

Borders and Price Convergence: The Role of Local Products*

Fernando Borraz[†] and Leandro Zipitriá[‡]

Abstract

While the impact of borders on price convergence for traded goods is well established, the role of regional disparities in product variety remains underexplored. We develop a model in which local products—those sold exclusively within a single country—emerge endogenously alongside traded products. In a symmetric setting, border costs affect pricing decisions but play a limited role in determining whether a product is local or traded; the latter depends on fixed production costs. The presence of local products leads to price divergence in traded goods by altering local competitive conditions.

We show that failing to account for local products can lead to biased estimates of border effects in standard empirical designs. A Monte Carlo exercise illustrates the magnitude of this bias in a controlled setting, showing that omitting local competition leads to overestimation of border effects, while explicitly controlling for it restores near-unbiased estimation. Finally, we discuss empirical strategies to account for local product competition in applied border regressions.

JEL Codes: D4, F40, F41.

Keywords: Law of One Price, Borders, Varieties.

We declare that we have not received any funding for this paper. Additionally, the authors declare that they have no conflicts of interest related to the paper.

*This is a substantially revised version of the paper "Law of One Price, Distance, and Borders". We thank the editor and two anonymous referees for their comments and suggestions, which led to a substantial revision of this paper. All remaining errors are ours.

[†]Corresponding author. Banco Central del Uruguay and Facultad de Ciencias Sociales, Universidad de la Repùblica. Uruguay. fborraz@bcu.gub.uy.

[‡]Departamento de Economía, Facultad de Ciencias Sociales, Universidad de la Repùblica. Uruguay. leandro.zipitria@cienciassociales.edu.uy.

1 Introduction

We examine the impact of competition from local products on the pricing decisions of traded products in two regions separated by a border. We show that border costs are unrelated to the decision to trade products. Specifically, whether products are local or traded depends on fixed production costs, such as distribution costs or brand positioning. We demonstrate that products are traded even when border costs are prohibitively high in terms of the model. Our model disentangles the role of fixed costs, which determine whether products are traded, from border costs, which affect pricing by shifting demand.

While the literature has long recognized multiple sources of price dispersion, including competition and price discrimination, the focus here is on how discontinuous changes in local competitive conditions at a border mechanically contaminate standard border regressions, leading to these effects being misinterpreted as border frictions.

We provide a simple extension of the Hotelling (1929) model to demonstrate that the border effect will be biased if local goods are not controlled for. First, we provide a benchmark for how borders lead to price dispersion among traded products in an otherwise symmetrical setting. This is the isolated effect of borders on the pricing decision for traded goods. Even when border costs are high, products are traded, i.e., sold in both countries. Nevertheless, border costs will affect prices by shifting demand between countries. Next, keeping our model simple, we add a local brand in one of the political regions and estimate price dispersion.¹ A local product is sold only on one side of the border, regardless of the demand for it on both sides. We found that dispersion increases from the estimated border due to local competition. We show that traded and local products arise in equilibrium. The key to the results is that fixed costs are high enough. If fixed costs are zero, no local products exist, and all goods are traded. Also, if fixed costs are too high, there could be no local products.

Next, we address the influence of local products on regression discontinuity (RDD) estimation, a widely used technique in empirical border research. A fundamental requirement of RDD is that all variables, other than the treatment, exhibit continuity at the cutoff. However, by their very nature, local products are discontinuous, existing on only one side of the border. This discontinuity creates a confounding effect, obscuring the border's actual impact if not accounted for. Our model shows that local products are determined by fixed production costs rather than border-related costs, so these costs should be controlled for in the estimates. Finally, we discuss various methods for addressing and correcting the bias introduced by local products in border-effect estimations, and we complement the theoretical analysis with a simple Monte Carlo exercise that quantifies the magnitude of the resulting bias in a controlled setting.

Borders between regions or countries have been one of the most extended explanations

¹Political regions can be countries, states, counties, or neighborhoods.

for the non-convergence of prices in the trade literature (Engel and Rogers (1996); Anderson and van Wincoop (2001); McCallum (1995); Parsley and Wei (2001); Gorodnichenko and Tesar (2009); and more recently Gopinath, Gourinchas, Hsieh, and Li (2011); Beck, Kotz, and Zabelina (2020); and Messner, Rumler, and Strasser (2024)). Additionally, trade costs play a significant role in explaining how goods are traded between different markets (Anderson and van Wincoop (2003), Anderson and van Wincoop (2004), Atkin and Donaldson (2015), Auer, Burstein, and Lein (2021), and Burstein, Lein, and Vogel (2024)).²

What is a border? Engel and Rogers (1996) defines a border as the political frontier between the US and Canada. In gravity trade models, borders conceal at least three factors: tariffs, language, and currencies. While the first affects prices directly, the other two are fixed costs that consumers must pay to arbitrage, and, as such, they shift demand. Analyzing trade between countries Head and Mayer (2014) reveals that borders have significant effects even when tariffs are small. They also conclude that language and currency differences between countries appear to have a more substantial impact than reasonable (p. 189). Nevertheless, in the price dispersion literature, borders remain political frontiers between nations or states within countries.

Geographical regions differ in consumers' incomes and product preferences. For example, Bronnenberg, Dube, and Gentzkow (2012) demonstrated that preferences are geographically based and, more interestingly, time persistent. In such settings, producers may offer products that match local characteristics. Those idiosyncrasies may include size, flavor, brand, and presentation. Consistently, the overwhelming evidence shows that most retail products are not traded; they are local. For example, Broda and Weinstein (2008) established that in “the typical bilateral city/region comparison between the US and Canada, only 7.5 percent of the goods are common” (page 11). Gopinath, Gourinchas, Hsieh, and Li (2011) found that only 3.4 percent of 125,048 products on their database were available in the US and Canada, even for the same retail chain. More recently, Messner, Rumler, and Strasser (2024) analyzes transactions at the border between Austria and Germany, establishing that “once we restrict the sample to products sold on both sides of the border, we are left with a tenth of products...” (page 8). Finally, Beck, Kotz, and Zabelina (2020) found that in Belgium, Germany, and the Netherlands, fewer than 10% of products appeared in both pairs of countries. The soda market provides a clear example: despite the dominance of global players like Coke and Pepsi, they operate alongside numerous distinct local products.³

²Other explanations for price divergence include the existence of high fixed costs of production for some goods (Coşar, Grieco, and Tintelnot (2015a); Coşar, Grieco, and Tintelnot (2015b)), price discrimination of consumers (Haskel and Wolf (2001), Dvir and Strasser (2018)), a different currency (Cavallo, Neiman, and Rigobon, 2015), or—within countries—sticky prices (Crucini, Shintani, and Tsuruga (2010), Elberg (2016)).

³See list at [Wikipedia: List of Soft Drinks by Country](#).

