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Estimating the Border Effect: Some New Evidence

Gita Gopinath, Pierre-Olivier Gourinchas,
Chang-Tai Hsieh, and Nicholas Li

Abstract:

To what extent do national borders and national currencies impose costs that segment markets across countries? To answer this question the authors use a dataset with product-level retail prices and wholesale costs for a large grocery chain with stores in the United States and Canada. They develop a model of pricing by location and employ a regression discontinuity approach to estimate and interpret the border effect. They report three main facts: One, the median absolute retail price and wholesale cost discontinuities between adjacent stores on either side of the U.S.-Canadian border are as high as 21 percent. In contrast, within-country border discontinuity is close to 0 percent. Two, the variation in the retail price gap at the border is almost entirely driven by variation in wholesale costs, not by variation in markups. Three, the border gaps in prices and costs co-move almost one-to-one with changes in the U.S.-Canadian nominal exchange rate. They show these facts suggest that the price gaps they estimate provide only a lower bound on border costs.

JEL Classifications: F3, F4, F1

Gita Gopinath is an associate professor of economics at Harvard University; her e-mail address is gopinath@harvard.edu. Pierre-Olivier Gourinchas is an associate professor of economics at the University of California at Berkeley; his e-mail address is pog@econ.berkeley.edu. Chang-Tai Hsieh is a professor of economics at the University of Chicago's Booth School of Business; his e-mail address is chsieh@chicagogsb.edu. Nicholas Li is a Ph.D. candidate in economics at the University of California, Berkeley; his e-mail address is nickli@econ.berkeley.edu.

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1 Introduction

To what extent do national borders and national currencies impose costs that segment markets across countries? Some of the central questions in international economics, ranging from the transmission of shocks across borders to the gains from regional integration, hinge on the answer to this question.

There is little doubt that borders generate additional transaction costs, from the use of different currencies to the regulatory costs of obtaining national permits, that can translate into price differences. In addition, national borders delineate different economic environments: variations in national tastes, market conditions, wages, and transportation infrastructures, among others, can generate additional sources of price differences. Further, the effect of border costs varies by market. From a consumer's perspective fairly small transaction costs can effectively segment markets. By contrast, at the wholesale level, given the large volumes involved, the gains to arbitraging even small price gaps are large. The relevant question then is about identifying the factors that generate the "border effect" and the magnitude of this effect.

We address these central questions by making the following contributions. First, we use unique weekly data on retail prices and wholesale costs at the barcode level for detailed products from a large grocery chain with stores in the United States and Canada to measure the border's effect on market segmentation. We present evidence of the impact of border costs at both the consumer and wholesale price level. Second, we develop a model of pricing by stores located on a circle to document possible patterns of cross-border prices. We then employ a regression discontinuity approach to estimate the border effect, exploiting the information we have about the geographic location of stores.

More specifically, our dataset has information on retail prices and wholesale costs for 250 U.S. stores (in 19 states) and 75 Canadian stores (in 5 provinces). Prices and costs are observed at the universal product code level (UPC or barcode) for 178 weeks between January 2004 and June 2007. This level of product detail alleviates concerns about compositional effects that arise with more aggregated price index data. From this dataset, we extract a sample of 4,221 identical products sold by this retailer in the two countries. We find that the median gap (across the UPCs) between the average price and cost in Canada and the United States increased from -5 percent in June 2004 to 15 percent in June 2007, and that the variation in this gap closely tracks the U.S.-Canadian nominal exchange rate. By contrast, the median markup deviation remains largely unchanged over this period.

While these raw facts are indicative of the border having a significant economic effect that departs from the law of one price, a comparison of the average prices masks potentially more significant differences in market conditions and arbitrage costs for U.S. and Canadian stores close to and far away from the shared border. We address this issue with a stylized model of pricing by stores located on a circle, along the lines of Salop's (1979) circular city model. Our model endogenously determines the distribution of prices within and across countries in the presence of a border cost and heterogeneity in marginal costs across countries. It delivers two important insights. First, the impact of border costs is observed only through changes in prices "close" (in terms of physical proximity) to the border, and has little effect on pricing decisions "far" away from the border, a distinction often overlooked in the empirical literature. Second, when border costs become sufficiently large, markets are fully segmented across countries, and the magnitude of border costs no longer affects pricing decisions. In that case, price differences at the border provide a *lower bound* for border costs and move one-to-one with cost differences, while markup differences remain almost unchanged. Thus, the model has the potential to account for the stylized facts exhibited in the data.

We then exploit the model's central prediction—that the border's impact on prices depends on the store's distance to the border—to estimate the border's effect using a regression discontinuity (RD) design. In recent years, the RD approach has become a popular way to estimate the causal effect of treatment in a variety of settings, and we apply it to the question of border effects. We use the precise geographic location of the stores in our data to answer the following question: do we see deviations from the law of one price between stores located right across the border from each other? To illustrate, for the first week of 2004, figure 1 plots the (log) average price across stores (in 50-kilometer bins) for 25 ounce bottles of Perrier Sparkling Natural Mineral Water against the individual store's distance from the border. As is evident, there is a clear price discontinuity at the border that is indicative of the border effect. The RD design controls for the fact that stores located far apart can face very different market conditions or arbitrage costs compared to stores located close to one another. A significant price discontinuity observed as we cross the border is then interpreted as the local effect of proximity to the border. We then decompose the border discontinuity in retail prices into a discontinuity in wholesale costs and in markups.

We report three main findings from the RD estimates. First, at the border we observe large and heterogenous discontinuities across products for retail prices, wholesale costs, and markups. The median price discontinuity (across UPCs) is as high as 15 percent for consumer prices and 17 percent for wholesale costs while the median absolute price discontinuity is 21 percent for consumer prices and 21 percent for wholesale costs. The standard deviation across UPCs is large, indicating that the discontinuity at the border across goods varies from large and positive to large and negative. Second, the median retail and wholesale price discontinuities at the border move one-to-one with the U.S.-Canadian nominal exchange rate. The Canadian dollar appreciated (in cumulative terms) by 16 percent over our sample period. Over the same period both the median retail price and wholesale cost discontinuities increased by almost 12 percent. Third, the markup discontinuity remained mostly unchanged over the sample period. These last two findings are consistent with a full segmentation of retail markets between the United States and Canada over the period of our study and the set of goods in our sample.

We probe the robustness of our results in four ways. First, we restrict the sample to stores located in Oregon, Washington, and British Columbia, and find that the estimates are unchanged. Second, we expand the number of products we consider by creating a store-level price index calculated over finely disaggregated subcategories of goods. Here, we compare the discontinuous change in the price index at the border and find similar results. Third, we compare the behavior of costs for store-branded products to our benchmark estimates to examine whether our cost data is allocative. As expected, we find much less co-movement between relative costs and the exchange rate for the store-branded products. Fourth, we contrast our results for the U.S.-Canadian border with similar within-country estimates. We focus on the Washington-Oregon border and find almost no evidence of a discontinuity at the border between these two states.

This paper builds on the large literature regarding the segmentation of retail markets across countries. This literature has generally found deviations from the law of one price that are large, volatile, and remarkably correlated with the nominal exchange rate.[1] In particular, a seminal paper by Engel and Rogers (1996) shows that the volatility of changes in price indexes for disaggregated product categories between U.S. and Canadian cities are much larger than that observed across cities within the same country. A large literature has followed up on Engel and Rogers's (1996) influential paper by studying goods at a more disaggregated level.[2] In this respect, our paper is related to the work of Broda and Weinstein (2007), who used a large amount of barcode-level price data collected at the consumer level and find a similar degree of price segmentation across and within national borders. While the level of disaggregation in Broda and Weinstein (2007) is similar to that in the data we use, a key difference is that our data captures prices charged by the *same* retailer in all locations, while the Broda and Weinstein (2007) data contains prices at which consumers purchase a particular good in a given location without any control for retailer heterogeneity.[3]

Another main difference from these papers and many others in the literature is our use of the regression discontinuity approach, which directly addresses an important critique raised by Gorodnichenko and Tesar (2009). That paper points out that estimates of the border effect in regressions like those used by Engel and Rogers (1996) are not identified. Heterogeneity in price-determining factors, such as variation in demand, can generate price dispersion that have little to do with border costs. Yet standard regressions will incorrectly attribute the difference to border costs. Our paper directly addresses the critique laid out in Gorodnichenko and Tesar (2009) as it both develops a stylized cross-border model of price determination and employs a regression discontinuity approach that exploits critical information about the geographical location of stores.[4]

[1]See Rogoff (1996) and Goldberg and Knetter (1997) for comprehensive reviews of this literature.

[2]Crucini and Shintani (2006) and Crucini et al. (2005) for instance, examine the retail price of narrowly defined product categories, such as "Washing Powder, "across countries within the European Union. Others focused on specific goods, such as *The Economist* magazine (Ghosh and Wolf 1994), *Ikea*'s furniture products (Haskel and Wolf 2001; Hassink and Schettkat 2001), or Scandinavian McDonald's *duty-free* outlets (Asplund and Friberg 2001). Parsley and Wei (2007) decompose the price of a Big Mac across countries into variation in marginal costs and variation in markups. Goldberg and Verboven (2005) study the automobile market in Europe. See Goldberg and Verboven (2001) for a survey.

[3]See Nakamura (2008) for novel evidence on pricing across and within retailer at the UPC level.

[4]In contemporaneous work, Burstein and Jaimovich (2008), also examine the pattern of prices in the United States and Canada using the same dataset. Unlike us, Burstein and Jaimovich (2008) take as given that markets are segmented and do not address the question of measuring border costs.

Sections 2 and 3 describe the data and present preliminary evidence on the pattern of prices, costs, and markups in the United States and Canada. Section 4 describes the circular world model while section 5 discusses the regression discontinuity design and the estimates of border costs across countries. Section 6 presents additional results and section 7 concludes. All proofs are contained in the appendix.

2 Data source

We have access to weekly store-level data for a sample of 325 grocery stores from a large retail chain that operates in the United States and Canada. This chain is one of the leading food and drug retailers in North America. Directly or through its subsidiaries it operates nearly 1,800 stores in a broad range of geographic locations and socioeconomic neighborhoods (1,400 stores in the United States and 400 in Canada).[5]

The dataset contains weekly total sales, quantities sold, wholesale unit costs as well as a measure of per-unit gross profit for 125,048 unique goods identifiers by UPC in 61 distinct product groups. During 178 weeks between January 2004 and June 2007, the data was obtained for 250 stores in 19 U.S. states, and 75 stores in 5 Canadian provinces.

Figure 2 plots the location of the stores in our data. Most U.S. stores are located in the western and eastern corridors, in the Chicago area, Colorado, and Texas, while most Canadian stores are located along a relatively narrow horizontal band running close to the border with the United States.

The total number of observations across stores and time is close to 40 million. Most of these observations are concentrated in the processed and unprocessed food and beverages categories, housekeeping supplies, books and magazines, and personal care products. Column 1 of table 4 in the appendix reports a breakdown of available UPCs by product categories. This level of disaggregation allows for a very precise identification of products. For instance, in our data, a 25 ounce Perrier Mineral Water with a Lemon Twist and a 25 ounce Perrier Mineral Water with a Lime Twist are two separate items in the soft beverages product group.

[5]The data sharing agreement between this retailer and the research community is managed through the SIEPR-Giannini data center (http://are.berkeley.edu/SGDC/).

Of the 125,048 unique UPCs in our dataset, our first task is to find the set of "matched UPCs," that is, the set of products that appear in identical form in at least one Canadian and one U.S. store, in at least one week.[6] This matched set represents the set of goods for which we can evaluate deviations from the law of one price (LOP). This dataset of matched UPCs contains 4,221 unique products, or about 3.3 percent of the original dataset.[7] This decline in matched products across the border is an important effect emphasized in Broda and Weinstein (2007) that carries across to our dataset, and underlies the importance of working with unique products, as identified by their UPCs. When comparing price indexes across countries at higher levels of aggregation, one is likely to suffer from a serious composition bias. One concern is that otherwise identical goods have different UPCs because of different labeling requirements in the United States and Canada (for example, language and nutritional information). To assess this difference we conducted a physical survey of the matched UPCs in one store in the United States (Oakland, CA) and in Canada (Vancouver, BC). We found that for most of the products the labeling was indeed different but the UPC was the same. Consequently, different labeling does not necessarily imply different UPCs, but it could still be a factor behind the low match rate.[8]

The set of matched UPCs are concentrated in books and magazine (2,505), alcoholic beverages (403), ethnic & gourmet food (306), and household cleaning products (159).[9] The distribution of products across product groups is very skewed, with a median around 11 products and a mean of 97.[10]

Table 1 reports information on the number of distinct products (among matched goods) per store-week and per store-pair-week in our data. The average store in the data carries 492

[6] There are 98,430 unique UPCs in the United States, and 32,961 unique UPCs in Canada. The total number of price observations across stores and time is close to 40 million.

[7] We arrive at this number in the following way. We start with the set of unique UPCs that appear in at least one U.S. and one Canadian store (6,343). We check the product descriptions to ensure that the products are identical (6,283). We further drop UPCs with less than 10 digits since these are generated internally by the retail chain and may not be consistent across countries (5,900). We further eliminate products in the fresh bread/baked goods, deli, food service, produce, seafood, meat, and floral arrangements categories since these goods contain a higher local labor content and are not available in identical form in different stores (4,221 goods).

[8] Matching goods that do not share the same UPC is an impossible task given the limited product information we have.

[9] "Books and magazines" have a printed sale price that is sticky in the local currency. We find that all our results hold similarly for the sample that excludes this category of goods.

[10] See column (4) of table 4 for a breakdown of matched UPCs by product groups.

distinct matched products for which we have data in a typical week. We find about 272 (243) matched products for a typical within-country store pair in the United States (Canada) in a given week, and 164 for a cross-border store-pair.

The dataset contains information on "gross" and "net" sales. We construct corresponding gross and net prices for each UPC by dividing sales by quantities. Both retail prices exclude U.S. sales and Canadian federal value-added taxes (VAT) and provincial sales taxes.[11] The net price can differ from the gross price when there are special sales (for example, coupons and promotions). It is always smaller than or equal to the gross price and exhibits significantly more variability.

