indicating a 12–15 percent increase in value added at the 20 kilometer threshold. Coefficient estimates for total sales and fixed assets are similar in magnitude, ranging from 11–18 percent, whereas coefficient estimates for the number of establishments, number of workers, and total wages are closer to zero though still positive. When the point estimates are taken literally, they imply that the distortion occurs mostly on the level of sales, rather than on the number of establishments or workers. To the extent that the preferential tax zone has increased the number of establishments, this increase may have occurred away from the 20 kilometer threshold or even at the U.S. border in Ciudad Juarez and other established urban areas. Still, the coefficients are not estimated with enough precision to make strong statements about the relative size of the different effects.

Figure 1 plots mean residuals from regressing economic activity on state indicator variables and a quartic polynomial in town population. Each observation represents a two kilometer area. For example, the first observation is the mean residual for all towns located between zero and two kilometers from the border. The figure also plots

Table 2

Tax Avoidance and the Preferential Tax Zone, RD Evidence

	Second Order Polynomial (1)	Third Order Polynomial (2)	Fourth Order Polynomial (3)
Number of Establishments	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)
Value Added	0.14	0.12	0.15
	(0.07)	(0.07)	(0.07)
Total Sales	0.16	0.15	0.18
	(0.09)	(0.09)	(0.09)
Number of Workers	0.04	0.03	0.05
	(0.02)	(0.03)	(0.02)
Total Wages	0.09	0.07	0.09
	(0.04)	(0.05)	(0.04)
Fixed Assets	0.13	0.11	0.13
	(0.07)	(0.08)	(0.08)

Notes: This table reports estimates corresponding to *1(<20 kilometers)* from 18 separate regressions. The row headings list the dependent variable used in each regression. All dependent variables are in logs. The regression is a stacked specification that includes a quartic polynomial in population, state indicator variables, and polynomials in distance to the U.S. border as indicated in the column headings for each of the 14 industrial sectors. The sample includes 7,303 towns within 100 kilometers of the U.S. border. Standard errors are robust to heteroskedasticity and arbitrary correlation within municipalities.

a quartic polynomial in distance with an intercept at the 20 kilometer threshold. The specification used for the figure is more restrictive than the specification used for the estimates in Table 2 that allows the polynomial in distance to vary across industries and estimates all coefficients in a single step. Nevertheless, the qualitative pattern in the figure is similar. Controlling for population, economic activity tends to decrease as one moves away from the U.S. border and the intercept at the 20 kilometer threshold is positive for all six measures of industrial activity.

Table 3 examines the sensitivity of the results to alternative window widths. Beginning with the baseline specification in column (1), the table reports value added estimates for progressively smaller windows. As the sample gets smaller, the number of polynomials used to model $f(x_i)$ decreases. Including towns between 5 and 100 kilometers in column

Figure 1

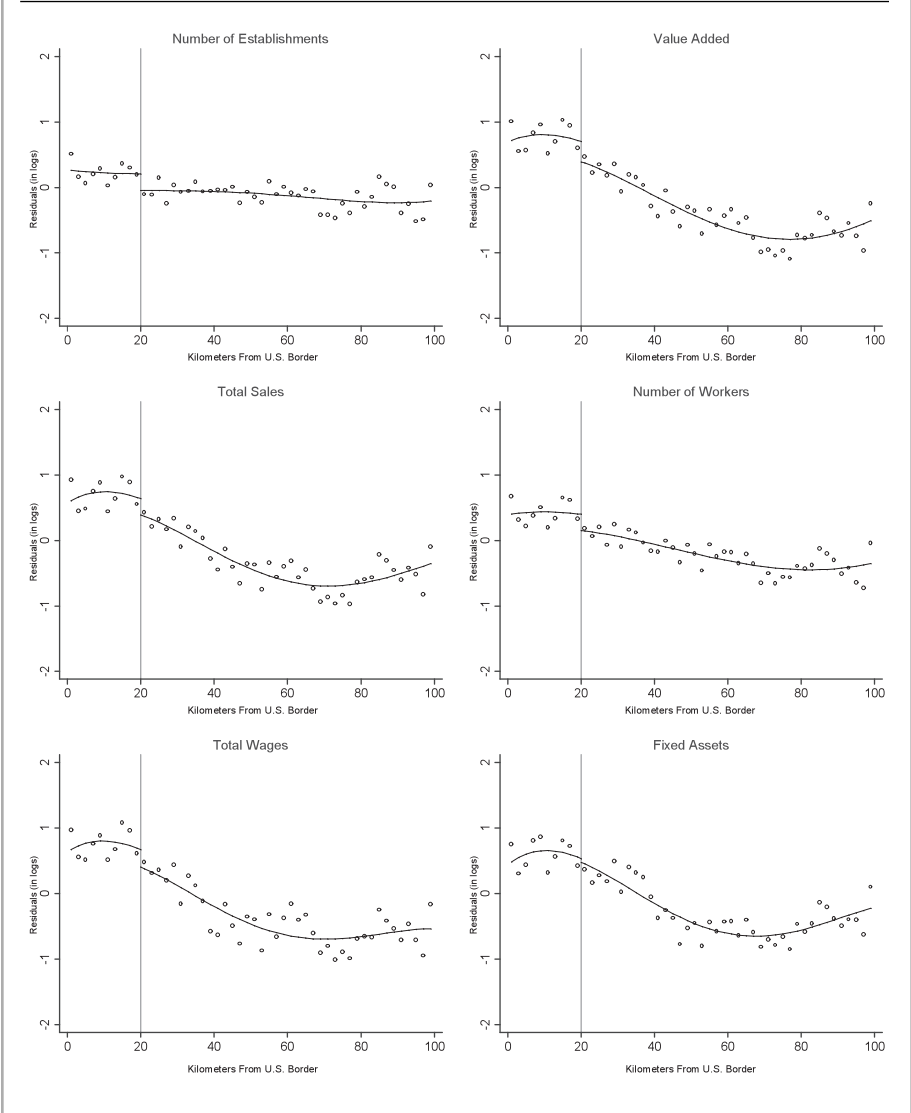Industrial Activity by Distance to U.S. Border