As a result of such a variety of local brands, traded goods in two different markets are exposed to very different competitive conditions. While the literature has examined the effect of borders on price convergence, if local goods influence the prices of traded goods in the local market, then the impact of borders may be misestimated. While a traded product is on both sides of the border, local products vary. Many local products compete with traded products in the same store, sometimes meters away on the same shelf. On the other hand, traded products may compete with each other even when they are kilometers apart.⁴ In terms of gravity, it is easy to justify that local brands should affect the price of traded brands.

In Borraz and Zipitria (2022), we showed that local brands create price dispersion regardless of the border. Prices are set by stores based on local competitive conditions and their product mix. The effects of local competition and local products must be distinguished from the role of international borders in the price dispersion of traded products. In other words, border costs on traded products may be eliminated, yet price dispersion persists because local products affect competition differently across locations. The paper extends this model to add a border. This simple setting enables us to disentangle the effects of local competition and fixed costs from those of borders. Why is this important? Any policy objective aimed at achieving price convergence must consider which trade barriers are relevant. Working on reducing trade costs—i.e., “borders”—that impede the movement of traded products may not be an optimal policy if other costs persist. In those cases, price dispersion has a lower bound above zero.

Our paper relates to the literature that has shown ample evidence of the effect of differences in varieties on prices within and between countries. Between countries, Cavallo, Feenstra, and Inklaar (2023) and Beck and Jaravel (2021) demonstrated that differences in varieties affect the cost of living. Within countries, Handbury and Weinstein (2015) showed how the availability of different varieties across cities in the US biases the estimation of price indexes. Auer, Burstein, and Lein (2021) showed that the appreciation shock to the Swiss Franc has distinct impacts depending on the share of imported products. While the paper does not address local products, it shows that the effects of an appreciation vary according to local conditions. In Borraz, Carozzi, González-Pampillón, and Zipitria (2024), we showed that following a demand shock in Montevideo, Uruguay, stores increased the number of varieties offered, leading to a 3% price decrease. While this literature documents how differences in varieties and local competition shape prices, it does not study how discontinuous changes in local product availability at borders mechanically bias standard border regressions, leading competition-driven price differences to be misinterpreted as border effects.

⁴In the empirical analysis, the distance to the border on each side may include stores or households 60 kilometers Messner, Rumler, and Strasser (2024), 80 kilometers Beck, Kotz, and Zabelina (2020), and reach up to 500 kilometers Gopinath, Gourinchas, Hsieh, and Li (2011).

The paper is organized as follows. In the next Section, we introduce the model and show how borders affect price dispersion. Section 3 derives price dispersion in the presence of borders and local goods. Section 4 shows how local products bias the estimations in the standard RDD models used in the literature. It also provides various methods for accounting for the local product effect in the border estimation. Finally, Section 5 shows the paper's main findings.

2 The Border Effect

We model our economy based on Hotelling (1929). This model is well-suited for simultaneously analyzing international and local settings and how the constellation of parameters determines whether products are local or traded in equilibrium. Most papers on price dispersion are empirical, except Gopinath, Gourinchas, Hsieh, and Li (2011). In that paper, they develop a circular city model rather than a linear one. As we introduce several parameters, this more straightforward model helps us understand the underlying economic forces that explain price dispersion. In this section, we establish the model's setup and define the border as an exogenous cost for consumers to buy goods from another country. Additionally, one of the key aspects of our model is to determine the conditions under which the pricing and choice selection of the stores constitute a Nash equilibrium. This section presents the baseline of the effect of the borders on the prices of traded goods. It is necessary to disentangle borders' impact on other effects, such as demand conditions or fixed distribution costs.

We assume a linear city with two stores and a continuum of consumers on a road of distance R . Consumer located at j has utility $U_j = u - t|x_j - x_d| - p_d$, where u is the reservation utility of the consumer located at j and equal for all consumers,⁵ t is the cost per unit of distance for the consumer located at j to move to the store located at d , and p_d is the product's price at the store in d . Stores are located at $d = \{0, R\}$, i.e., at the beginning and end of the road, denoted S_0 and S_R , respectively. For simplicity, assume that variable production costs are zero.⁶ Nevertheless, firms must pay a fixed cost of F for each product sold, which may include expenses related to brand positioning or distribution. Although it may not be relevant here, we will revisit this assumption in Section 3.

To solve this model, we first need to find the indifferent consumer between buying in either store, denoted \hat{x} . For this consumer, we have: $u - t(\hat{x} - 0) - p_0 = u - t(R - \hat{x}) - p_R$. As the consumer \hat{x} is indifferent between buying in either store, those to its right or

⁵If reservation utility differs, then it will difficult to find the indifferent consumer. It is a standard assumption in the literature.

⁶This is a simplifying assumption. Lifting does not change the model's results and makes the model more difficult to interpret.

left are not. They have to travel more to reach any store. Then, all consumers up to \hat{x} will buy at store S_0 , and its demand will be $D_0 = \hat{x}$, while the remaining $R - \hat{x}$ consumers will buy at store S_R , whose demand we denote as D_R . Solving, we have that $\hat{x} = D_0 = \frac{p_R - p_0 + tR}{2t}$. Firms maximize profits, which are $\pi_0 = \left(\frac{p_R - p_0 + tR}{2t}\right)p_0 - F$ and $\pi_R = \left(\frac{p_0 - p_R + tR}{2t}\right)p_R - F$. Maximizing prices, we obtain the reaction functions of each firm: $p_0 = \frac{p_R + tR}{2}$ and $p_R = \frac{p_0 + tR}{2}$. Equilibrium prices are $p_0 = p_R = tR$; therefore, this setting has no price dispersion. Firms have market power, as they are imperfect substitutes for consumers due to travel costs t .

Now, we introduce a cost for the consumer to cross a hypothetical border between stores.⁷ We assume the border is at some place B between both stores at the right of \hat{x} .⁸ As in Gopinath, Gourinchas, Hsieh, and Li (2011), the border implies a fixed cost of β for consumers who cross it to buy from a store on the other side. This may be due to differences in currencies, languages, or traveling costs between countries. From now on, we will refer to stores and countries interchangeably, as each region will have only one store. The utility is now:

$$U_j = u - t|x_j - x_d| - \beta \times \mathbb{1}\{c_j \neq c_d\} - p_d, \quad (1)$$

Where $\mathbb{1}\{c_j \neq c_d\}$ is an indicator function that equals one if the country of the consumer j and the store d differ, and zero otherwise. With a positive border cost, if the border B is to the right of \hat{x} , the indifferent consumer \hat{x} will shift to x^B , depending on the magnitude of the border cost β . We refer to x^B as the indifferent consumer between the two stores if $\beta > 0$. Intuitively, if some consumers in country 0 would buy in country R without the border, they would now prefer to buy in their home country due to the border cost. Figure 1 below depicts the setting. The consumers who shift stores or countries due to border restrictions are represented by the 45-degree dashed lines.

Note that if the border B is at \hat{x} , the border does not play any role as it does not shift demand between locations. The following Lemma shows this result.