We also have information on the "wholesale cost" which refers to the list price at which the retailer purchases a given product from the wholesaler. These costs need not represent the true cost to the retailer given that there are typically freight and transport costs as well as retail allowances—that is, rebates provided by the wholesaler to the retailer or vice versa. To correct for this, we use data on "adjusted gross profits" per unit to back out the "net cost,"or imputed cost of goods. The precise link between the wholesale cost and the net cost is as follows:[12]

$$\begin{aligned} \text{Net cost} &= \text{Wholesale cost} - \text{Allowances} \qquad (1) \\ &= \text{Net price} - \text{ Adjusted gross profits} \end{aligned}$$

At short horizons, with rent, capital, and labor taken as given, it is natural to interpret the net cost as a measure of the marginal cost of goods. Equivalently, "adjusted gross profits" measure the markup at the product and store level. At longer horizons, adjusted gross profits represent an upper bound for the product markup.

[11]From a consumer's perspective the relevant price is the price inclusive of sales taxes and VAT. We do not have this tax information which varies by UPC and location both within and across countries. For instance, many food products are exempt from sales tax both in the United States and Canada. On the other hand, we found that sales taxes and VAT are higher in British Columbia (13 percent) as compared to Washington State (around 8 percent). To the extent that before-tax prices are higher in Canada than in the United States, as we find for most goods, this implies that the after-tax price gap is even larger than what we measure.

[12]According to information provided by our retailer, total allowances consist of the sum of shipping allowances, scan allowances, direct-store-delivery case billback allowances, header flat allowances, late flat allowances, and new item allowances, *minus* the sum of buying allowances, freight allowances, overseas freight, and distress and other allowances.

It is natural to question whether our measure of net costs is allocative. This requires that freight, transport, and retail allowances, among other things, are measured correctly at the product-and store-level. There are a number of reasons why this might be difficult, potentially affecting our measure of marginal costs.[13] Since we do not have a breakdown of allowances between their different components, we cannot directly address this question. Nevertheless we propose in section 6.2 an indirect way to assess whether our cost measure is allocative by comparing wholesale costs and net costs for store-brand products and other products. Since our retailer controls most of the supply chain for store-brand products, we would expect—as we indeed find—a very different behavior of cross-border relative costs for these two categories of products, especially for wholesale costs. This result is consistent with the view that our cost measures are indeed allocative.

3 Preliminary analysis of law of one price deviations at the border

3.1 Median cross-border price deviations over time

As a first pass at the data, the top left part of figure 3 reports the median average cross-border price gap over time. That is, for each week and each UPC, we compute the log-deviation between the average Canadian and U.S. net prices across stores. The figure reports the median of that distribution across UPCs over time. When positive, this number indicates that more Canadian goods have a higher average price than the corresponding U.S. good. The figure indicates that the median price gap has increased over time from roughly -5 percent in June 2004 to 15 percent in June 2007. The figure also reports (the dashed line on the right-axis) the (log) U.S./Canadian nominal exchange rate. The overall correlation between the two series is striking: the evolution over time in the median price gap mirrors almost perfectly the evolution of the nominal exchange rate.

[13] For example, one may imagine that a soft drink manufacturer negotiates global allowances on a broad range of drinks sold to the retailer; similarly, it may be difficult to assess the transport cost and freight component for a single bottle of milk.

Using the identity:

$$\ln p^k = \ln\left(\text{cost}^k\right) + \ln\left(\text{markup}^k\right),$$

where p^k is the price of good k, cost^k is the marginal cost, and markup^k denotes the markup for good k. The top-right and bottom-left panels perform the same exercise for the imputed (net) cost and the resulting markup. Looking at the two figures side by side reveals a striking fact: most of the movements in the median price gap result from corresponding movements in relative costs, while relative markups show barely any response to the fluctuations in the exchange rate. This result is robust to the definition of the price (gross versus net) or of the costs (wholesale versus imputed).

Prices in our sample change very frequently. The median frequency across UPCs is 0.41 for net prices (0.22 for gross prices), implying a median duration of 2.4 (4.5) weeks.[14] Despite the high median frequency, a significant fraction of goods do not change price during the entire sample. To ensure that these goods do not drive the results we divided the product sample into high- and low-frequency adjusters depending on whether their frequency of price adjustment is above or below the median. In both cases, we found that the median price gap increases over time.[15]

Overall, the evidence indicates that the median price gap moves closely with the nominal exchange rate and that cost differences play an important role.

3.2 Price dispersion across UPCs

Figure 4 sheds light on the extent of price gap dispersions across UPCs at a point in time. Figure 4(a) reports the distribution of the cross-border net price gap across UPCs for the first week of 2004 (2,242 UPCs) and the twenty-first week of 2007 (2,267 UPCs).[16] The figure shows that there is a large dispersion of price gaps across UPCs at any given point

[14]The frequency number was arrived at as follows: we estimated the frequency of price adjustment for each UPC-store combination; Then we estimated the average frequency across these store combinations for each UPC. We then estimated the median within each category and the median across these categories.

[15]The contribution of imputed costs is smaller for the frequent adjusters. Finally, the median markup gap movements are small relative to prices and costs. These additional results are available from the authors upon request.

[16]This corresponds to the beginning and (end-1) weeks of our sample. In the twenty-second week of 2007 there is a significant drop in the number of UPCs given to us, which is why we use the twenty-first week.

in time. Hence, while the median price gap moves closely with the exchange rate, the price gap for any individual UPC is likely to be dominated by idiosyncratic factors, a feature also documented in Crucini and Shintani (2007).

Figures 4(b) and 4(c) report the same distribution for the cross-border average imputed cost gap and markup gap. The figures indicate significant dispersion in relative costs across the border, but a much tighter distribution of markup differences across the border. The distributions for price and cost shift to the right between 2004 and 2007 alongside the appreciation of the Canadian dollar.

3.3 Price dispersion across stores

Finally, table 2 reports some raw statistics for the extent of price dispersion within and across U.S. and Canadian stores. Panel A reports statistics for the net price charged across stores located in the United States and Canada during the first week of 2005. USA-USA (CAN-CAN, respectively) reports prices for store-pairs located within the United States (Canada), while CAN-USA examines prices for cross-border store pairs. With 250 U.S. stores and 75 Canadian stores, there are 31,125 USA-USA store-pairs, 2,775 CAN-CAN pairs, and 18,450 cross-border pairs. Define p_i^k as the gross U.S. dollar price of product k in store i. We construct the (log) price gap between two stores i and h for good k as $\ln\left(p_i^k/p_h^k\right)$.

The median number of common UPCs for store pairs is 373 (405) within the United States (Canada) and 248 for cross-border pairs.[17] Columns (1)–(3) report the mean, median, and standard deviation of price differences for store-pairs for the first week of 2005. This distribution's statistics are reported in the rows. The median across store-pairs of the median price gap is 0 for this week both within U.S. and within Canadian pairs. This result corroborates the evidence in Crucini et al. (2005) and Broda and Weinstein (2007) that price differentials are centered around zero within countries in some periods. Cross-border store pairs, however, have a large median gap of 12 percentage points. Since the U.S. store is always treated as the store of reference, this implies that Canadian retail prices were 12

[17] The median number of UPCs differs from the numbers in table 1 because we are only looking at a single week of data.

percent higher than U.S. prices in the first week of 2005.[18]

Similarly, the median absolute price gap (column 5) is larger for cross-border stores (15 percent) as compared to either the within-U.S. (3.7 percent) pairs or the within-Canadian (0 percent) pairs. The fact that there is less price dispersion within Canada as compared to within the United States is also consistent with the evidence in Engel and Rogers (1996) and Gorodnichenko and Tesar (2009) and unlike Broda and Weinstein (2007). Panel B indicates similar results for the median absolute imputed cost gap: it is much larger for cross-border store pairs (18 percent) as compared to within-U.S. store pairs (1 percent) and within-Canadian pairs (0 percent). This difference is small for markups.

While these raw statistics documenting the failure of the law of one price are indicative of border costs, there are other reasons for these differences that one needs to control for. One popular approach to estimating the border effect consists in estimating regressions of some measure of deviation from the law of price across store-pairs against the distance between these stores and a border dummy, along the lines of Engel and Rogers (1996).[19] As argued by Gorodnichenko and Tesar (2009), estimates of the border effect from these regressions are generically not identified. In particular, cross-country heterogeneity in price determinants can generate price dispersion that has little to do with border costs. Standard regressions will incorrectly attribute these differences to border costs. Another important issue is that market conditions and arbitrage costs may be very different for U.S. and Canadian stores located close to or far away from the border, a feature that is not captured by the median price gaps described above or by the usual border regressions.

In the next sections we address both issues by presenting a model of price determination as a function of the distance to the border, along with other usual price determinants (such as costs, demand, and market structure). The analysis both motivates a departure from the standard regressions used in the literature to one that uses a regression discontinuity design and helps interpret the estimated "border effect."

[18]Since these are pre-tax prices, the 7 percent Canadian value-added tax (or GST) cannot account for the result.

[19]For comparison with the previous literature we estimated border regressions similar to Engel and Rogers (1996) and Broda and Weinstein (2007). We find that the "border coefficient" is both sizeable and robust to the exclusion of within-country store pairs in Canada or in the United States However, we depart from this regression framework in the rest of the paper for reasons discussed below.

4 Circular world

We present a stylized model that endogenizes the distribution of prices across locations in the presence of border costs. The model is a two-country version of Salop's (1979) circular city model of horizontal differentiation. We define a location as a position indexed by $\omega \in [0, 1]$ on a circle of unit circumference. A border splits the circle into two countries (country A and country B). Figure 5 provides a graphical representation of this circular world.

4.1 Stores

There are $N_{AB} = N_A + N_B$ retail stores located at exogenous equidistant intervals along the circle, with N_A stores in country A and N_B stores in country B. The borders are located at $\omega = 0$ and $\omega = N_A/N_{AB}$. We refer to stores by their location, parameterized by the variable ω_i where $i \in \{1, \ldots, N_{AB}\}$, with $\omega_i = (2i - 1)/2N_{AB}$. The stores closest to the border are $i = 1,\ N_A$ for country A and $i = N_A + 1,\ N_{AB}$ for country B. We further assume that each store sells a homogenous good (same UPC) and sets the price of this good independently.[20]

4.2 Consumers

We assume that a unit mass of consumers is uniformly distributed on the unit circle. Each consumer buys one unit of the good and, all else equal, strictly prefers to shop in stores that are located close to them. They incur a cost $t \geq 0$ per unit of distance traveled that reflects transportation costs or the individual consumer's value of time, as well as a cost $b \geq 0$ when crossing the border. The utility of a consumer located at ω and shopping in store i is given by

$$u(\omega) = \nu - \theta p - t|\omega_i - \omega| + bI(\omega_i, \omega).$$

Here, $I(\omega_i, \omega)$ is an indicator function for whether the consumer and store are located in

[20] This assumption may seem at odds with our data, which consists of stores operated by a single retail chain. Yet this is a reasonable assumption that captures the notion that pricing decisions in any given location are more influenced by the pricing decisions of competitors located in the immediate vicinity than by the pricing decisions of stores belonging to the same chain located further apart. In our model, if we assume that the particular retail chain we have data from operates every other store along the circle, then each store in the chain behaves exactly like an independent store.

different countries, θ captures the own price elasticity of demand, and t is inversely related to the degree of substitutability across store locations. We assume that ν is large enough so that in equilibrium all consumers purchase one unit of the good.

4.3 Costs

The marginal cost of goods in location i is

$$c_i = \begin{cases} \min\{\chi_A, \chi_B + b_c\}, & \text{if} \quad i \in A \\ \min\{\chi_B, \chi_A + b_c\}, & \text{if} \quad i \in B \end{cases}$$

Here, χ_j denotes the wholesale price of the good in country j and $b_c \geq 0$ is the border cost incurred by the retailer. Note that it will always be the case that c_i is the same for all stores in the same region.

4.4 Demand functions

We solve for the equilibrium distribution of prices in the following manner. We first solve for the profit-maximizing price for interior stores, defined as stores not adjacent to the border. We then consider the profit-maximizing prices of the border stores. If we assume that the parameters of the model are such that all stores earn positive profits in equilibrium, this implies that consumers will not shop at stores that are further than $1/N_{AB}$ from their own location. In particular, between any pair of stores i and $i-1$, there will be a marginal consumer indifferent between shopping at either store.

4.4.1 Interior stores

Consider an interior store i in country j. Given the previous discussion, the total demand for products at that store is[21]

$$D_i(p_{i-1}, p_i, p_{i+1}) = \frac{1}{N_{AB}} + \frac{p_{i+1} - 2p_i + p_{i-1}}{2t}.$$

[21] This is derived by finding the location of the marginal consumers between store i and $i-1$ and between stores i and $i+1$.

That store chooses its price p_i to maximize static profits:

$$\pi_i = (p_i - c_j)D_i(p_{i-1}, p_i, p_{i+1}), \tag{2}$$

taking p_{i-1} and p_{i+1} as given. The following proposition characterizes the distribution of interior prices.

Proposition 1 *The distribution of interior prices takes the following form*

1. *For stores in the interior of country A :*

$$p_i = \big(\hat{p}_A - c_A - \frac{t}{N_{AB}}\big) \cdot \frac{\cosh\left(\kappa(i - \frac{N_A+1}{2})\right)}{\cosh\left(\kappa(\frac{N_A-1}{2})\right)} + c_A + \frac{t}{N_{AB}}, \tag{3}$$

2. *For stores in the interior of country B :*

$$p_i = \big(\hat{p}_B - c_B - \frac{t}{N_{AB}}\big) \cdot \frac{\cosh\big(\kappa(i - N_A - \frac{N_B+1}{2})\big)}{\cosh(\kappa(\frac{N_B-1}{2}))} + c_B + \frac{t}{N_{AB}}. \tag{4}$$

In the expressions above, cosh denotes the hyperbolic cosine function, $\kappa \equiv \cosh^{-1} 2 \approx 1.317$ is a constant, $\hat{p}_A = p_1 = p_{N_A}$ represents the price in the border store in country A and $\hat{p}_B = p_{N_{AB}} = p_{N_A+1}$ represents the price in the border store in country B.[22]

As equations (3) and (4) indicate, prices are increasing in marginal costs c_i, decreasing in the elasticity of substitution across locations $(1/t)$ and the total number of stores N_{AB}, and increasing in the price of the store located at the border $\hat{p}_A$ and $\hat{p}_B$. Importantly, the border cost only affects prices of interior stores through its effect on prices at the border stores, and this effect decreases with the distance from the border.

4.4.2 Border stores

The final step is to characterize the prices of the border stores, $\hat{p}_A$ and $\hat{p}_B$. We consider two cases: (a) full market segmentation, for the case where border costs are large enough relative to the equilibrium price gap across the border such that consumers do not cross the border; (b) partial market segmentation, for the case when some consumers cross the border.