Number of Establishments

Value Added

Total Sales

Number of Workers

Total Wages

Fixed Assets

Kilometers From U.S. Border

Residuals (in logs)

Table 3

Tax Avoidance and the Preferential Tax Zone,
RD Evidence with Smaller Windows

	0–100 Kilometers (1)	5–100 Kilometers (2)	10–50 Kilometers (3)	15–40 Kilometers (4)
Value Added	0.15 (0.07)	0.14 (0.08)	0.15 (0.08)	0.14 (0.06)
Order of Polynomial	4	3	2	1
Number of Towns	7,303	6,289	2,833	1,728
R^2	0.42	0.50	0.55	0.56

Notes: This table reports estimates corresponding to *1(<20 kilometers)* from four separate regressions. The dependent variable in all regressions is value added in logs. The regression is a stacked specification that includes a quartic polynomial in population, state indicator variables, and polynomials in distance to the U.S. border as indicated for each of the 14 industrial sectors. Standard errors are robust to heteroskedasticity and arbitrary correlation within municipalities.

(2) has little effect on the point estimate. This is reassuring because several large cities such as Ciudad Juarez are located at the international border and one would not want these observations to be driving the results. The results in columns (3) and (4) narrow the window to 10–50 and 15–40 kilometers, respectively. The sample size decreases but the point estimates remain close to 0.15, providing evidence that the estimates are not unduly sensitive to a particular window width.

B. Results by Sector

Table 4 reports RD estimates of the effect of the preferential tax zone by sector. Except for mining, all coefficients are positive indicating that, controlling flexibly for distance to the border, there is an increase in value added as one enters the preferential tax zone. Overall the results conform with expectations about the disproportionate impact of the preferential tax zone across sectors. As discussed in Section IIB, the preferential tax zone creates a distortion because final consumers have an incentive to make purchases in the preferential tax zone. The preferential tax rate does not directly influence incentives for the location of sales of intermediate goods or the location of residence of firms that produce intermediate goods. Thus the structure of the VAT implies that one would expect to see less distortion in, for example, agriculture and mining. Indeed this appears to be

Table 4

Tax Avoidance and the Preferential Tax Zone, RD Evidence by Sector

	Estimated Coefficient	Standard Error
Agriculture	0.05	(0.04)
Mining	−0.06	(0.12)
Water Services	0.15	(0.12)
Manufacturing	0.35	(0.26)
Wholesale Sales	0.24	(0.14)
Retail Sales	0.26	(0.12)
Media Services	0.15	(0.06)
Real Estate and Furniture	0.26	(0.11)
Professional Services	0.13	(0.05)
Company Administration	0.02	(0.01)
Educational Services	0.13	(0.05)
Health and Public Assistance	0.09	(0.05)
Food, Beverages, and Hotels	0.20	(0.07)
Other	0.15	(0.07)

Notes: This table reports estimates corresponding to *1(<20 kilometers)* from 14 separate regressions. The dependent variable in all regressions is value added in logs. Each regression restricts the analysis to a particular industrial sector indicated in the row headings. All specifications include quartic polynomials in population and distance to the U.S. border as well as state indicator variables. The sample includes 7,303 towns within 100 kilometers of the U.S. border. Standard errors are robust to heteroskedasticity and arbitrary correlation within municipalities.

the case, and in these sectors the estimates are small and not statistically significant. One also would expect to see less distortion in industries in which a large fraction of business is exempt. In Mexico most educational and health services are exempt from the VAT so one would not expect to see a substantial distortion in these sectors and it is reassuring these are among the smaller estimates. Results are also generally as expected for sectors where a large fraction of sales are made to final consumers. One would expect to see distortions in retail sales, media services, real estate and furniture, professional services, and food/beverages/hotels because these involve a large fraction of sales to final consumers. In these five sectors the estimates are positive and statistically significant at the 5 percent level.