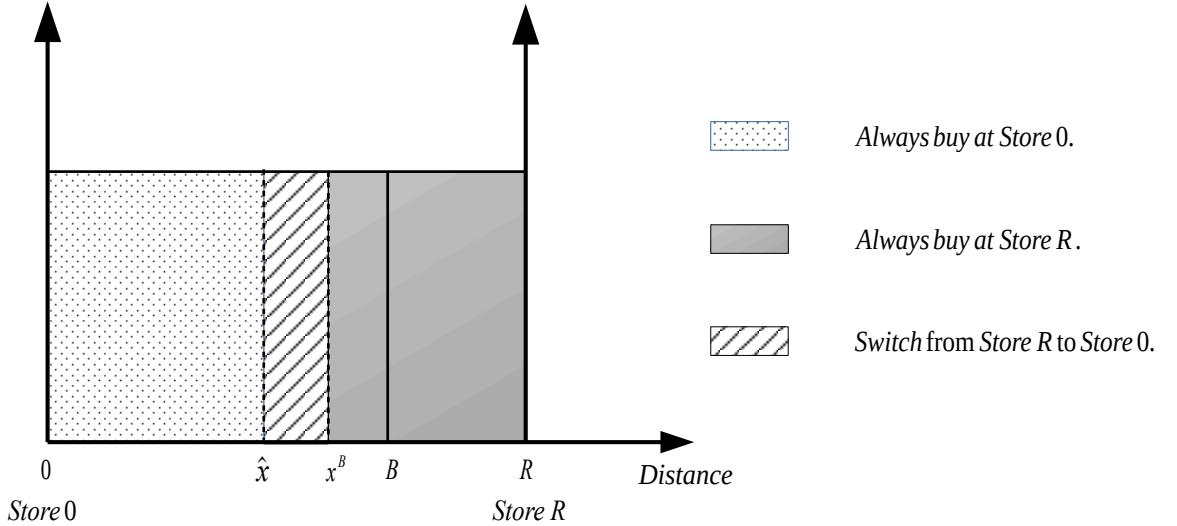
Lemma 1. *If the border is at the same place as the indifferent consumer, then any positive border cost is irrelevant.*

Proof. Assume two consumers, each located at a small ε distance to the border B . As the consumer at the left of B prefers to buy at S_0 , then it must be that $u - t(B - \varepsilon) - p_0 > u - t[R - (B - \varepsilon)] - p_R + \beta$, and solving for $(B - \varepsilon)$ we obtain $(B - \varepsilon) > \frac{p_R - p_0 + tR}{2t} - \frac{\beta}{2t}$. For the consumer located at the right, as she prefers S_R to S_0 , her utility must be such as $u - t(B + \varepsilon) - p_0 + \beta < u - t[R - (B - \varepsilon)] - p_R$, and solving for $(B + \varepsilon)$ we obtain $(B + \varepsilon) < \frac{p_R - p_0 + tR}{2t} + \frac{\beta}{2t}$. As $\varepsilon \rightarrow 0$, we obtain $\frac{p_R - p_0 + tR}{2t} - \frac{\beta}{2t} < B < \frac{p_R - p_0 + tR}{2t} + \frac{\beta}{2t}$. Then, $B = \frac{p_R - p_0 + tR}{2t} = \hat{x}$. \square

⁷A similar assumption is made in Gopinath, Gourinchas, Hsieh, and Li (2011).

⁸The scenario of the border being at the left of \hat{x} is symmetrical to the one derived here.

Figure 1: A Linear City with Border



Notes: Consumers are uniformly distributed along a linear city with two stores located at the extremes. A border at B separates the two countries and imposes a fixed cost on consumers who cross it to purchase from the store in the other country. The dashed lines indicate consumers who switch stores due to this border cost, illustrating how borders can generate discrete shifts in demand even when consumer locations vary smoothly across space.

Assume that $\hat{x} < B$, i.e., the border is to the right of the indifferent consumer. Then, for every positive border cost β , the indifferent consumer should move from \hat{x} through x^B . The new indifferent consumer x^B should be at $\hat{x} + \beta$, as the utility is linear in cost. As a result, $x^B = \hat{x} + \beta = \frac{p_R - p_0 + tR}{2t} + \beta$, where $\beta \in [0, (B - \hat{x})]$. The demand for store S_0 is $D_0^B = \frac{p_R - p_0 + tR + 2t\beta}{2t}$, and profits are $\pi_0^B = D_0^B \times p_0 - F = \left(\frac{p_R - p_0 + tR + 2t\beta}{2t}\right) \times p_0 - F$. Maximizing in price p_0 we obtain the reaction function is $p_0 = \frac{p_R + tR + 2t\beta}{2}$. Demand for store S_R is $D_R^B = \frac{p_0 - p_R + tR - 2t\beta}{2t}$, and profits $\pi_R^B = D_R^B \times p_R - F = \left(\frac{p_0 - p_R + tR - 2t\beta}{2t}\right) \times p_R - F$. Maximizing in price p_R we obtain the reaction function $p_R = \frac{p_0 + tR - 2t\beta}{2}$. The equilibrium prices are $p_0^B = tR + \frac{2t\beta}{3}$ and $p_R^B = tR - \frac{2t\beta}{3}$. Our second Lemma follows.

Lemma 2. *Borders make price convergence less likely.*

Proof. Now $(p_0^B - p_R^B) = \frac{4}{3}t\beta$. □

If x^B is at the left of \hat{x} instead, then the prices p_0^B and p_R^B reverse, but price difference is the same. We now compute the size of the border by substituting p_0^B and p_R^B in $x^B = \hat{x} + \beta = \frac{\beta}{3} + \frac{R}{2}$. As x^B is at the right of \hat{x} , then $x^B \in [\frac{R}{2}, R]$. Substituting we obtain that $\beta \in [0, \frac{3}{2}R]$. If the border value is zero, there is no border; i.e., $x^B = \hat{x}$. As the border cost β increases, x^B moves further to the right until it reaches B . Now,

countries are in autarky, and while β could be as high as infinity, it does not change the result: markets are segmented.

Because borders shift demand, prices change in response to borders, and price convergence becomes more challenging. Our results also predict which store or country increases its market power. Store S_0 gains from having a border, as some consumers who would otherwise travel to another country now have to buy at home. This allows firm S_0 to increase its price from $p_0 = tR$ to $p_0^B = tR + \frac{2t\beta}{3}$. The reverse is true for store S_R , which loses demand due to the border cost and has to decrease its price. Also, the model predicts which consumers will cross the border. Consumers $(B - x^B)$ in country 0 cross the border and buy at store S_R . Nevertheless, the border costs allow store S_0 to capture demand $(x^B - \beta)$ that it would otherwise lose without the border. Lastly, and more importantly for Section 4, we still have traded products even if border costs β reach their maximum. A product to be traded does not depend on border costs but on the fixed costs F , as shown in Section 3 and formally in Appendix A.