[22] The hyperbolic cosine function is given by $cosh(x) = (e^x + e^{-x})/2$.

The following set of propositions characterizes border prices in these two cases, if such equilibria exists.[23]

Proposition 2 *[Full Segmentation] If the marginal consumer is at the border, that is*

$$|\hat{p}_A - \hat{p}_B| < b$$

then national markets are fully segmented and

(i) the prices of stores at the border are given by

$$\hat{p}_A = c_A + \frac{t}{N_{AB}} \frac{3-\nu_A}{2-\nu_A}, \qquad \hat{p}_B = c_B + \frac{t}{N_{AB}} \frac{3-\nu_B}{2-\nu_B}, \tag{5}$$

where

$$\nu_A = \frac{\cosh \kappa(\frac{N_A-3}{2})}{\cosh \kappa(\frac{N_A-1}{2})}, \qquad \nu_B = \frac{\cosh \kappa(\frac{N_B-3}{2})}{\cosh \kappa(\frac{N_B-1}{2})}.$$

(ii) The difference in border store prices moves one-to-one with the difference in costs, that is, $\partial(\hat{p}_A - \hat{p}_B)/\partial(c_A - c_B) = 1$*.*

Proposition 2 corresponds to the case where the difference in prices between border stores, $|\hat{p}_A - \hat{p}_B|$, is smaller than the border cost b. In this case the demand functions are independent of prices on the other side of the border, and markets are completely segmented. The observed difference in prices at the border is also independent from the border cost b, and only provides a lower bound on its true value.

Proposition 3 *[Partial Segmentation]*

(i) If the marginal consumer for the border stores is located in country A, that is

$$\hat{p}_A - \hat{p}_B > b, \tag{6}$$

[23]Whether partial or full market segmentation exists in equilibrium depends in a nontrivial way on the parameters of the model. Checking for all the conditions for a particular equilibrium to exist in our multistore setup is a complicated theoretical problem, largely orthogonal to our main purpose. In a simpler environment with two symmetric stores located on a line and characterized by linear transportation costs, d'Aspremont et al. (1979) show that the profit function has two discontinuities and under some conditions an equilibrium may not exist. An equilibrium requires that both firms not be located too close to each other. In our setting the number of possible demand scenarios faced by a firm increases relative to the case analyzed in d'Aspremont et al. (1979) because in our study there are more than two firms, and the shape of the profit function varies with the border cost parameter and with differences in costs.

then markets are partially segmented and the prices of stores at the border are given by

$$\hat{p}_A = \frac{(4-\nu_B)(j_A+b)+(j_B-b)}{(4-\nu_A)\,(4-\nu_B)-1}, \qquad \hat{p}_B = \frac{(4-\nu_A)(j_B-b)+(j_A+b)}{(4-\nu_A)\,(4-\nu_B)-1}, \tag{7}$$

where ν_A and ν_B are as before and

$$j_A = (3-\nu_A)\left(c_A+\frac{t}{N_{AB}}\right), \qquad j_B = (3-\nu_B)\left(c_B+\frac{t}{N_{AB}}\right).$$

(ii) If the marginal consumer for the border stores is located in country B, that is

$$\hat{p}_B - \hat{p}_A > b,$$

then markets are partially segmented and the prices of stores at the border are given by

$$\hat{p}_A = \frac{(4-\nu_B)(j_A-b)+(j_B+b)}{(4-\nu_A)\,(4-\nu_B)-1}, \qquad \hat{p}_B = \frac{(4-\nu_A)(j_B+b)+(j_A-b)}{(4-\nu_A)\,(4-\nu_B)-1}. \tag{8}$$

The last proposition illustrates the case when $|\hat{p}_A - \hat{p}_B| > b$. In this case, the demand functions depend on prices on the other side of the border, the border parameter b enters the pricing equations and changes in relative costs affect both the relative prices of stores at the border as well as the relative markups of these stores.

4.4.3 Graphic illustration of the model

Figures 6 and 7 illustrate the qualitative features of the model. These figures depict prices as a function of the distance to the border, where the border is represented by the solid vertical line at 0. Prices for region A (region B) are to the right (left) of the border. In figure 6 we consider the case where the border parameter b is high enough that markets are fully segmented (Proposition 2). We assume that the number of stores is the same in the two countries and set $N_A = N_B = 20$.

For the left figure we assume that $c_A = c_B$.[24] Since markets are entirely segmented, stores close to the border are shielded from competition from stores across the border and charge

[24] This will be the case if either $\chi_A = \chi_B$ or $\chi_A \neq \chi_B$ and $b_c = 0$. In the latter case, there is no border cost at the wholesale level and retailers' wholesale cost is $c_i = \min\langle\chi_A, \chi_B\rangle$.

a higher price than interior stores. Given the symmetry, however, there is no difference in border prices: $\hat{p}_A = \hat{p}_B$. As stated earlier, this equivalence does not imply that there is no border cost ($b = 0$), simply that it cannot be estimated from price differences across borders. For the panel on the right, we consider the case where wholesale costs differ on each side of the border, with costs in region A being greater than costs in region B: $c_A > c_B$. This difference in wholesale costs generates a price discontinuity at the border, but the discontinuity is unrelated to the border cost. As we will see in the empirical section, this case seems to be the relevant case.

In figure 7 the border parameter b is set to 0 so we know that markets must be integrated across borders. All else is the same as in figure 6. In the panel to the right, there is still a price discontinuity that arises purely from the differences in costs. The magnitude of this discontinuity is always smaller than the difference in costs.[25] Intuitively, since markets are integrated, stores compete for customers on the other side of the border. This explains why, in the case when $c_A - c_B > 0$, the border store in country A charges a lower price compared to the interior stores in country A, while the border store in country B charges a higher price than interior stores in country B.

Finally, in figure 8, we report the gap in price ($\ln(\hat{p}_A/\hat{p}_B)$) and markups ($\ln((\hat{p}_A/c_A)\,/\,(\hat{p}_B/c_B))$) at the border as a function of the gap in marginal costs ($\ln(c_A/c_B)$). The parameters are the same as in figure 6, except that $c_B = 0.02$ and c_A varies from 0.01 to 0.03. In panel (a), the border cost b is high enough to ensure full segmentation. We observe that retail markups are inversely related to relative costs, offsetting some of the cross-border cost differential. However, most of the variation in relative costs translates into relative border prices. In panel (b), $b = 0$ and thus there is full market integration. Here, we observe that relative costs have a smaller effect on relative border prices and a larger effect on relative markups.

4.4.4 Discussion

The model presented in the previous section delivers the following insights. First, if countries are completely symmetric, the endogenous distribution of prices is identical across

[25] When $N_A = N_B = 20$, $\hat{p}_A - \hat{p}_B = [(3-\nu)/(5-\nu)](c_A - c_B)$. The derivative of $(\hat{p}_A - \hat{p}_B)$ relative to $(c_A - c_B)$ is $(3-\nu)/(5-\nu)$, strictly less than 1.

countries and there are no border price discontinuities, regardless of the size of border costs. Consequently, the border cost cannot be estimated by comparing price differences across borders alone: regressions along the lines of Engel and Rogers (1996) and Broda and Weinstein (2007) reveal no information about the extent of the border effect.[26] A related point is that if border costs are sufficiently high, markets are perfectly segmented and the magnitude of border costs does not affect pricing decisions. In that case, price differences at the border provide only a lower bound on the true size of border costs.

Second, prices of stores that are located far from the border are minimally affected by the size of the border cost b. As seen in the right panel of figures 6 and 7, prices of stores far from the border barely change even when we move from full segmentation to $b = 0$. The border effect is observed mainly for stores close to the border.[27] In most of the existing literature, owing to a lack of data, no distinction is made between stores that are close to the border and stores that are far from it. Our dataset allows us to use the stores' precise geographic location to make this important distinction.

Third, the behavior of relative prices and relative markups is very different in situations of full and partial market segmentation. As figure 8 demonstrates, when markets are fully segmented, fluctuations in relative costs are reflected mostly in relative prices, with minimal impact on relative markups. By contrast, when markets are partially segmented, fluctuations in relative costs impact both relative prices and relative markups. We will exploit the time series dimension of our dataset and the movements in the U.S.-Canadian nominal exchange rate, interpreted as exogenous shocks to the relative costs, to explore this implication of the model.

Lastly, equilibrium prices depend on many factors such as the degree of substitutability across locations, the number of competitors, and the own price elasticity of demand all of which can vary with location. If this heterogeneity is not taken into account price differences can be attributed to border costs even when these costs are zero, a point made by Gorodnichenko and Tesar (2009). The next section details how the regression discontinuity

[26]This point is distinct from the one made in Gorodnichenko and Tesar (2009), who emphasize the problems that arise with heterogeneity across countries.

[27]It follows straightforwardly that this will also be true for wholesale costs if we extend the model to allow for transportation costs that increase with distance.

approach addresses this concern.

5 Regression discontinuity design

This section implements a regression discontinuity (RD) design to measure the effect of the U.S.-Canadian border on store prices.[28] The central difficulty with estimating the border effect is that border costs affect mostly stores close to the border while market conditions and arbitrage costs may be very different for stores located far away from the border. We will address this difficulty by exploiting the precise geographic location of each store in our dataset. We will compare the price of identical products sold in adjacent stores located on different sides of the border and measure the discontinuous change in prices across the border. [29]

Consider the following empirical model of the relationship between the U.S. dollar price p_i^k of product k in store i and various covariates:

$$\ln p_i^k = \alpha^k + \gamma^k C_i + \beta^k X_i + \epsilon_i^k, \tag{9}$$

where C_i is a dummy variable that is equal to 1 if store i is located in Canada, X_i measures other observable characteristics of market i, and ϵ_i^k captures unobserved characteristics that are store-and good-specific. The parameter of interest is γ^k. The inference problem is that the unobserved characteristics may not be independent from the location of store i, that is $E\left[\epsilon_i^k|C_i\right] \neq 0$, which can bias simple border regression estimates.

However, if the unobserved characteristics are a continuous function of the distance between the stores, we can control for these characteristics by introducing the distance between stores as an additional regressor. Define D_i as the distance (in kilometers) from store i to the border. By convention, stores located in the United States are at a positive distance from the border ($D_i > 0$), while stores located in Canada are at a negative distance ($D_i < 0$). With this convention, a store exactly on the border would have $D_i = 0$. The key identifying

[28]See Imbens and Lemieux (2007) for a practical guide to the RD framework. See also the February 2008 special issue of the *Journal of Econometrics*.

[29]Holmes (1998) uses a similar approach to estimate the effect of right-to-work laws on employment across U.S. states.

assumption then is that the unobserved characteristics do not change discontinuously at the border:

$$\lim_{\varepsilon\uparrow 0} E\left[\epsilon_i^k|D_i=\varepsilon\right] = \lim_{\varepsilon\downarrow 0} E\left[\epsilon_i^k|D_i=\varepsilon\right].$$

The effect of the border is then estimated as:

$$\gamma^k = \lim_{\varepsilon\uparrow 0} E\left[\ln p_i^k - \beta^k X_i|D_i=\varepsilon\right] - \lim_{\varepsilon\downarrow 0} E\left[\ln p_i^k - \beta^k X_i|D_i=\varepsilon\right].$$

In this expression γ^k answers the question: how do prices change when one crosses from $D_i=\varepsilon$ to $D_i=-\varepsilon$, where ε is some small number.

We follow Imbens and Lemieux (2007) and estimate γ^k using a local linear regression approach including distance as an additional regressor, interacted with the border dummy:

$$\ln p_i^k = \alpha^k + \gamma^k C_i + \theta^k D_i + \delta^k C_i\cdot D_i + \beta^k X_i + \tilde{\epsilon}_i^k. \tag{10}$$

Importantly, this local linear regression restricts the sample to stores within a distance of ε_D from the border, that is $|D_j|<\varepsilon_D$. The optimal distance ε_D is selected using a standard bandwidth selection criterion based on the cross-validation procedure advocated by Imbens and Lemieux (2007).[30] As for the observable covariates X_i, we measure these by variables that capture the demand characteristics of location i.[31] We consider the number of supermarkets per square kilometer,[32] the population density measured by population per square kilometer, the proportion of people aged 0–19 years and aged 65 years and over, the proportion of black people in the population, the year the store was opened, and household income expressed in U.S. dollars.[33]

The key assumption is that the unobserved characteristics ϵ_i^k do not change discontinu-

[30] The procedure looks for the minimum value of the cross-validation criterion in 100 kilometers increments. The optimal bandwidth ranges from 100 to 700 kilometers. For most weekly product-group pairs, the optimal bandwidth is either 100, 350, or 500 kilometers. All store-level observations beyond this cut-off are effectively discarded.

[31] Holmes (2008), who estimated demand for products sold in Walmart Stores, considered similar variables.

[32] These are establishments in NAICS 445110 (supermarkets and other grocery stores, but not convenience stores)

[33] U.S. data comes from from the U.S. population census and economic census data base. Canadian data comes from from Statistics Canada. There is a difference in the level of disaggregation at which the data is collected because Canadian data is collected at the county level while U.S. data is collected at the zip code level.

ously at the border. Although we cannot test this assumption directly, we do three things to assess its plausibility. First, we examine whether the observable characteristics X_i change discontinuously at the border. If the observable characteristics do not change discontinuously at the border, then this is also likely to be the case for the unobservable characteristics. Moreover, even if observable characteristics are not continuous at the border, this does not invalidate our design as long as the effect of the covariates X_i on the dependent variable remains the same and we control for these characteristics. In the same spirit, we compare estimates of γ^k with controls for observable characteristics and without controls. Third, we provide estimates of the border effect over time, exploiting the 16 percent nominal devaluation of the U.S. dollar against the Canadian dollar from 2004 through 2007. Even if unobserved market features are different for U.S. and Canadian stores that are very close to the border, these differences are likely to be fairly stable over time and uncorrelated with the nominal exchange rate.

5.1 Graphical analysis

We begin by plotting the distribution of the store distances in our sample from the U.S.-Canadian border (in kilometers).[34] Figure 9 plots the density of all stores in our sample as a function of the algebraic distance from the border (that is, this distance is negative for Canadian stores and positive for the U.S. stores). Each bin width is 50 kilometers.