C. Non-Conforming Areas

All Mexican towns within 20 kilometers of an international border are part of the preferential tax zone. As discussed in Section IIA, in addition to this 20 kilometer

band, the preferential tax zone includes six areas that lie partially outside of the 20 kilometer band. These areas were excluded from the analysis described in the previous subsection because one would not expect to observe changes in economic activity at the 20 kilometer threshold in these areas. This section returns to these non-conforming areas, examining them individually using similar techniques to those implemented in the previous subsection.

Table 5 reports the estimates from this analysis. The estimating equation is identical to (1) except the *1(<20 kilometer)* indicator has been replaced by indicator variables for the six non-conforming areas. For example, row (1) reports the coefficient corresponding to an indicator variable for towns located in the state of Baja California Norte. As before, the regression is a stacked specification that includes quartic polynomials

Table 5

Tax Avoidance and the Preferential Tax Zone, Non-Conforming Areas

Baja California Norte, Entire State	0.26
	(0.05)
Baja California Sur, Entire State	−0.08
	(0.07)
Quintana Roo, Entire State	0.30
	(0.05)
Caborca Municipality (State of Sonora)	0.39
	(0.03)
Cananea Municipality (State of Sonora)	0.16
	(0.04)
San Luis Rio Colorado Municipality (State of Sonora)	0.01
	(0.05)
Number of Towns	185,414
R^2	0.31

Notes: This table reports estimates from regressing value added (in logs) on indicator variables for towns located in the six non-conforming areas of Mexico's preferential tax zone. For example, the first row reports the coefficient corresponding to an indicator variable for towns located in the state of Baja California Norte. The regression is a stacked specification that includes quartic polynomials in population and distance to the U.S. border for each of the 14 industrial sectors. The sample includes all towns except those located within 20 kilometers of the U.S. border in the parts of the preferential tax zone that conform to the 20 kilometer rule. Standard errors are robust to heteroskedasticity and arbitrary correlation within municipalities.
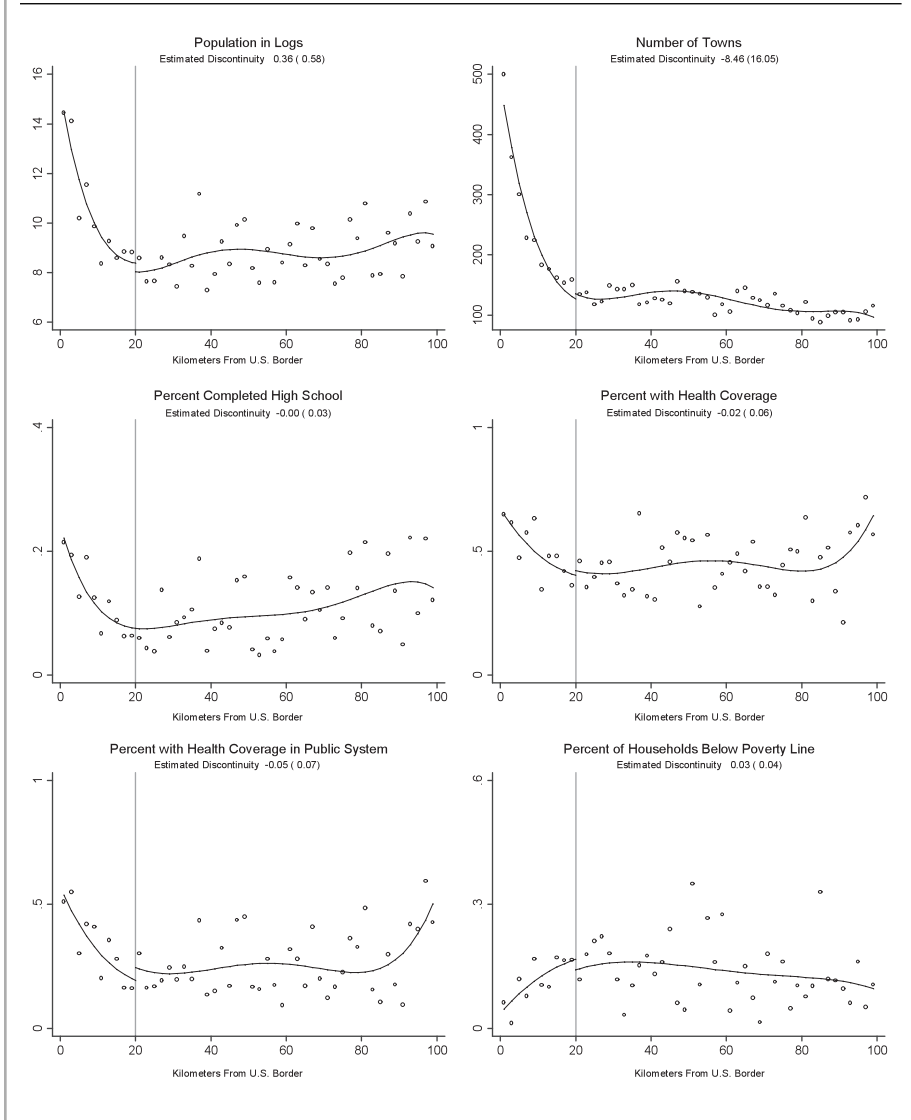
in town population and distance to the U.S. border for each of the fourteen industrial sectors. Whereas the analysis in the previous subsection was restricted to towns located within 100 kilometers of the U.S. border, for these results the sample includes all Mexican towns except for towns within 20 kilometers of the U.S. border in conforming areas.