We now have a baseline of the actual costs of the border on price dispersion. This analysis has isolated the border cost from other possible explanations for price differences between countries. In the next section, we introduce demand for a second product variety that competes with the local product—i.e., another variety of soda—and analyze how the results change. We then demonstrate how price dispersion changes due to the presence of these local brands.

3 The border with local products

Section 1 demonstrated that countries vary in the types of goods offered to consumers. As a result, traded brands must contend with different local brands in each country, resulting in varying levels of competition. What happens when a traded brand — the one sold in both countries — competes with a local brand? Following Borraz and Zipitria (2022), we investigate this asymmetry between countries by endogenously allowing a local product to be sold exclusively in one store, specifically in one of the countries. In that paper, we demonstrated that prices do not converge when competition conditions differ between stores, even without borders. In that paper, we showed that local brands can arise endogenously without borders. This simple setting enables us to explain how price convergence is influenced when local brands or local varieties of products are available in different markets and how this affects the estimation of the border effect. That is, we will disentangle the impact of borders on competition between traded brands from competition between traded brands and local brands at the country level. In what follows, we will interchange brands and varieties to refer to products that can be traded internationally or locally. We assume that the local and traded products are varieties of the same product market, such as two brands of sugar or soda.

At each point along the line, there are now two types of consumers, differing in their preference for product variety, $z_i = \{z_T, z_L\}$. While the distance dimension is continuous, variety is discrete. Furthermore, a mass $(1 - \lambda)$ of consumers prefer variety z_T , and a mass λ of consumers prefer variety z_L . The model could be represented as two lines of distance R , one on top of the other.⁹ We assume no difference between countries in their preferences for goods, as we want local brands to arise endogenously in a symmetrical setting. Stores could offer varieties s_q , with $q = \{T, L\}$. If a product is sold in both countries, it is the traded brand. If it is sold in only one country, it is considered a local brand, regardless of the demand for the product in other countries. Product T , the traded product, is available at both stores, but product L is a local product available only at the store S_0 . That is, we are imposing brand asymmetry between stores that affects local pricing decisions for products on both sides of the border, consistent with the literature discussed in Section 1. Appendix A shows that this setting is a Nash equilibrium. We maintain our assumption that the fixed cost per brand sold is F and that variable costs are zero.

The consumer utility is now:

$$U_{ji} = u - \theta \times \mathbb{1}\{z_i \neq s_q\} - t|x_j - x_d| - \beta \times \mathbb{1}\{c_j \neq c_d\} - p_{dq},$$

Where j represents the consumer's location and i represents her brand preference, θ is a fixed cost the consumer pays if the brand available (s_q) differs from her preferred one (z_i). The utility function has three costs on consumer utility: one that lowers his utility if his preferred variety is unavailable (θ), one that taxes her for buying in another country (β), and a transport cost t for reaching the store regardless of brand preference.

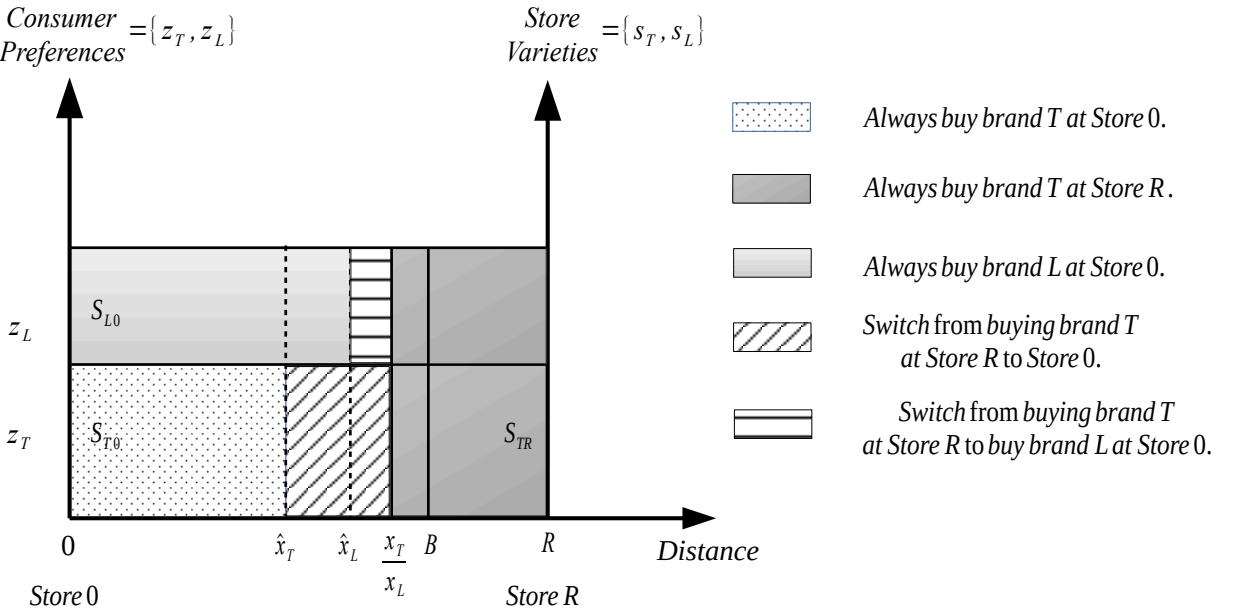
In Borraz and Zipitria (2022), if there is no border (i.e., $\beta = 0$), we found that the price of the traded products is $p_{T0} = tR - \frac{\lambda\theta}{6}$ and $p_{TR} = tR - \frac{\lambda\theta}{3}$, and prices do not converge due to different competitive conditions at the store. Prices are lower than if no local product is available, as competition is higher. Nevertheless, stores are differently affected by the local product. The price difference between both products is $(p_{T0} - p_{TR}) = \frac{\lambda\theta}{6}$. In this setting, there are two indifferent consumers: the "location" consumer ($\widehat{x_T}$, similar to our previous \widehat{x}) who is indifferent between buying the traded product T in either store/country, and the "local" consumer ($\widehat{x_L}$), who is indifferent between buying the L local product at S_0 instead of reaching store S_L and buying the T non-preferred traded variety. We also showed that the indifferent consumer for the local variety ($\widehat{x_L}$) should be to the right of the indifferent consumer for location ($\widehat{x_T}$). The intuition is simple. The indifferent consumer of local products faces two penalties: one for purchasing the non-preferred traded brand and another for switching to another store. Then, compared to consumers who only need to move to another store to buy their preferred variety, a

⁹See Borraz and Zipitria (2022).

larger number of consumers of the local brand will stick to their preferred brand because it is unavailable at the other store.

Assume the border B is to the right of \hat{x}_T and \hat{x}_L . As $x_T \neq x_L$, the effect of the border will differ for the consumers of a local product L than for consumers of the traded product T . Figure 2 below depicts the setting. Again, store S_R loses sales due to the border; some consumers prefer the trade brand T , and others like the local product L . To keep the figure simple, we show only the two border-indifferent consumers, x_T and x_L , at their exact locations, whereas they should be separated.