As can be seen, all Canadian stores are located less than 1,000 kilometers from the border, while many stores in the United States are more than 1,000 kilometers from the border. Obviously, the geographic concentration of economic activity in the United States is very different from that in Canada, highlighting Gorodnichenko and Tesar's (2009) caution about estimates that do not take within-country heterogeneity differences into account. Nonetheless, we do not observe any significant discontinuity in store density right at the border. This suggests that for this retailer the location of stores does not appear to be directly influenced by proximity to the border. Although this is less of a concern with our approach, since we are only looking at U.S. and Canadian stores that are physically close to each other, we need

[34] The distance was calculated using the ArcGIS software.

to recognize that not all border points are the same. From figure 2, it is clear that many Canadian stores close to the border have no counterpart on the U.S. side. To address both issues, we will also present results with a sample of stores located in Oregon, Washington, and British Columbia (21 Canadian and 41 U.S. stores) where market conditions are likely to be more homogenous and there is an important concentration of stores close to the border. We refer to this group of 62 stores as the "west coast sample."

Figure 10 depicts graphically the regression discontinuity for some relevant covariates. Each point is the average value of the relevant variable within 50-kilometer bins. For several of these variables no stark graphical discontinuity is apparent. We formally test for this result and find that when all stores are included there is some discontinuity at the border for the age variables as well as for the proportion of African-Americans. When we restrict attention to our West Coast subsample of stores, these discontinuities disappear, but we find some discontinuities for the fraction of senior citizens as well as for median household income. As mentioned above, we will include these variables in our specification when exploring the price and costs gaps.

5.2 Regression discontinuity estimates

Figures 11(a)–11(f) plot the kernel density of point estimates obtained by estimating regression (10) by UPC for the first week of 2004 and the 21st week of 2007. For our main specification we use all stores within 500 kilometers from the border.[35] We also estimated the coefficients using the optimal bandwidth selection criterion proposed in Imbens and Lemieux (2007), obtaining similar results. We do this estimation separately for the retail price, wholesale cost, and markup for each UPC and for each week, both with controls for the covariates and without the controls. Figures 12(a)-12(f) illustrate that the border effect on prices varies substantially across products.[36] As can be seen, the border discontinuity in prices is centered around zero in the first week of 2004, but shifts significantly to the right by 2007. The distribution of the border discontinuity in costs also shifts to the right from 2004 to 2007. Thus,

[35]We restrict the sample to those UPCs that have a minimum of 10 store observations on both sides of the border.

[36]This finding is consistent with the fact that stores in our sample may not choose their location as a function of the border since for many products, the price gap is positive, but for many others it is negative.

it appears that the depreciation of the U.S. dollar over this period increased both the costs and the prices in Canadian stores close to the border relative to U.S. stores on the other side of the border. As for the markups, the border effect on markups shifted slightly to the left from 2004 through 2007, suggesting that the depreciation of the U.S. dollar lowered markups in Canadian stores relative to the markups in U.S. stores. However, a visual inspection of the shift in the distribution of costs and markups suggests that the shift in wholesale costs overwhelms the change in retail markups.

We make two additional points. First, the distributions look very similar when the regression is estimated without (left panel) and with (right panel) covariates. This comparison assuages concerns that an omitted variable might result in biased estimates of the border effect. Second, we see the same high pass-through from costs to prices when we extend the sample of stores to those farther away from the border as we do with stores close to the border. Our model suggests that if markets are integrated between the United States and Canada, the border effect as estimated using stores located at or very near to the border should be smaller than that estimated from the larger sample of stores (all else equal). Therefore, the fact that this is not the case suggests that the retail markets for the products we consider are almost fully segmented between the United States and Canada.

Table 3 reports the summary statistics of the distribution of prices, costs, and markups for week 21 of year 2007 (in the no-covariates case) plotted in Figures 11(a)–11(f). The median net price (imputed cost) gap is 15 percent (17 percent) for the full sample. When restricted to the west coast subsample (Panel B) the estimates are 22 percent (22 percent). The median absolute net price (imputed cost) gap is 21 percent (21 percent) for all stores and 24 percent (24 percent) for west coast stores.

Next, we plot in figures 12(a)–12(d) the median (across UPCs) estimate for price (both net and gross), costs (imputed and wholesale), and markups over time. We also plot the U.S-Canadian nominal exchange rate. As can be seen, there is virtually a one-to-one correspondence between movements in the median price discontinuity and the median cost discontinuity and the exchange rate. By contrast, the movements in the markup are much smaller. In January 2004, the median net price gap was 5 percent lower in Canada relative to the United States. By the middle of 2007, the median price gap was 15 percent higher in

Canada. Over this time period, the U.S. dollar depreciated by roughly 16 percent relative to the Canadian dollar. Since wholesale costs can be viewed as the most ”traded” component of the retailers costs, the discontinuity in this component of costs is particularly striking. All these results hold similarly for the west coast subsample.

We take four messages from this evidence. First, there is a great deal of heterogeneity in the border's “effect” on prices, with both negative and positive price gaps present. Second, the fact that the price gaps move almost one-to-one with cost gaps suggests that the two markets are fully segmented. In that case, our model indicates that price gaps provide a lower bound on the border costs. Since we find significant gaps in both prices and costs, we conclude that the effect of the border is sizeable. Third, the fact that the estimates obtained when comparing adjacent stores across the border are similar to estimates obtained from the entire sample of stores also suggests that markets are fully segmented. Fourth, it appears that wholesale markets are highly segmented, even when servicing the same retailer. This result is especially striking since the wholesale component is the most tradable component of overall costs.

6 Further results

6.1 Price indexes

So far we have compared products with the same UPCs. Although this approach has the virtue of comparing identical products in the two countries, the limitation is that the sample of products with common UPCs is a small subset of the available products. We now expand the sample of products by constructing price indexes at the store level for each product group and product class. There are 61 product groups in the first week of 2004. At this level of aggregation the match rate across borders is 96 percent. At a more intermediate level of aggregation, such as ”product class,” the match rate is 70 percent (out of 1165 product classes in the first week of 2004). For details about the construction of the price index refer to Appendix B.

We then use the RD approach to measure the discontinuity in the *percentage change* of the price index as one crosses the border. For this calculation, we consider all the stores that are within 200 kilometers of the border. The results are reported in figures 13(a)–13(d). Each panel reports the median discontinuity in the percentage change in the price index across time. The top row presents the median discontinuity for the product groups and the bottom row does the same for the product classes. Superimposed is rate of depreciation of the exchange rate. As is evident the co-movement between the percentage change in price and cost indexes, and the rate of depreciation of the exchange rate is very high.

6.2 Store-brand products

A question arises whether the cost measures we use are allocative or whether they are simply accounting costs? In this section we focus on products that are sold under the retail chain's store brand to examine this issue. The idea is that the retail chain arguably controls a larger segment of the supply chain for store-branded products, and thus the cost measures are arguably less allocative for these products.[37] To the extent that all production is not done in-house it is still possible that manufacturers might segment markets across borders. However, we expect this segmentation to be less severe than for other products. We investigate this in figures 14(a)–14(b) by plotting the co-movement between the median RD estimates for store brands and the exchange rate. As is shown the co-movement is much less evident for these goods as compared to the full sample that includes mainly non-store brands (see figures 12(a)–12(d)).

6.3 Intra-national borders

This section compares our evidence on cross-border price costs and markup gaps to within-country estimates at the Washington-Oregon border, which is a subset of our west coast subsample. This serves an important purpose: within-country border discontinuities—where transactions costs are presumably lower—provide a natural benchmark for cross-border discontinuities. In the language of the treatment effect literature, this internal border serves as the placebo.

[37] We identify manually 225 store-brand products in our sample of 4,221 matched products.

In figure 15 we plot the net price of regular Perrier water as a function of the distance from the Washington-Oregon border. Stores in Washington are plotted to the left of the border line ($D_i < 0$) and stores in Oregon to the right ($D_i > 0$). Each dot represents the average gross price within a 50-kilometer bin. As is clear, unlike the case of the U.S.-Canada border, there is no evidence of a discontinuity for the Perrier water.

Next, we estimate the RD at the internal border for the products that were matched across borders. Very similar results were obtained when the sample was extended to include all UPCs that were traded within U.S. boundaries. Panel C of table 3 reports the results for the internal borders. There is no evidence of a discontinuity in prices or costs.

In figures 16(a) and 16(b) we plot the distribution of regression discontinuity estimates by UPC at the Washington-Oregon border for net prices and imputed costs. We find that, in contrast to figures 11(a)–11(f), the point estimates are almost all concentrated at 0 for every week in our sample.

7 Conclusion

This paper revisits a classic question about the role of international borders in segmenting markets. Our paper improves upon the existing literature on three dimensions. First, we use barcode level price and cost data from a single retail chain operating in the United States and Canada. Second, we develop a stylized model of price determination along the circle. Third, we use the model to motivate a regression discontinuity estimate of the border effect.

We find strong evidence of international market segmentation, even for identical goods. The failure of the law of one price that we observe at the UPC level is very similar to the failure observed at a more aggregate level. Therefore the argument that aggregate-level evidence arises mainly from a composition bias is not supported by our results. We also find that most differences in cross-border consumer prices arise from differences in an apparently tradeable component of costs, and not from systematic markup differences.

Since the gains to arbitrage are greater at the wholesale level, where transacted volumes are much larger than at the retail level, this finding reaffirms the existence of large border costs. A limitation of our work is that we examine a specific set of goods sold by a large grocery store chain. To the extent that the nature of price setting and the costs to arbitrage vary across goods, or across retailers, further work that encompasses a wider range of goods and retailers would be very useful.

References

Asplund, M. and Friberg, R. (2001). The law of one price in Scandinavian duty-free stores. *American Economic Review*, 91(4):1072–1083.

Broda, C. and Weinstein, D. (2007). Understanding international price differences using barcode data. Technical report, Chicago GSB.

Burstein, A. and Jaimovich, N. (2008). Understanding movements in aggregate and product-level real exchange rates. Working paper, UCLA.

Crucini, M. J. and Shintani, M. (2006). Persistence in law-of-one-price deviations: Evidence from micro-data. Working Paper 06-W17, Department of Economics, Vanderbilt University.

Crucini, M. J. and Shintani, M. (2007). Microeconomic sources of real exchange rate variability. Working paper, Vanderbilt University.

Crucini, M. J., Telmer, C. I., and Zachariadis, M. (2005). Understanding european real exchange rates. *American Economic Review*, 95(3):724–738.

d'Aspremont, C., Gabszewicz, J., and Thisse, J. (1979). On Hotelling's "Stability in Competition". *Econometrica*, 47(5):1045–1150.

Engel, C. and Rogers, J. (1996). How wide is the border? *American Economic Review*, 86:1112–1125.

Ghosh, A. R. and Wolf, H. C. (1994). Pricing in international markets: Lessons from the economist. Working Paper 4806, National Bureau of Economic Research, Inc.

Goldberg, P. and Knetter, M. (1997). Goods prices and exchange rates: What have we learned? *Journal of Economic Literature*, 35(3):1243–1272.

Goldberg, P. and Verboven, F. (2001). The evolution of price dispersion in the european car market. *Review of Economic Studies*, pages 811–48.

Goldberg, P. and Verboven, F. (2005). Market integration and convergence to the law of one price: Evidence from the european car market. *Journal of International Economics*, pages 49–73.

Gorodnichenko, Y. and Tesar, L. (2009). Border effect or country effect? seattle may not be so far from vancouver after all. *American Economic Journal: Macroeconomics*, 1(1):21941.

Haskel, J. and Wolf, H. (2001). The law of one price–a case study. *Scandinavian Journal of Economics*, 103(4):545–58.

Hassink, W. H. and Schettkat, R. (2001). On price-setting for identical products in markets without formal trade barriers. Discussion Paper 315, Institute for the Study of Labor (IZA).

Holmes, T. (1998). The effect of state policies on the location of manufacturing: Evidence from state borders. *Journal of Political Economy*, 106(4):667–705.

Holmes, T. (2008). The diffusion of wal-mart and economies of density. NBER Working Papers 13783.

Imbens, G. and Lemieux, T. (2007). Regression discontinuity designs: A guide to practice. Working Paper 13039, National Bureau of Economic Research, Inc.

Nakamura, E. (2008). Pass-through in Retail and Wholesale. *American Economic Review*, 98(2):430–437.

Parsley, D. and Wei, S. (2007). A prism into the ppp puzzles: The micro-foundations of big mac real exchange rates. *Economic Journal*, 117(523):1336–1356.

Rogoff, K. (1996). The Purchasing Power Parity Puzzle. *Journal of Economic Literature*, 34:647–668.

Salop, S. (1979). Monopolistic Competition with Outside Goods. *Bell Journal of Economics*, 10:141–156.

8 Tables and figures

	Number of unique products							
	per store-week				per store-pair-week			
	mean	median	10%	90%	mean	median	10%	90%
United States	492	497	355	643	272	273	187	365
Canada	414	425	263	533	243	252	146	365
Cross-border pairs	-	-	-	-	164	168	101	225

Table 1: Descriptive statistics

Note: The table reports the mean, median, 10th percentile, and 90th percentile of the number of unique matched products per store per week, and per store-pair per week.

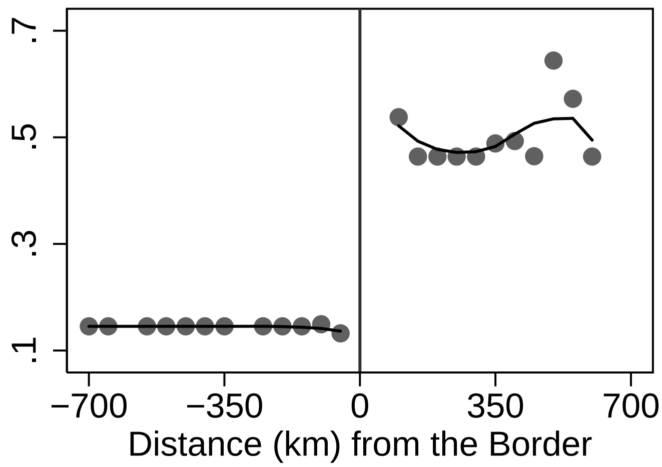
	Mean	Median	St. dev.	Mean absolute	Med. absolute
	(1)	(2)	(3)	(4)	(5)
	Panel A: Net prices				
	USA-USA store-pairs (31125)				
Median	0.010	0.000	0.147	0.085	0.037
Average	0.015	0.005	0.145	0.087	0.042
St. Dev.	0.038	0.025	0.034	0.029	0.032
	CAN-CAN store-pairs (2775)				
Median	0.007	0.000	0.055	0.030	0.000
Average	0.010	0.001	0.057	0.030	0.005
St. Dev.	0.025	0.006	0.024	0.020	0.012
	CAN-USA store-pairs (18450)				
Median	0.153	0.118	0.254	0.219	0.146
Average	0.151	0.116	0.255	0.222	0.156
St. Dev.	0.048	0.044	0.030	0.033	0.041
	Panel B: Imputed costs				
	USA-USA store-pairs (31125)				
Median	0.000	0.000	0.124	0.057	0.008
Average	0.001	0.001	0.126	0.058	0.018
St. Dev.	0.025	0.009	0.038	0.023	0.021
	CAN-CAN store-pairs (2775)				
Median	0.000	0.000	0.122	0.038	0.000
Average	0.000	0.000	0.124	0.038	0.000
St. Dev.	0.013	0.000	0.036	0.011	0.001
	CAN-USA store-pairs (18450)				
Median	0.184	0.144	0.263	0.238	0.178
Average	0.189	0.152	0.267	0.242	0.182
St. Dev.	0.043	0.049	0.035	0.039	0.046

Table 2: Deviations from the law of one price for retail and wholesale prices

Note: Panel A refers to net prices and panel B refers to imputed costs. The table reports within and between-country statistics (the rows) for the mean, median, standard deviation, mean absolute, and median absolute (log) price gap within store-pairs (the columns) for the first week of 2005.