As before, positive coefficients are consistent with higher levels of value added in the preferential tax zone. Five out of six estimates are positive, and four out of the six estimates are positive and statistically significant at the 1 percent level. This pattern of increased economic activity in the preferential tax zone is consistent with the previous estimates, indicating higher levels of economic activity inside the preferential tax zone. However, it is important to interpret these results with caution. The preferential tax zone was augmented to include these additional areas through a political process. The decision to engage in a lobbying effort to change the tax code for a municipality and the decision by Mexican policymakers to include a municipality in the zone may driven by municipality characteristics so these areas may be different from the rest of Mexico. In addition to possible endogeneity, it is important to highlight that identification in this context comes from comparisons of economic activity across states and municipalities, and thus is more likely to suffer from omitted variables bias. These concerns make the results for non-conforming areas less compelling than the estimates based on those parts of the preferential tax zone that adhere to the 20 kilometer rule. Still, it is reassuring that the results from this analysis are broadly consistent with the estimates in the previous subsection.

D. Demographic Characteristics

Figure 2 plots population, number of towns and other population demographics as a function of distance to the U.S. border. The figure also includes a quartic polynomial in distance with an intercept at the 20 kilometer threshold. None of the six estimated discontinuities are statistically significant. Population is highly skewed toward the border, but the estimated change at the 20 kilometer threshold is not statistically significant. Of the 3.9 million people represented in the figure, 3.2 million live within four kilometers of the U.S. border. That is, 83 percent of the population is represented in the first two observations. The distribution of towns is also skewed toward the U.S. border, but to a much lesser extent. Of the 7,303 towns represented in this figure, only 862 (12 percent) are located within four kilometers of the U.S. border. The lack of evidence of discontinuous changes in population demographics at the 20 kilometer threshold is interesting. It also provides something of a falsification test, providing evidence that other factors that affect economic activity are not changing discontinuously at the threshold. As described in Section IV, the empirical analysis hinges on the assumption that only tax rates change discontinuously at the threshold, and these figures tend to corroborate that assumption.

Figure 2

Population Demographics by Distance to U.S. Border

Population in Logs
Estimated Discontinuity 0.36 (0.58)

Number of Towns
Estimated Discontinuity -8.46 (16.05)

Percent Completed High School
Estimated Discontinuity -0.00 (0.03)

Percent with Health Coverage
Estimated Discontinuity -0.02 (0.06)

Percent with Health Coverage in Public System
Estimated Discontinuity -0.05 (0.07)

Percent of Households Below Poverty Line
Estimated Discontinuity 0.03 (0.04)

VI. CONCLUSION

This paper examines an unusual feature of the Mexican VAT — a long narrow preferential tax zone along the 3,100-kilometer border with the United States. Implemented to reduce international cross-border shopping, the policy creates an artificial internal "border" 20 kilometers from the international border where the tax rate changes abruptly by 5 percentage points. Unlike most other tax boundaries that have been studied in the extensive literature on tax avoidance, this discontinuity does not correspond to state or international borders. Using an RD strategy to control for omitted variables, the results provide evidence of a modest but statistically significant distortion in economic activity toward the preferential tax zone. Results are robust across alternative specifications and correspond reasonably closely with expectations about the disproportionate impact of preferential VAT rates across sectors.

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