Figure 2: A linear city with varieties and border



Notes: The figure extends the linear city framework by introducing two product varieties: a traded product T , available in both countries, and a local product L , available only in country 0. Consumers differ in their preferred variety. The border generates two distinct marginal consumers: x_T , who switches stores while continuing to consume the traded product, and x_L , who switches both store and product. This distinction illustrates how local product availability creates a discontinuous change in local competitive conditions at the border, which, in turn, affects the prices of traded goods.

The indifferent "location" consumer x_T , who prefers the traded brand, has utility: $u - t|x_T - 0| - p_{T0} = u - t|x_T - L| - p_{TR} - \beta$. This is the same problem we saw in Section 2, adding the $-\beta$ on the right side of the equality. Then, $x_T = \hat{x} + \beta_T = \frac{p_{TR} - p_{T0} + tR}{2t} + \beta_T$. $\beta_T \in [0, (B - \hat{x})]$ measure the number of consumers of product T that shift from store S_R to store S_0 due to the border cost β , and are represented by the 45-degree dashed lines in Figure 2. The indifferent "local" consumer x_L , the one that switches brands and stores,

has utility: $u - t|x_L - 0| - p_{L0} = u - t|x_L - R| - p_{TR} - \theta - \beta$, then $x_L = \widehat{x}_L + \beta_L = \frac{p_{TR} - p_{L0} + tR + \theta}{2t} + \beta_L$, where $\beta_L \in [0, (B - \widehat{x}_L)]$ and $\beta_L \leq \beta_T$. β_L represents the number of L consumers who shift from buying brand T at store S_R to buying brand L at store S_0 due to the border, as represented by the horizontal lines in Figure 2. Additionally, \widehat{x}_L represents the indifferent consumer between buying product L at store S_0 and product T at store S_R , as established previously, and is similar to \widehat{x} for the traded product.

An additional restriction implies that, given a location, consumers should prefer to buy their preferred brand, ensuring each variety has a positive demand. That is, the consumer at 0 who prefers variety T should buy variety T , while the consumer at 0 who prefers variety L should buy variety L . The condition is $|p_{T0} - p_{L0}| < \theta$, that is, the price difference between brands at Store S_0 not being that large.¹⁰

Store S_0 sells the traded variety T and the local variety L , so its profits are $\pi_0 = p_{T0} \times (1 - \lambda)x_T + p_{L0} \times \lambda x_L - 2F = p_{T0} \times (1 - \lambda)(\frac{p_{TR} - p_{T0} + tR}{2t} + \beta_T) + p_{L0} \times \lambda(\frac{p_{TR} - p_{L0} + tR + \theta}{2t} + \beta_L) - 2F$. Maximizing in p_{T0} and p_{L0} we obtain $p_{T0} = \frac{p_{TR} + Rt + 2t\beta_T}{2}$ and $p_{L0} = \frac{p_{TR} + tT + \theta + 2t\beta_L}{2}$.

Store S_R sells only the traded variety T to both consumers, so its profits are $\pi_R = p_{TR} \times [(1 - \lambda) \times (R - x_T) + \lambda \times (R - x_L)] - F$ $= p_{TR} \times \left[(1 - \lambda)(R - (\frac{p_{TR} - p_{T0} + tR}{2t} + \beta_T)) + \lambda(R - (\frac{p_{TR} - p_{L0} + tR + \theta}{2t} + \beta_L)) \right] - F$. Maximizing in p_{TR} we obtain $p_{TR} = \frac{(1 - \lambda)p_{T0} + \lambda p_{L0} + Rt - \lambda\theta - 2t[\beta_T + \lambda(\beta_L - \beta_T)]}{2}$.

Substituting reaction functions, we obtain:

$$p_{T0}^{BV} = tR - \frac{\lambda\theta}{6} + \frac{t[2\beta_T + \lambda(\beta_T - \beta_L)]}{3}, \quad (2)$$

$$p_{TR}^{BV} = tR - \frac{\lambda\theta}{3} - \frac{2t[\beta_T - \lambda(\beta_T - \beta_L)]}{3}. \quad (3)$$

For completion, $p_{L0}^{BV} = tR + \frac{(3-\lambda)\theta}{6} + \frac{t[(3-\lambda)\beta_L - (1-\lambda)\beta_T]}{3}$.¹¹ We now compute the size of the border by substituting prices into $x_T = \widehat{x} + \beta_T = \frac{p_{TR} - p_{T0} + tR}{2t} + \beta_T$ and $x_L = (R - \widehat{x}) + \frac{\theta}{2t} + \beta_L = \frac{p_{TR} - p_{L0} + tR + \theta}{2t} + \beta_L$. The equation for x_T has a solution $x_T = \frac{R}{2} - \frac{\lambda\theta}{12t} + \left(\frac{1}{3} + \frac{\lambda}{6}\right)\beta_T - \frac{\lambda}{6}\beta_L$, while the equation for x_L has a solution $x_L = \frac{R}{2} + \left(\frac{1}{2} - \frac{\lambda}{6}\right)\beta_L + \left(\frac{\lambda-1}{6}\right)\beta_T + \left(\frac{\theta}{4t} - \frac{\lambda\theta}{12t}\right)$. As $x_T \in \left(\frac{R}{2}, R\right)$ and $x_L \in \left(\frac{R}{2} + \frac{\theta}{2t}, R\right)$, we obtain $\beta_T \in \left(0, \frac{3R}{2}\right)$, and $\beta_L \in \left(0, \frac{3R}{2} - \frac{\theta}{2t}\right)$. Note that the border for the local product is always lower than that of the traded product. This is due to θ penalizing brand substitution and making the border less relevant for the local product.

The price difference is now:

¹⁰The consumer at 0 that prefer brand T has utility $u - t(0 - 0) - p_{T0} > u - t(0 - 0) - p_{L0} - \theta \implies (p_{T0} - p_{L0}) < \theta$. On the other hand, a consumer at 0 that prefer brand L has utility $u - t(0 - 0) - p_{T0} - \theta < u - t(0 - 0) - p_{L0} \implies (p_{L0} - p_{T0}) < \theta$.

¹¹Subtracting $p_{T0}^{BV} - p_{L0}^{BV} = \theta/2$ which meets the restriction $|p_{T0} - p_{L0}| < \theta$.

$$(p_{T0}^{BV} - p_{TR}^{BV}) = \underbrace{\frac{4-\lambda}{3}t\beta_T}_{(I)} + \underbrace{\frac{\lambda\theta}{6}}_{(II)} + \underbrace{\frac{\lambda}{6}t\beta_L}_{(III)} \quad (4)$$

The next proposition shows the main result of the analysis.