	Median	Mean	SD	Frac. sign.	Median abs.	Mean abs.	No. of UPCs	Median bandwidth
				Panel A: All stores				
Net price	0.15	0.13	0.37	0.70	0.21	0.28	481	10
Imputed cost	0.17	0.15	0.31	0.80	0.21	0.26	481	10
Imputed markup	0	-0.02	0.37	0.40	0.14	0.23	481	10
				Panel B: West Coast stores				
Net price	0.22	0.26	0.32	0.86	0.24	0.33	212	12
Imputed cost	0.22	0.20	0.27	0.83	0.24	0.27	212	12
Imputed markup	0	0.06	0.36	0.44	0.13	0.23	212	12
				Panel C: Washington-Oregon stores				
Net price	0	0.01	0.09	0.24	0.01	0.04	370	6
Imputed cost	0	0	0.06	0.17	0	0.02	370	6
Imputed markup	0	0	0.10	0.22	0.02	0.04	370	6

Table 3: Regression discontinuity estimates — minimizing the cross-validation criterion



Perrier sparkling natural mineral water, 25 ounce (UPC 074780000055). Local linear regression of (log) net price on border dummy B_i, algebraic distance to the border D_i and interaction term. Store distance to the border is positive for the United States, negative for Canada. First week of 2004.

Figure 1: Graphical depiction of border discontinuity for Perrier Sparkling Mineral Water

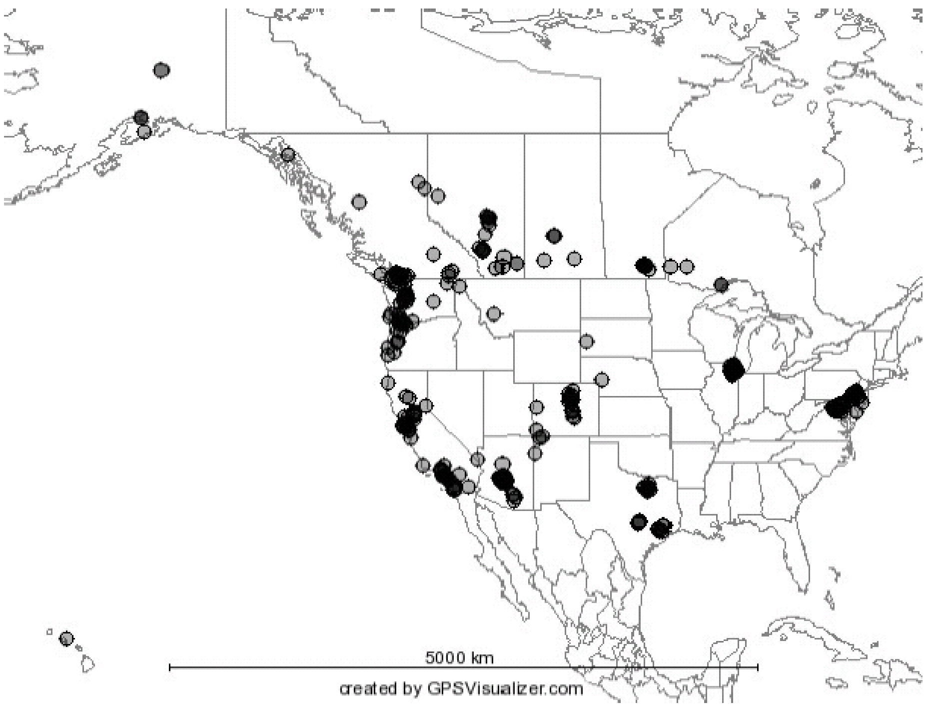


Figure 2: Map of the 325 North American retail stores in our data (250 U.S. and 75 Canadian)

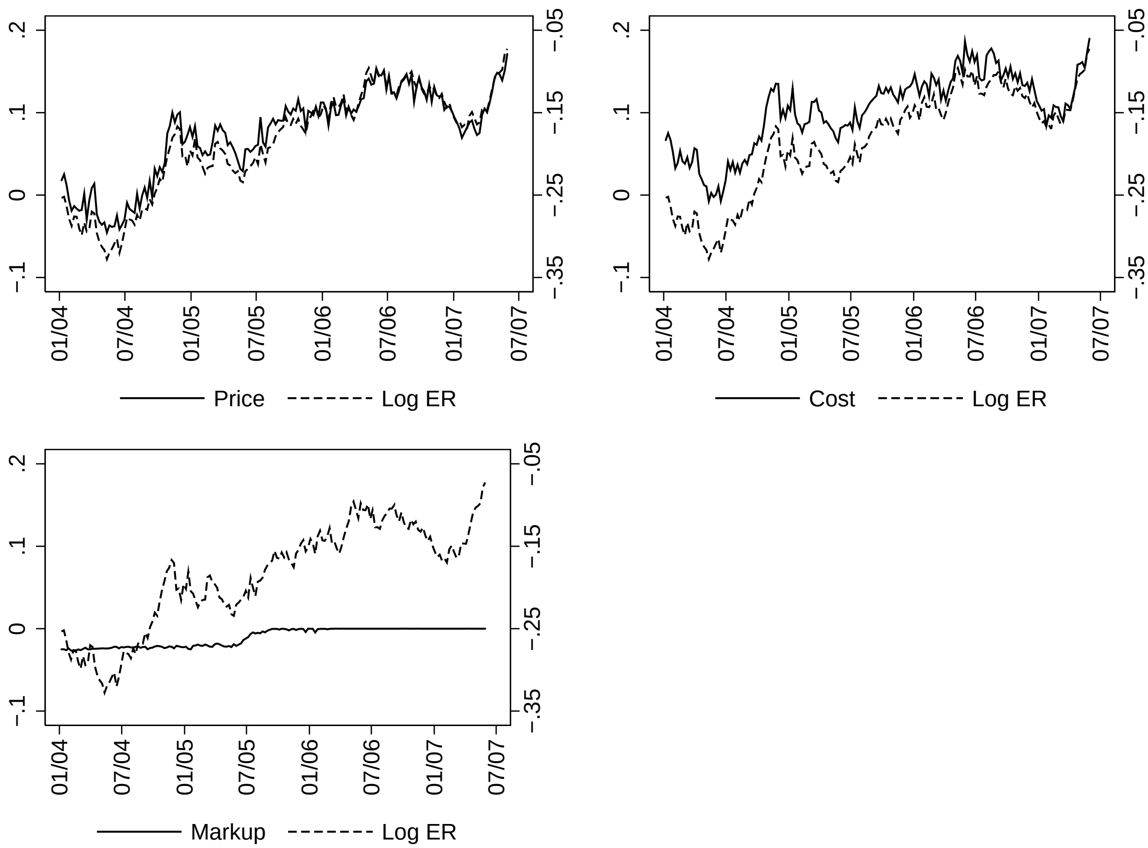
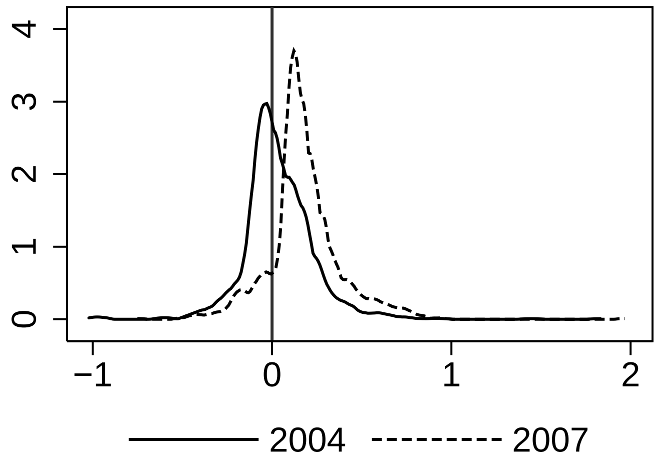
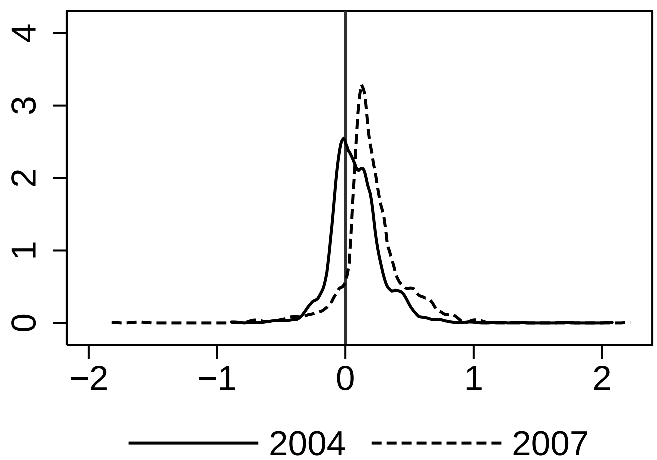


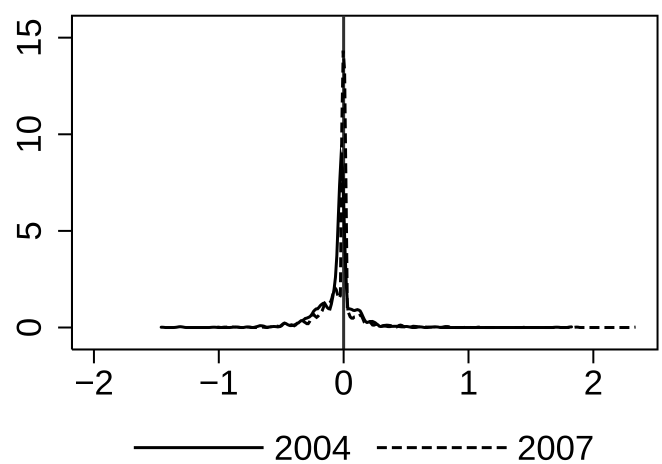
Figure 3: Median net price, imputed cost, and markup cross-border gap and exchange rate



(a) (log) net price



(b) (log) imputed cost



(c) (log) markup

Note: 2004 refers to the first week of 2004; 2007 refers to the 21st week of 2007.

Figure 4: The dispersion of cross-border average price, cost, and markup gap

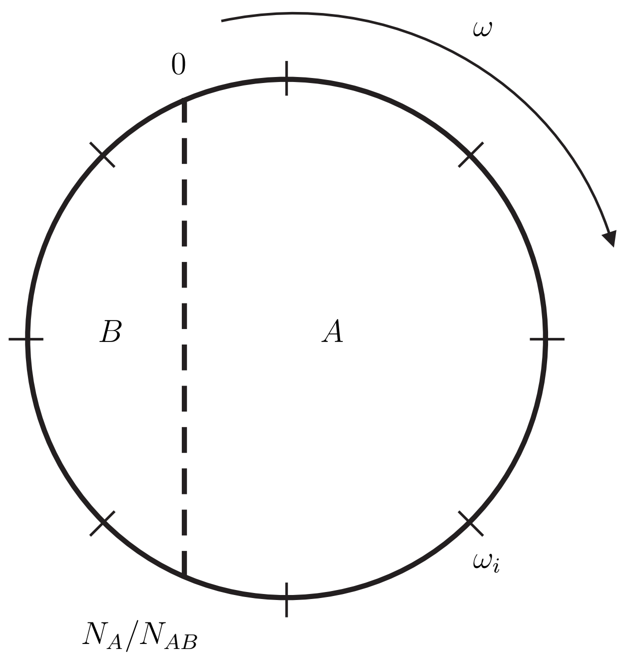
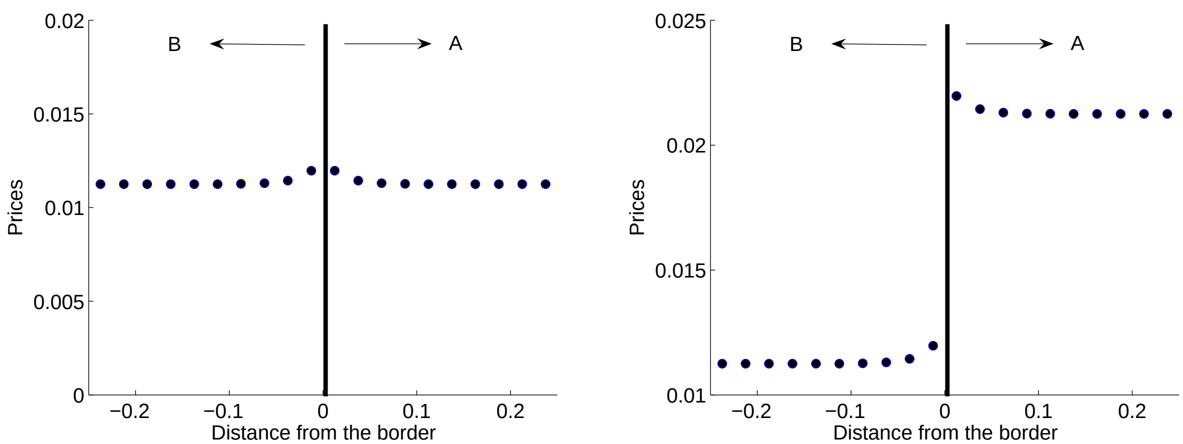
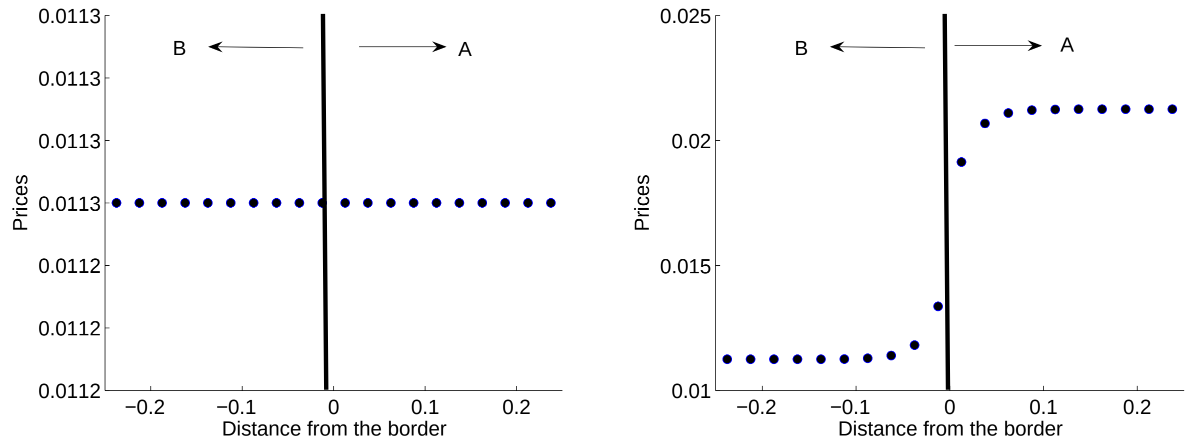


Figure 5: Circular World



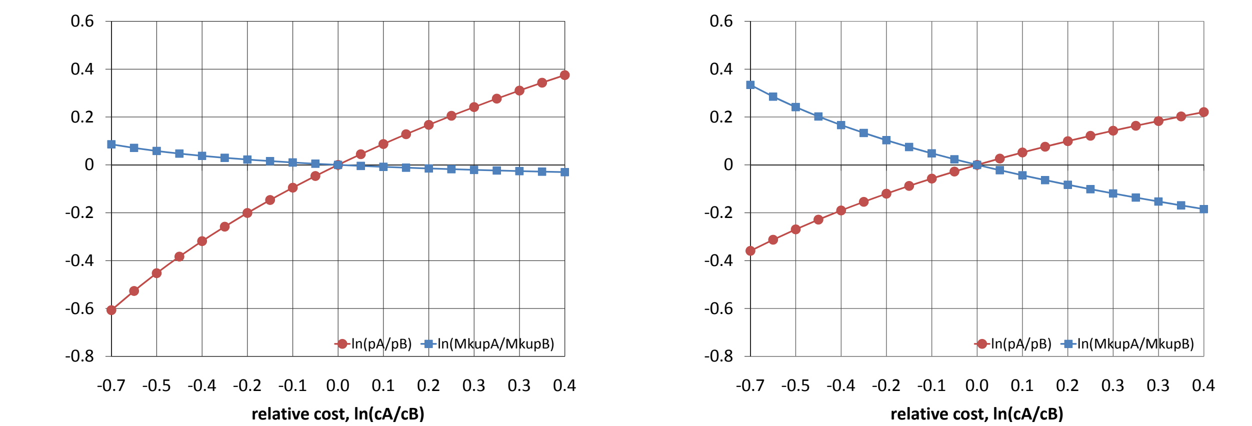
Note: For the left figure the parameters are $N_A = N_B = 20$, $t = 0.05$, and $c_A = c_B = 0.01$, and for the figure on the right the parameters are $N_A = N_B = 20$, $t = 0.05$, and $c_A = 0.02 > c_B = 0.01$

Figure 6: Price discontinuity at the border: full segmentation



Note: For the left figure the parameters are $N_A = N_B = 20$, $t = 0.05$, $c_A = c_B = 0.01$, and $b = 0$, and for the figure on the right the parameters are $N_A = N_B = 20$, $t = 0.05$, $c_A = 0.02 > c_B = 0.01$, and $b = 0$.

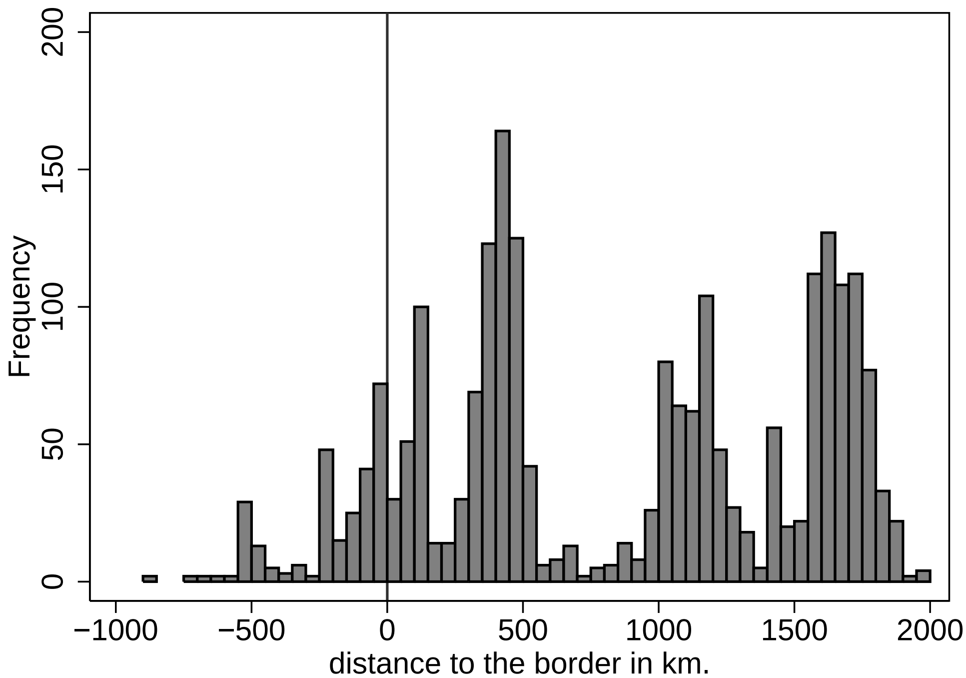
Figure 7: Price discontinuity at the border: partial segmentation



(a) Full segmentation (b) Partial segmentation

Note: The parameters are $N_A = N_B = 20$ and $t = 0.05$. For panel (a), $|\hat{p}_A - \hat{p}_B| < b$, which is the case of Proposition 2; panel (b) assumes $b = 0$, which is consistent with the case in Proposition 3.

Figure 8: Price and markup discontinuities at the border



Note: Distance to the border is positive for U.S. stores, negative for Canadian stores.

Figure 9: Distance to the border

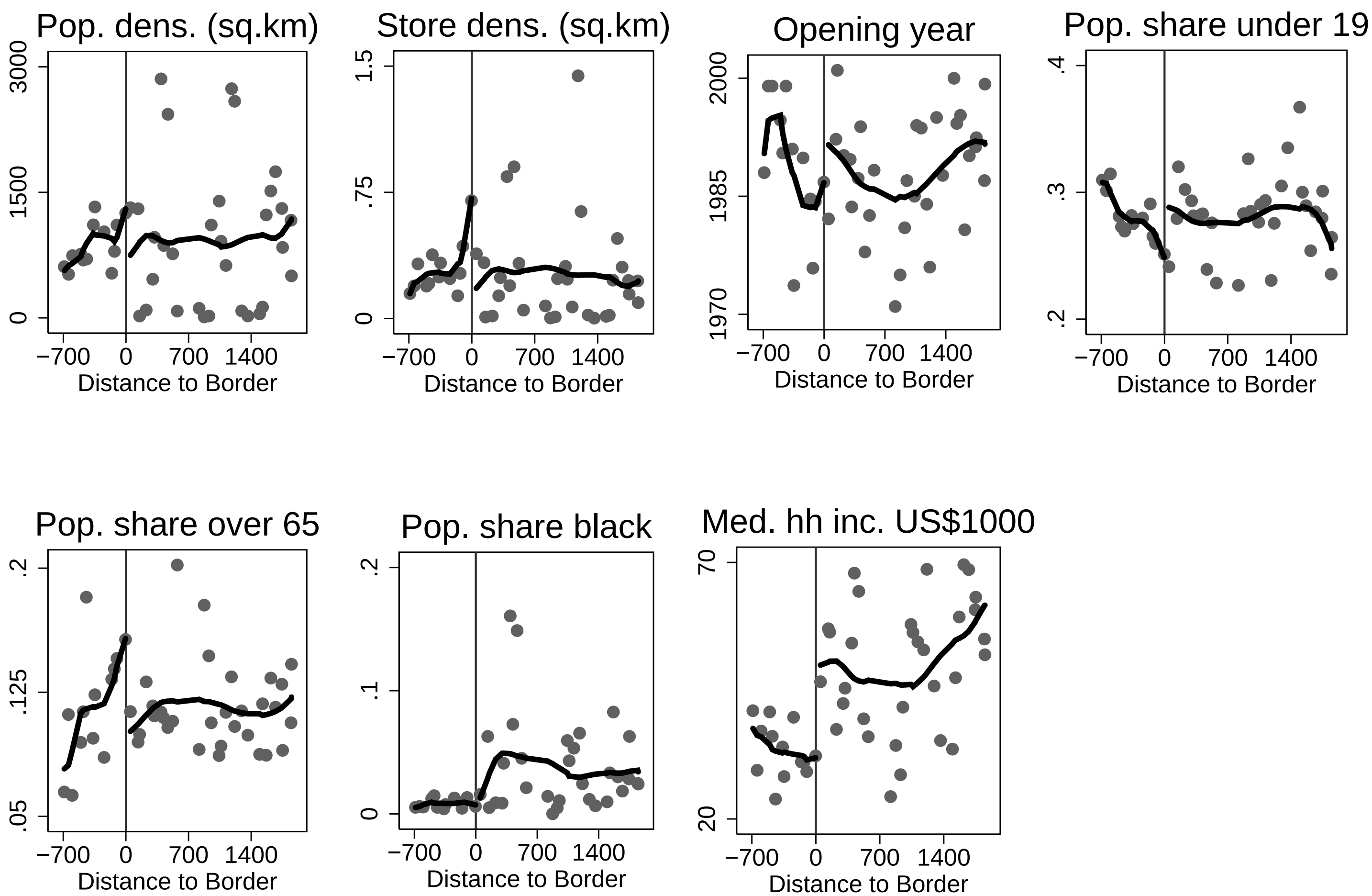
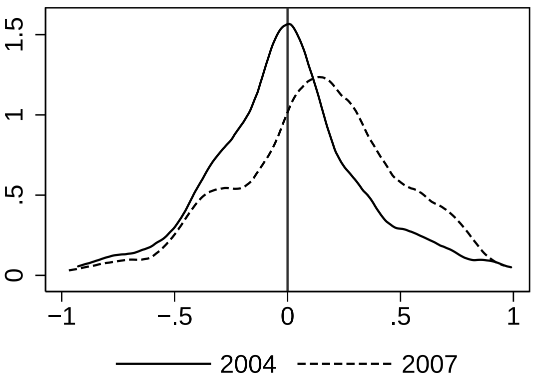
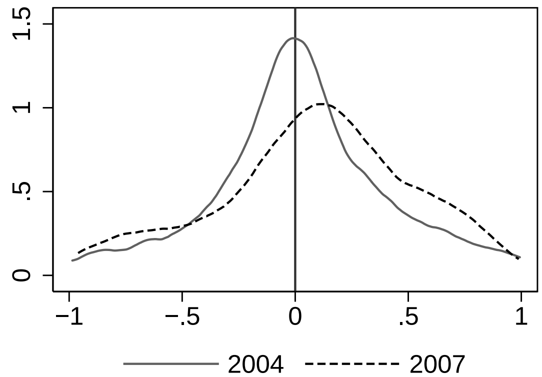


Figure 10: Regression discontinuity for covariates

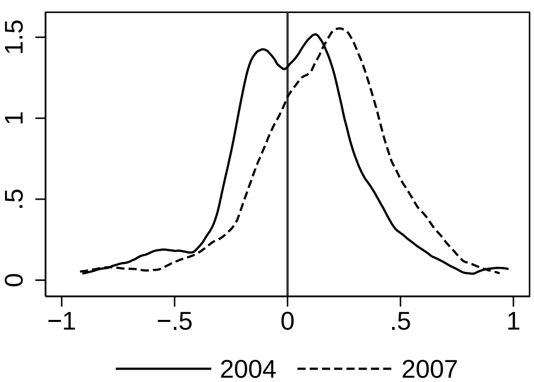
Note: Local linear regression of covariates X_i on border dummy B_i, algebraic distance to the border D_i and interaction term. Store distance to the border is positive for the United States, negative for Canada.



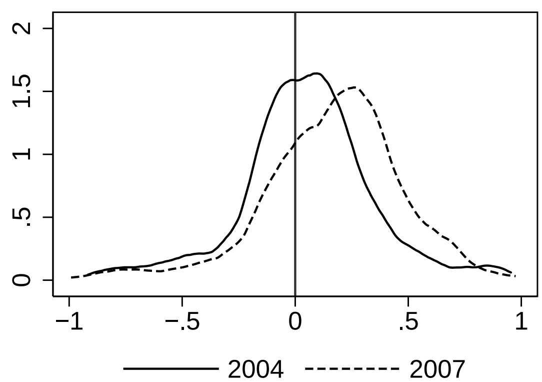
(a) Net price, no covariates



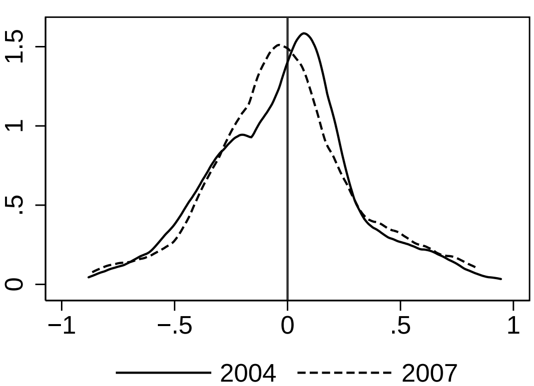
(b) Net price, with covariates



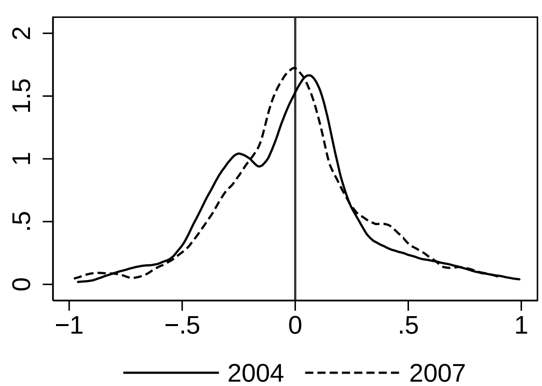
(c) Imputed Cost, no covariates



(d) Imputed Cost, with covariates



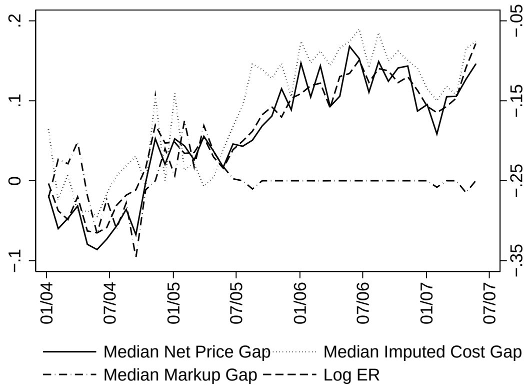
(e) Mark up, no covariates



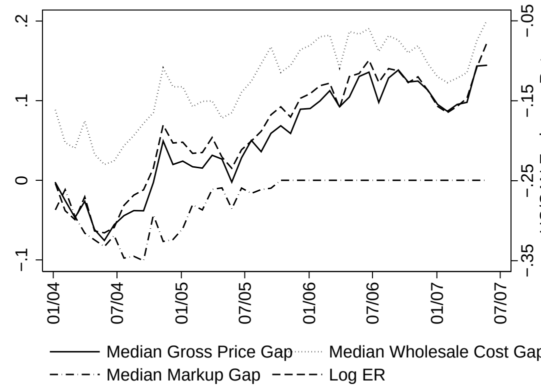
(f) Mark-up, with covariates

Note: 2004 refers to the first week of 2004; 2007 refers to the 21st week of 2007.