Proposition 1. *The availability of local brands affects the estimation of the border effect.*

Proof. In Equation 4. □

The term in (I) in Equation 4 is the adjusted border estimation. Previously, we showed in Lemma 2 that the border coefficient was $\frac{4}{3}t\beta$ higher than the term in (I). That is, the existence of local brands decreases the relevance of borders. As some consumers can switch to local brands within countries, less arbitrage is required between countries. It simply reflects differences in countries' preferences for traded goods. In our model, λ is the share of consumers who prefer the local product over the traded product. As some consumers in country 0 have access to the local brand, the impact of the border becomes less significant. If $\lambda = 0$, all consumers prefer the traded brand; then we are back to Lemma 2.

The term under (II) refers to the effect of substituting local brands, which reduces the market power of the traded brand in the local market. Due to competition from local brands, the traded brand at location 0 needs to adjust its prices downward. As shown in Borraz and Zipitria (2022), this effect is purely competitive and unrelated to the border. This is the effect of local competition that decreases market power at the country level: consumers of the traded product can switch to the local product. As λ —the share of consumers who prefer the local product—or θ —the cost of switching varieties—increases, the more significant the price difference of the traded product becomes.

The term under (III) reflects how easily consumers who prefer the local brand in country 0 can switch to the traded product *in country R*. Similar to term (I), it includes the transport cost t , and the border costs β_L , which are incurred by those who prefer local brands and switch to a different product or country. That is, the availability of a local brand on one side of the border affects the traded product on that side and on the *other side*. Consumers of the local brand have the same outside option as consumers of the traded brand: to cross the border and buy the traded product in another country (in our model, at L). This term is increasing in λ , t , and the border cost β_L .

Equation 4 decomposes the effect of border and local competition on price dispersion. The terms (I) and (III) are due to the border, but the term (II) is not. It could be debated whether the term in (III) is purely a border effect, given that the local brands' effect mediates it, although it cannot be disentangled.

Appendix A shows that this result constitutes a Nash equilibrium. The results depend on several parameters; however, general conditions can be summarized in Table 1. Also, in the Appendix A, we show that the key for the equilibrium is that fixed costs F should be moderate, neither too high to Store S_0 dropping the local brand, nor too low to Store S_R also incorporating a local brand—i.e., all brands are traded—. The thresholds will be functions of the parameters of the model:

$$F(R, t, \theta, \lambda, \beta, \beta_T, \beta_L) \leq F \leq \bar{F}(R, t, \theta, \lambda, \beta, \beta_T, \beta_L)$$

Nevertheless, the conditions for being a traded good are entirely based on F , not β 's. As we demonstrated in Section 2, traded products can still exist even when $\beta = \frac{3}{2}L$. In those cases, each country sells the traded brand to its local consumers. Border costs translate not into local or traded products but into how many consumers buy from each store.

Before turning to the empirical implications, it is useful to briefly clarify the role of the key assumptions underlying the model. The fixed cost of crossing the border is essential to generate discrete differences in product availability across locations, which in turn give rise to discontinuous changes in local competitive conditions. Without such fixed costs, product availability would vary smoothly across space, and the source of bias highlighted in the paper would vanish.

Similarly, the assumption that local and traded products are imperfect substitutes is critical for prices of traded goods to respond to changes in local competition. If local and traded goods were perfect substitutes, variation in local product availability would not affect the equilibrium prices of traded goods, thereby eliminating the mechanism by which local competition contaminates border estimates.

The following Section translates our theoretical model and the results under Equation 4 into a standard regression discontinuity design. We discuss the exogeneity assumption for the border and its relation to empirical evidence on local brands.

4 Econometric Implications

4.1 Border Regressions and Local Products

Most papers' empirical analyses used nonparametric sharp regression discontinuity designs to estimate the effect of borders on traded products. At a distance small enough on both sides of the border, everything should be equal except the price of the traded goods. Then, the border causes prices to diverge, and the effect can be measured. A fundamental requirement of RDD is that all variables, other than the treatment, exhibit continuity at the cutoff. However, the data in all the papers reviewed in section 1 showed that this is not the case: most products are local, that is, are on one side or the other,

Table 1: Sufficient parameter conditions for equilibrium existence and positivity

Parameter	Desired Condition	Rationale
Market size (R)	Sufficiently large	Scales quadratic and linear profit components; increases the value of variety and market segmentation.
Local preference share (λ)	Balanced (e.g., $0.4 < \lambda < 0.6$)	Ensures balanced market access and profit gains from both consumer segments.
Transport cost (t)	Intermediate	Very low t weakens market power, while very high t limits market access. Differentiation incentives are strongest at intermediate levels.
Brand switching cost (θ)	Intermediate	Supports product segmentation without excessive exclusion, avoiding profit erosion from prohibitively high switching costs.
Benchmark border cost (β)	Moderate to high	Increases disutility in the benchmark model, lowering benchmark profits and enhancing the relative gains from introducing local product competition.
Traded product border cost (β_T)	Moderate to high (within $(0, \frac{3R}{2})$)	Amplifies differentiation and interaction effects in the richer model with local varieties.
Local product border cost (β_L)	Close to β_T (within $(0, \frac{3R}{2} - \frac{\theta}{2t})$)	Strengthens brand loyalty and pricing power by reinforcing the interaction between border frictions and local competition.

Notes: The table reports sufficient (but not necessary) parameter conditions ensuring the existence of an interior Nash equilibrium with positive prices and quantities. The conditions are intended to illustrate economically plausible ranges consistent with the model rather than knife-edge restrictions. All parameters are defined in Section 3.

but not on both. Assume the impact of the border on prices is measured according to the following equation:

$$p_i^h = \alpha_i + \beta B + \theta D^h + \psi D^h B + \gamma^h X^h + \varepsilon_i^h, \quad (5)$$

Where i is for good, h is the unit of analysis (store as in Gopinath, Gourinchas, Hsieh, and Li (2011), or household as in Beck, Kotz, and Zabelina (2020)) B is a dummy variable that takes the value one if the store or household is not in the reference country, say in Canada vs. being in the US, D^h is the distance of the unit of analysis—store, household—

to the border, and X^h are observable characteristics of the unit of analysis—income, age, size of the store, etc.—. Note the similarity between the paper’s empirical equation and our theoretical model and how the model can adopt an empirical estimation strategy. The parameter of interest is β , and the identifying assumption is that the error term ε_i^h is uncorrelated with the border dummy variable B , i.e., $E[\varepsilon_i^h|B] = 0$.

In Section 3, we showed that the prices of traded products are affected by local products. We incorporate local products into Equation 5 by adding two terms: X_{ij}^{h-} for product i at unit h at the left of the border $h-$, and X_{ij}^h for product i at unit h at the right of the border h , the convention for the reference country, and where j refers to local products in the same product category of product i . As shown in Section 3, the existence of local products is independent of border costs and is determined by fixed costs. As a result, they are uncorrelated with the border B .

In empirical applications, the objects X_{ij}^h and X_{ij}^{h-} should be interpreted as observable proxies for local product competition. Examples include measures of local product density, store-level variety, the presence or absence of specific product categories, or indicators of product availability constructed from scanner data or retail censuses. The key requirement is that these variables capture local competitive conditions that may change discontinuously at the border and that directly affect pricing.