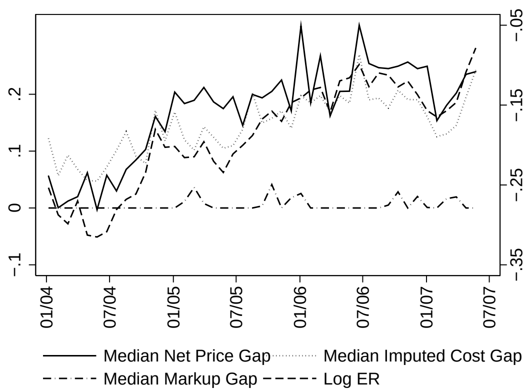
Figure 11: Distribution of regression discontinuity estimates of price, cost and markup gaps



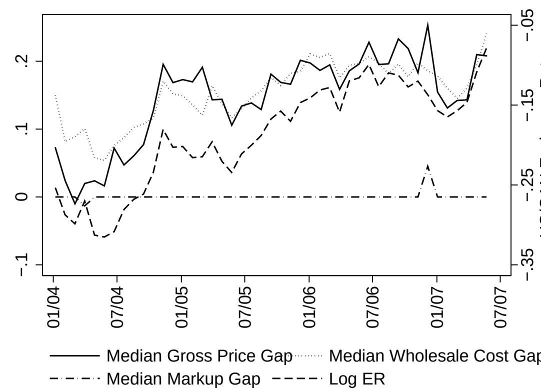
(a) Net, all stores



(b) Gross, all stores



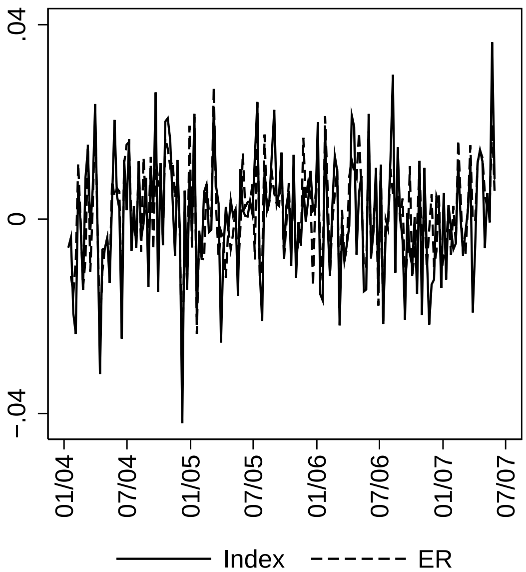
(c) Net, west coast stores



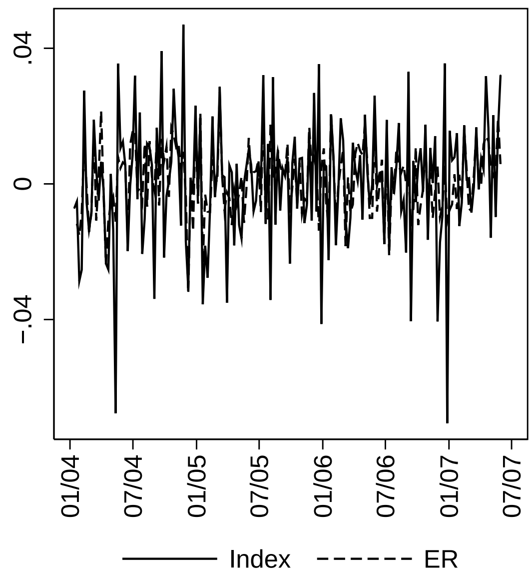
(d) Gross, west coast stores

Note: In each panel, the median regression discontinuity (left axis) is plotted alongside the U.S.-Canada (log) nominal exchange rate (right axis). RD includes covariates.

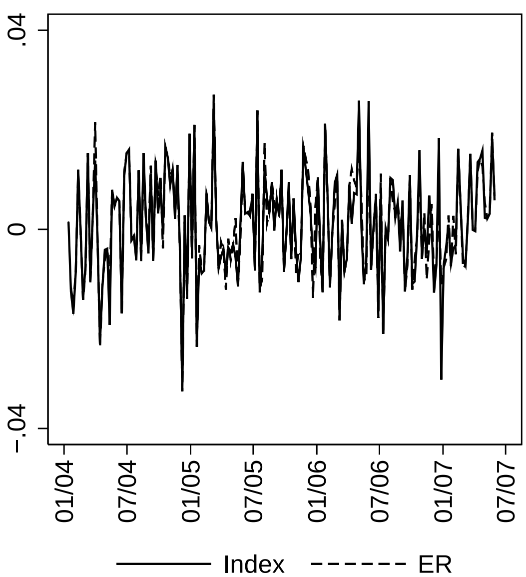
Figure 12: Co-movement in RD estimates of price and cost gaps over time



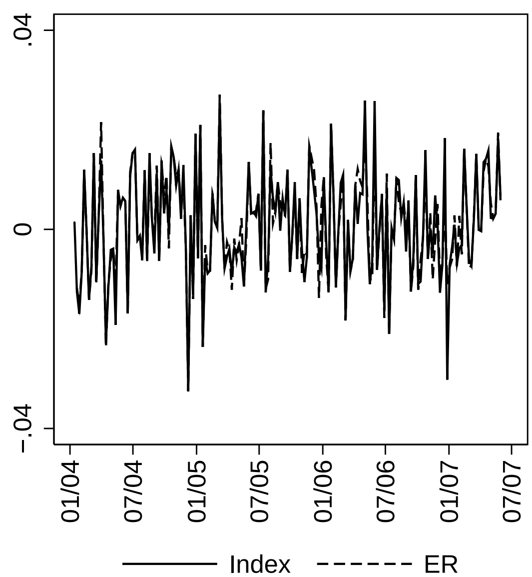
(a) Net price, product group



(b) Imputed cost, product group

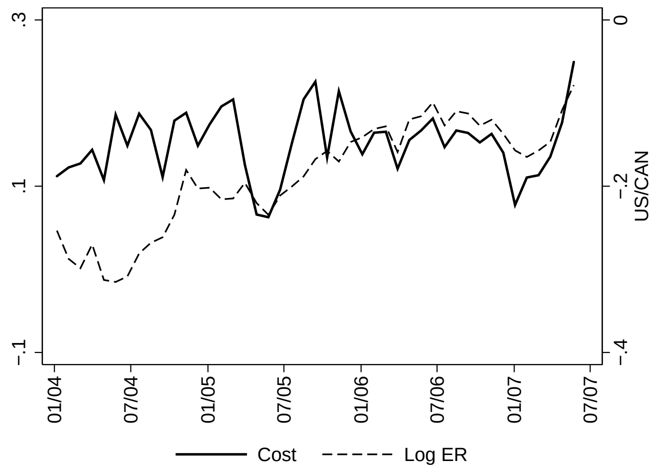


(c) Net price, product class

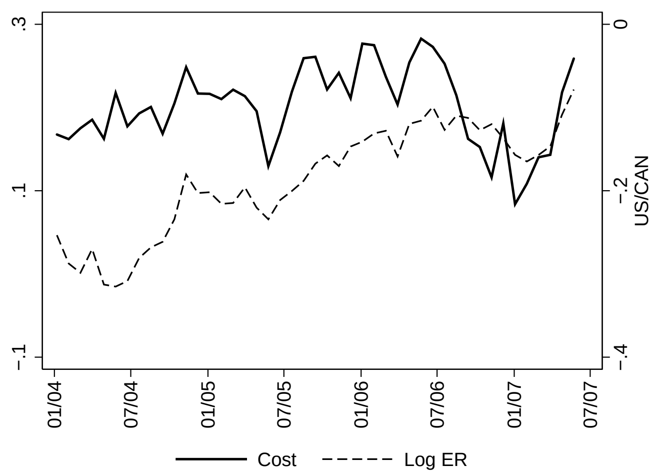


(d) Imputed cost, product class

Figure 13: Price index

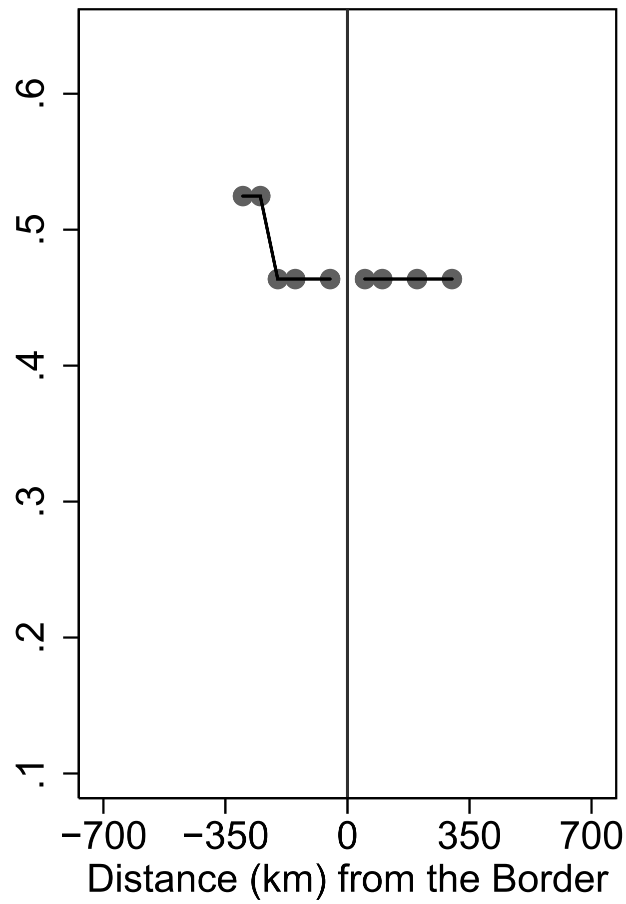


(a) Wholesale cost



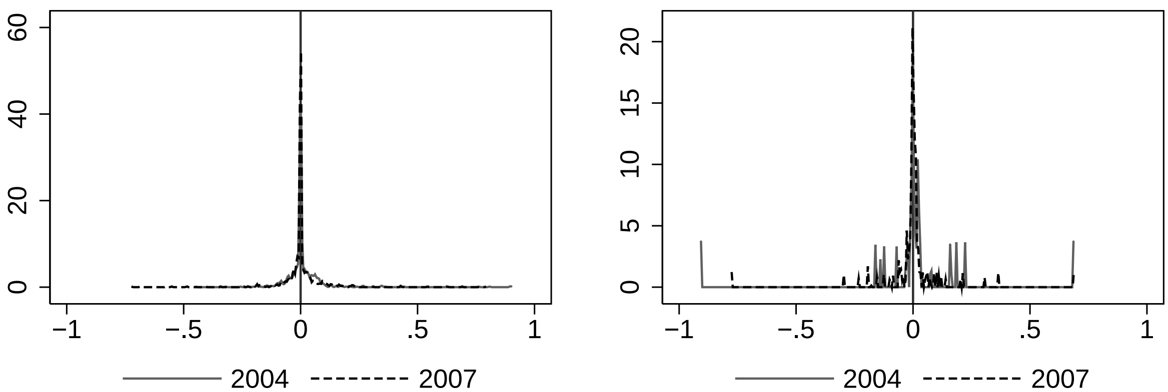
(b) Imputed cost

Figure 14: Retail chain brands



Perrier sparkling natural mineral water, 25 ounce (UPC 074780000055). Local linear regression of U.S. (log) net price on Washington-Oregon border dummy B_i, algebraic distance to the border D_i, and interaction term. Store distance to the border is positive for Oregon, negative for Washington.

Figure 15: Graphical depiction of internal border regression discontinuity for Perrier Sparkling Mineral Water



(a) Distribution of net price discontinuity (b) Distribution of imputed cost discontinuity

Note: 2004 refers to the first week of 2004 and 2007 refers to the 21st week of 2007.

Figure 16: Intra-national borders regression discontinuity: the Washington-Oregon border

Appendix

A Derivations for the circular world model

A.1 Prices charged by interior stores

Let us consider region A. Given our assumptions in section 4.3, all stores in region A face the same cost c_A. Each interior store maximizes static profits by choosing p_i as determined by the first order condition:

$$p_i = \frac{t}{2N_{AB}} + \frac{p_{i+1} + p_{i-1}}{4} + \frac{c_A}{2}, \; i = 2, \dots, N_A - 1. \tag{11}$$

We solve this system of equations, subject to the boundary condition,

$$p_1 = p_{N_A} = \hat{p}_A.$$

In the difference equation (11) all terms are linear in prices (up to the constant term), so we can expect a solution in the form of a sum of two exponentials plus a constant. Because of the symmetry between p_1 and p_{N_A}, the sum of the two exponentials should reduce to a hyperbolic cosine centered at $\omega = N_A/2N_{AB}$, or $i = (N_A+1)/2$. For this reason, we propose the following solution[38]

$$p_i = A \cosh \kappa \left(i - \frac{N_A + 1}{2} \right) + B.$$

By plugging this conjecture back into equation (11), we can determine the unknown coefficients A, B, and κ. We obtain

$$\begin{aligned} A \cosh \kappa (i - \frac{N_A+1}{2}) + B = & \frac{t}{2N_{AB}} + \frac{1}{4} \left(A \cosh \kappa (i + 1 - \frac{N_A+1}{2}) + B \right) \\ & + \frac{1}{4} \left(A \cosh \kappa (i - 1 - \frac{N_A+1}{2}) + B \right) + \frac{c_A}{2}. \end{aligned}$$

Using the property that $\cosh(x+y) = \cosh x \cosh y + \sinh x \sinh y$ and after some simplification, it follows that these equations will be satisfied for all i if[39]

$$\kappa = \cosh^{-1} 2 \approx 1.317,$$

and

$$B = c_A + \frac{t}{N_{AB}}.$$

[38] We thank Michal Fabinger for providing us with this conjecture.

[39] $\sinh x = \frac{e^x - e^{-x}}{2}$

The value of A is determined using the boundary condition

$$\hat{p}_A = A \cosh \kappa \left(1 - \frac{N_A + 1}{2}\right) + B.$$

This provides,

$$A = \frac{\hat{p}_A - c_A - \frac{t}{N_{AB}}}{\cosh \kappa (\frac{N_A - 1}{2})}.$$

We can summarize the interior solution for stores in region A as

$$p_i = \left(\hat{p}_A - c_A - \frac{t}{N_{AB}}\right) \frac{\cosh \kappa (i - \frac{N_A+1}{2})}{\cosh \kappa \left(\frac{N_A-1}{2}\right)} + c_A + \frac{t}{N_{AB}}. \tag{12}$$

By analogy, the interior solution for country B is

$$p_i = \left(\hat{p}_B - c_B - \frac{t}{N_{AB}}\right) \frac{\cosh \kappa \left(i - \frac{N_B+1}{2} - N_A\right)}{\cosh \kappa \left(\frac{N_B-1}{2}\right)} + c_B + \frac{t}{N_{AB}}, \tag{13}$$

where $\hat{p}_B$ is the price charged by border stores N_{AB} and $N_A + 1$ in region B.

A.2 Prices charged by stores at the border

We use the profit maximization conditions for stores at the border to paste the interior solutions together. As discussed previously, we need to consider several different cases.

A.2.1 Case 1 — The marginal customer is at the border

If $|\hat{p}_A - \hat{p}_B| < b$, the marginal consumer between stores $i = 1$ and $i = N_{AB}$ will be exactly at the border. Similarly for the border between stores N_A and $N_A + 1$. Store 1 will choose $\hat{p}_A$ to maximize

$$\pi_1 \equiv (\hat{p}_A - c_A) \left(\frac{1}{N_{AB}} + \frac{p_2 - \hat{p}_A}{2t}\right),$$

and store N_{AB} will choose $\hat{p}_B$ to maximize

$$\pi_{N_{AB}} \equiv (\hat{p}_B - c_B) \left(\frac{1}{N_{AB}} + \frac{p_{(N_{AB}-1)} - \hat{p}_B}{2t}\right).$$

The corresponding first-order conditions are:

$$\hat{p}_A = \frac{t}{N_{AB}} + \frac{p_2}{2} + \frac{c_A}{2},$$

and

$$\hat{p}_B = \frac{t}{N_{AB}} + \frac{p_{(N_{AB}-1)}}{2} + \frac{c_B}{2}.$$

We can substitute for p_2 and $p_{N_{AB}-1}$ from equations (12) and (13). After some manipulation, we obtain,

$$\hat{p}_A = \frac{\frac{3t}{N_{AB}} + 2c_A - \left(c_A + \frac{t}{N_{AB}}\right)\frac{\cosh\kappa\left(\frac{N_A-3}{2}\right)}{\cosh\kappa\left(\frac{N_A-1}{2}\right)}}{2 - \frac{\cosh\kappa\left(\frac{N_A-3}{2}\right)}{\cosh\kappa\left(\frac{N_A-1}{2}\right)}}\ ,\ \hat{p}_B = \frac{\frac{3t}{N_{AB}} + 2c_B - \left(c_B + \frac{t}{N_{AB}}\right)\frac{\cosh\kappa\left(\frac{N_B-3}{2}\right)}{\cosh\kappa\left(\frac{N_B-1}{2}\right)}}{2 - \frac{\cosh\kappa\left(\frac{N_B-3}{2}\right)}{\cosh\kappa\left(\frac{N_B-1}{2}\right)}}.$$

With some simplification we arrive at the expressions in equation (5).

A.3 Case 2a — The marginal customer for the border stores is located in Country A

For it to be the case that the marginal customer for border stores is in country A, we need $\hat{p}_A - \hat{p}_B > b$. The demand for the border stores located near $\omega = 0$, that is $i = 1$ and $i = N_{AB}$, are given by:

$$D_1(\hat{p}_A, \hat{p}_A, p_2) = \frac{1}{N_{AB}} + \frac{p_{(N_{AB}-1)} - 2\hat{p}_A + p_2}{2t} + \frac{b}{2t},$$
$$D_{N_{AB}}(p_{(N_{AB}-1)}, \hat{p}_B, \hat{p}_A) = \frac{1}{N_{AB}} + \frac{p_{(N_{AB}-2)} - 2\hat{p}_B + \hat{p}_A}{2t} - \frac{b}{2t}.$$

The profit maximizing prices for store 1 are then

$$\hat{p}_A = \frac{t}{2N_{AB}} + \frac{\hat{p}_B}{4} + \frac{p_2}{4} + \frac{b}{4} + \frac{c_A}{2},$$

and for store N_{AB},

$$\hat{p}_B = \frac{t}{2N_{AB}} + \frac{p_{(N_{AB}-1)}}{4} + \frac{\hat{p}_A}{4} - \frac{b}{4} + \frac{c_B}{2}.$$

Substituting for $p_{N_{AB}-1}$ and p_2 using equations (12) and (13), and after some manipulations, we arrive at the expressions in Proposition 6 (see p. 15).

$$\hat{p}_A = \frac{(4-\nu_B)\, j_A\ + j_B}{15 - 4\nu_A - 4\nu_B + \nu_A\nu_B}, \qquad \hat{p}_B = \frac{(4-\nu_A)\, j_B\ + j_A}{15 - 4\nu_B - 4\nu_A + \nu_B\nu_A}$$

where

$$\nu_A \equiv \frac{\cosh\kappa(\frac{N_A-3}{2})}{\cosh\kappa(\frac{N_A-1}{2})}, \qquad \nu_B \equiv \frac{\cosh\kappa(\frac{N_B-3}{2})}{\cosh\kappa(\frac{N_B-1}{2})},$$

and

$$j_A \equiv \frac{3t}{N_{AB}} + 3c_A + b - (c_A + \frac{t}{N_{AB}})\nu_A; \qquad j_B \equiv \frac{3t}{N_{AB}} + 3c_B - b - (c_B + \frac{t}{N_{AB}})\nu_B$$

A.4 Case 2b — The marginal customer for the border stores is located in Country B

This case is symmetric to the previous one when $\hat{p}_B - \hat{p}_A > b$ and is derived analogously.

B Price index construction

We calculate the change in the chain-weighted Törnqvist log price index, $\ln P_t^{TQ}(K,i)$, of category K in store i between period $t-1$ and t as

$$\Delta \ln P_t^{TQ}(K,i) \equiv \sum_{k \in K} \ln \left(\frac{p_t(k,j)}{p_{t-1}(k,j)} \right)^{\frac{1}{2}[s_t(k)+s_{t-1}(k)]} \equiv \sum_{k \in K} \omega_t(k) \cdot \Delta \ln p_t(k,j)$$

where the weights $\omega_t(k) = \frac{1}{2}[s_t(k)+s_{t-1}(k)]$ use the expenditure shares of good k as a fraction of total expenditures on category K in week t, that is

$$s_t(k) = \frac{\sum_j x_t(k,j)p_t(k,j)}{\sum_{k \in K} \sum_j x_t(k,j)p_t(k,j)} = \frac{\sum_j amt_t(k,j)}{\sum_{k \in K} \sum_j amt_t(k,j)}.$$

In summing over j we use all stores in the United States and in Canada so that differences in the change in the store-level price index arises from differences in the rate of change in prices across stores. However, there are many weeks when a particular UPC is not sold in a particular store, so we have no recorded price change. In this case we drop the observation for the store that is missing a price change and re-weight the shares across the UPCs for which price information is available in that store. We construct these price indexes for different levels of product classifications: subsubclass, subclass, class, category, and group. For the case of net (gross) prices we use the net (gross) expenditure shares. Similarly for the imputed net cost (wholesale cost) measure we use the net (gross) expenditure shares.

C Data Description

Table 4 describes the distribution of unique UPCs by product groups.

Product Groups	Unique UPCs Freq. (1)	Unique UPCs Percent	Canada Freq. (2)	Canada Percent	United States Freq. (3)	United States Percent	Matched UPCs Freq. (4)	Matched UPCs Percent
Alcoholic Beverages	10,038	8.03	2,268	6.88	8,173	8.3	403	9.55
Baby Food/Diapers/Baby Care	1,220	0.98	384	1.17	930	0.94	94	2.23
Batteries	94	0.08	68	0.21	61	0.06	35	0.83
Books & Magazines	5,361	4.29	3,908	11.86	4,266	4.33	2,505	59.35
Candy, Gum & Mints	4,065	3.25	1,128	3.42	2,967	3.01	29	0.69
Canned Fish & Meat	740	0.59	203	0.62	540	0.55	3	0.07
Canned Fruits	228	0.18	64	0.19	164	0.17		
Canned Vegetables	459	0.37	85	0.26	374	0.38		
Cereal And Breakfast	2,438	1.95	570	1.73	1,875	1.9	7	0.17
Cheese	1,453	1.16	335	1.02	1,130	1.15		
Coffee/Tea/Hot Cocoa...	3,215	2.57	729	2.21	2,606	2.65	120	2.84
Commercial Bread & Baked Goods	4,596	3.68	492	1.49	4,111	4.18	7	0.17
Condiments & Sauces	37	0.03			37	0.04		
Cookies/Crackers & Snacks	2,869	2.29	733	2.22	2,205	2.24	69	1.63
Cough, Cold, Flu, Allergy	15	0.01	1	0	14	0.01		
New Age, Mixers, Bottled Water	4,295	3.43	1,197	3.63	3,135	3.19	36	0.85
Deli/Food Service Items	6,623	5.3	2,313	7.02	4,936	5.01		
Dessert & Baking Mixes	412	0.33	121	0.37	291	0.3		
Detergents & Laundry Needs	1,448	1.16	539	1.64	963	0.98	54	1.28
Diet, Ethnic & Gourmet Foods	3,992	3.19	901	2.73	3,397	3.45	306	7.25
Enhancements	1,086	0.87	279	0.85	825	0.84	18	0.43
Floral	7,360	5.89	1,719	5.22	5,914	6.01		
Flour, Sugar, Corn Meal	122	0.1	26	0.08	96	0.1		
Food Service	1,729	1.38	625	1.9	1,222	1.24		
Fresh Produce	9,985	7.98	2,572	7.8	8,069	8.2		
Frozen Breakfast Items	260	0.21	55	0.17	207	0.21	2	0.05
Frozen Vegetables	895	0.72	139	0.42	757	0.77	1	0.02
Hair Care	1,641	1.31	582	1.77	1,061	1.08	2	0.05
Health Supplements	1,356	1.08	310	0.94	1,064	1.08	18	0.43
Hispanic Products	1,077	0.86	68	0.21	1,013	1.03	4	0.09
Household Cleaners	2,566	2.05	935	2.84	1,790	1.82	159	3.77
Housewares	364	0.29	95	0.29	280	0.28	11	0.26
Ice Cream & Ice	2,713	2.17	544	1.65	2,172	2.21	3	0.07
Fresh Bread & Baked Goods	959	0.77	312	0.95	666	0.7		
Jams, Jellies & Spreads	1,026	0.82	247	0.75	798	0.81	19	0.45
Mayo, Salad Dressings & Toppings	1,268	1.01	249	0.76	1,029	1.05	10	0.24
Meat	5,604	4.48	1,301	3.95	4,370	4.44		
Natural Markets	12	0.01	12	0.04	2	0	2	0.05
Oral Hygiene	978	0.78	303	0.92	682	0.69	7	0.17
Paper, Foil & Plastics	1,378	1.11	322	0.98	1,121	1.14	65	1.54
Pasta & Pasta Sauce	1,963	1.57	362	1.1	1,624	1.65	23	0.54
Pet Food & Pet Needs	2,647	2.12	656	1.99	2,070	2.1	79	1.87
Pickles, Peppers & Relish	849	0.68	147	0.45	709	0.72	7	0.17
Prepared Frozen Foods	3,197	2.56	432	1.31	2,774	2.82	9	0.21
Ready To Eat Prepared Foods	408	0.33	57	0.17	351	0.36		
Refrigerated Dairy	2,841	2.27	786	2.38	2,070	2.1	15	0.36
Refrigerated Foods	1,201	0.96	214	0.65	994	1.01	7	0.17
Refrigerated Juice	435	0.35	105	0.32	331	0.34	1	0.02
Respiratory	537	0.43	219	0.66	319	0.32	1	0.02
Rice & Beans	1,177	0.94	253	0.77	930	0.94	5	0.12
Salt, Seasoning & Spices	1,133	0.91	205	0.62	936	0.95	8	0.19
Salty Snacks	2,367	1.89	579	1.76	1,797	1.83	9	0.21
Seafood	1,901	1.52	311	0.94	1,607	1.63		
Shelf Stable Juices & Drinks	1,267	1.01	383	1.16	887	0.9	3	0.07
Shortening & Cooking Oils	509	0.41	112	0.34	423	0.43	24	0.57
Skin Care	431	0.34	127	0.39	314	0.32	10	0.24
Social Expressions	2,028	1.62			2,028	2.06		
Soft Beverages	707	0.57	167	0.51	541	0.55		
Soups	1,351	1.08	370	1.12	1,011	1.03	30	0.71
Syrups & Pancake/Waffle Mix	291	0.23	65	0.2	227	0.23	1	0.02
Tobacco And Smoking Needs	1,831	1.46	677	2.05	1,154	1.17		
Total	125,048	100	32,961	100	98,430	100	4,221	100

Table 4: Number of distinct products by product group for both countries, Canada and the United States, and the set of uniquely matched products