Noting that X_{ij}^{h-} and X_{ij}^h are each one only on one side of the border, they can be written as $X_{ij}^{h-}(1 - B)$ and $X_{ij}^h B$, we add both terms to Equation 5 and rewrite it as:

$$p_i^h = \alpha_i + [\beta + (\delta_1 X_{ij}^h - \delta_2 X_{ij}^{h-})] B + \delta_2 X_{ij}^{h-} \theta D^h + \psi D^h B + \gamma^h X^h + u_i^h, \quad (6)$$

Two conclusions can be reached from Equations 5 and 6. First, ε_i^h in Equation 5 is correlated with B due to the omitted variable bias. Formally, $\varepsilon_i^h = (\delta_1 X_{ij}^h - \delta_2 X_{ij}^{h-}) B + u_i^h$, which is correlated with the border. Secondly, we can rearrange Equation 6 to isolate the effect of local varieties from the estimation of the border, as with the interaction of the distance parameter:

$$p_i^h = \alpha_i + \beta \underbrace{B}_{(I)} + \delta_2 \underbrace{X_{ij}^{h-}}_{(II)} + (\delta_1 - \delta_2) \underbrace{(X_{ij}^h - X_{ij}^{h-}) B}_{(III)} + \theta D^h + \psi D^h B + \gamma^h X^h + u_i^h, \quad (7)$$

The underset numbers mirror those in Equation 4. Although Equation 4 is in differences and Equation 7 is in levels, as the terms (I) to (III) are turned on and off depending on whether we are on the right or left of the border, it mimics an equation in differences. Omitting control for local brand bias can lead to biased estimates of the border effect in terms (II) and (III). Both are required to estimate the border’s impact on price dispersion.

No paper has previously addressed the issue of price dispersion across countries due to local products. Within countries, excluding the border effect, we estimate that a one-

product difference between two stores accounts for up to 0.8% of price differences. The counting of products — or UPCs — between locations has also been used by (Cavallo, Feenstra, and Inklaar, 2023) to show that differences in varieties with the US are the primary source of the increased cost of living. While this is a first approximation, the measure will assign the same value to very different competitive settings: a product that is hardly sold will be valued the same as a high-selling brand, and thus will have the same effect on price dispersion.

Alternatively, in Borraz and Zipitria (2024), we analyze both short- and long-run price dispersion and use an entropy index to measure product differences within a given product category across markets. In this setting, an entropy index measures the sparsity of product offerings across markets and increases as the number of countries offering different varieties increases, especially when local brands are prevalent. Additionally, since the border variable is a dummy variable, there will be no collinearity between the two variables.

Lastly, Auer, Burstein, and Lein (2021) proposed a method to correct the impact of traded products on the exchange rate pass-through in Switzerland. They provide shares of traded and local products by category, based on traded product volumes, to control for the impact of the Swiss Franc's appreciation in 2015. This approach could also be used to control for local products when estimating the effect of borders on prices and to isolate their impact.

The corrections will depend on the information available. For example, Auer, Burstein, and Lein (2021) has information on purchases but not on other products not consumed at the store. This limits the ability to control for actual restrictions on consumer purchase options and store pricing decisions. On the other hand, Borraz and Zipitria (2022) provide information on prices for products sold at the same store, but not on actual purchases. While this information is useful for better controlling local brands, when combined with purchase data, it will be challenging to assess the relevance of each product (θ).

Taken together, Equations (5)–(7) suggest a simple practical implication for applied work. When local competitive conditions change discontinuously at the border, standard border regressions should explicitly incorporate proxies for local product competition on each side, such as measures of product availability, store-level variety, or local product density within narrowly defined categories. When such information is unavailable, estimated border coefficients should be interpreted with caution, as they may capture not only border frictions but also discontinuous changes in local competition. The Monte Carlo exercise that follows illustrates the quantitative relevance of this mechanism.

4.2 Monte Carlo Illustration of Omitted-Variable Bias¹²

To provide a transparent, quantitative illustration of the bias mechanism discussed previously, we conduct a simple Monte Carlo exercise in which local product competition changes discontinuously at a border. The simulation abstracts from fixed costs, which in the model govern product entry and the existence of local varieties. The Monte Carlo exercise conditions on a given competitive structure and is designed to isolate the pricing and econometric implications of discontinuous local competition at the border. As a result, fixed costs play no role in the simulation's data-generating process.

In each replication, we draw locations uniformly from a neighborhood of the border and define a treatment indicator for locations on the right side of the border. Prices are generated according to

$$p_i = \alpha + \beta Right_i + \theta LocalComp_i + g(x_i) + \varepsilon_i, \quad (8)$$

where β is the true border effect, $LocalComp_i$ captures local product competition, $g(x_i)$ is a smooth function of distance to the border, and ε_i is an i.i.d. disturbance term. Local competition exhibits a discrete jump at the border and directly affects prices, generating omitted-variable bias when it is excluded from the regression.

In the simulation, local competitive conditions are allowed to have a quantitatively relevant effect on prices, potentially larger than the direct border effect itself. The objective is not to calibrate magnitudes, but to illustrate how omitting such competition can mechanically lead to substantial overestimation of border effects.

For each replication, we estimate two specifications within the same bandwidth: (i) a misspecified regression that omits $LocalComp_i$, and (ii) a correctly specified regression that explicitly controls for local competition. We run 10,000 Monte Carlo replications with 5,000 observations per replication.

Table 2 reports the mean, standard deviation, bias, and root mean squared error (RMSE) of the estimated border coefficient across replications. When local competition is omitted, the estimated border effect is upward-biased: the mean estimate is approximately 0.40, while the true parameter is $\beta = 0.10$. In contrast, once local competition is controlled for, the estimator becomes essentially unbiased, and its RMSE falls by more than an order of magnitude.

Figure 3 plots kernel densities of the estimated border coefficient across replications. The distribution from the misspecified regression is shifted markedly to the right of the true parameter, while the correctly specified estimator is tightly centered around β . Together, the table and the figure provide a clear quantitative illustration of how discontinuous variation in local competitive conditions contaminates standard border estimates if not properly accounted for.

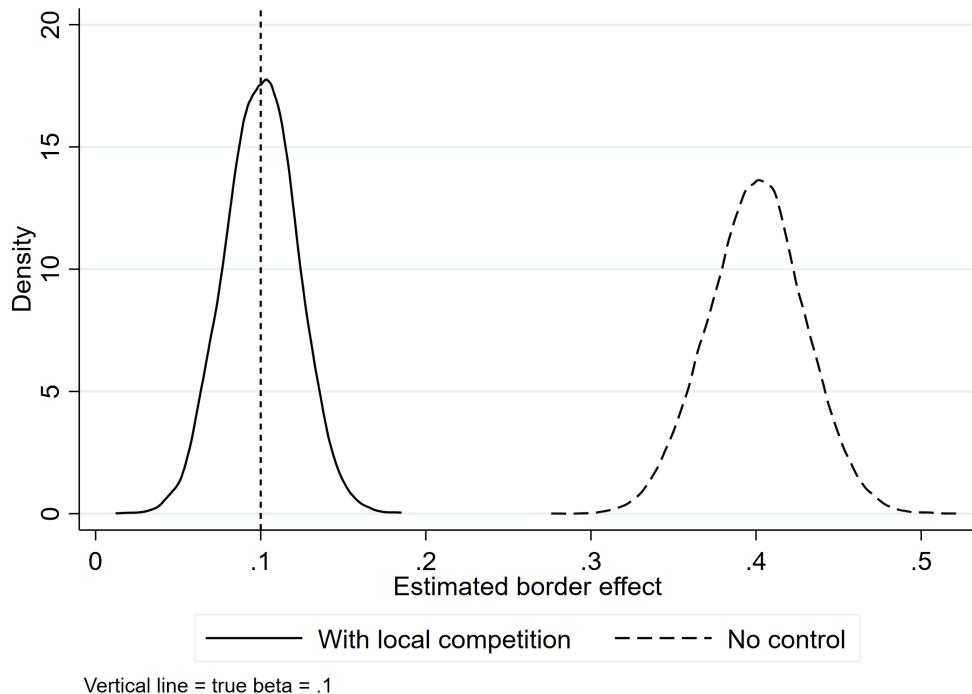
¹²We thank a referee for this useful suggestion.

Table 2: Monte Carlo performance of the border effect estimator under omitted local competition

Specification	Mean ($\hat{\beta}$)	SD ($\hat{\beta}$)	Bias	RMSE
No control	0.4001	0.0293	0.3001	0.3015
With local comp.	0.1002	0.0219	0.0002	0.0219

Notes: Monte Carlo results based on 10,000 replications with 5,000 observations per replication. The true border effect is $\beta = 0.10$. The first specification omits local product competition, while the second controls for local competition. Bias is defined as the mean deviation from the true parameter and RMSE is the root mean squared error.

Figure 3: Kernel densities of the estimated border effect across Monte Carlo replications



Notes: The solid line corresponds to the regression controlling for local competition, while the dashed line corresponds to the misspecified regression omitting local competition. The vertical line denotes the true parameter $\beta = 0.10$. The parameter θ is set to 0.50. The figure illustrates the substantial upward bias in the estimated border effect when local competition is omitted.

5 Conclusions

The paper aims to clarify the role of borders, their impact on prices, and their effect on product entry decisions. We define two product types: traded products, sold in more than one country, and local products, sold only in one country. Within-country fixed costs explain whether products are traded or sold in both countries. After characterizing the isolated effect of borders on price dispersion, we show how the presence of local products affects the estimation of the border effect. We decompose price dispersion into three components: an adjusted border effect for traded products, the impact of local products on the prices of traded products, and a border-related component associated with local products. This decomposition highlights how standard border estimations differ from the benchmark once local competition is taken into account.

A Monte Carlo exercise further quantifies the magnitude of this bias in a controlled setting, showing that omitting local competitive conditions can lead to substantial overestimation of border effects, while explicitly controlling for them restores near-unbiased estimation.

We then show how regression discontinuity designs are affected by local products that are not carried forward at the cutoff, generating bias in the estimation of border effects. Finally, we discuss empirical measures proposed in the literature that can be adapted to account for local competition and provide more reliable estimates of border effects. Overall, standard border regressions may overestimate the impact of borders on price dispersion when local competitive conditions differ across countries and are not appropriately controlled for. In such cases, differences in competition can explain a non-negligible share of the estimated border effect.

More broadly, the paper emphasizes that border regressions are informative only to the extent that local competitive conditions are smooth at the border or explicitly controlled for. Recognizing and measuring such conditions is therefore central to interpreting border effects in empirical work.

References

ANDERSON, J., AND E. VAN WINCOOP (2001): “Borders, Trade, and Welfare,” *Brookings Trade Forum*.

——— (2003): “Gravity with Gravitas: A Solution to the Border Puzzle,” *American Economic Review*, 93(1), 170–192.

——— (2004): “Trade Costs,” *Journal of Economic Literature*, XLII, 691–751.

ATKIN, D., AND D. DONALDSON (2015): “Who’s Getting Globalized? The Size and Implications of Intra-national Trade Costs,” Working Paper 21439, National Bureau of Economic Research.

AUER, R., A. BURSTEIN, AND S. M. LEIN (2021): “Exchange Rates and Prices: Evidence from the 2015 Swiss Franc Appreciation,” *American Economic Review*, 111(2), 652–686.

BECK, G., AND X. JARAVEL (2021): “Prices and Global Inequality: New Evidence from Worldwide Scanner Data,” mimeo.

BECK, G. W., H.-H. KOTZ, AND N. ZABELINA (2020): “Price gaps at the border: Evidence from multi-country household scanner data,” *Journal of International Economics*, 127, 103368.

BORRAZ, F., F. CAROZZI, N. GONZÁLEZ-PAMPILLÓN, AND L. ZIPITRÍA (2024): “Local Retail Prices, Product Variety, and Neighborhood Change,” *American Economic Journal: Economic Policy*, 16(1), 1–33.

BORRAZ, F., AND L. ZIPITRÍA (2022): “Varieties as a Source of Law of One Price Deviations,” *International Economics*, 172, 1–14.

——— (2024): “Assessing Long-Run Price Convergence in Retailing,” Discussion Paper Series 1424, Global Labor Organization.

BRODA, C., AND D. E. WEINSTEIN (2008): “Understanding International Price Differences Using Barcode Data,” *NBER Working Paper 14017*.

BRONNENBERG, B. J., J.-P. H. DUBE, AND M. GENTZKOW (2012): “The Evolution of Brand Preferences: Evidence from Consumer Migration,” *American Economic Review*, 102(6), 2472–2508.

BURSTEIN, A., S. LEIN, AND J. VOGEL (2024): “Cross-border shopping: Evidence and welfare implications for Switzerland,” *Journal of International Economics*, 152, 104015.

CAVALLO, A., R. C. FEENSTRA, AND R. INKLAAR (2023): “Product Variety, the Cost of Living, and Welfare across Countries,” *American Economic Journal: Macroeconomics*, 15(4), 40–66.

CAVALLO, A., B. NEIMAN, AND R. RIGOBON (2015): “The Price Impact of Joining a Currency Union: Evidence from Latvia,” *IMF Economic Review*, 63(2), 281–297.

COŞAR, A. K., P. L. GRIECO, AND F. TINTELNOT (2015a): “Bias in estimating border- and distance-related trade costs: Insights from an oligopoly model,” *Economics Letters*, 126, 147–149.

——— (2015b): “Borders, Geography, and Oligopoly: Evidence from the Wind Turbine Industry,” *The Review of Economics and Statistics*, 97(3), 623–637.

CRUCINI, M. J., M. SHINTANI, AND T. TSURUGA (2010): “The Law of One Price without the Border: The Role of Distance versus Sticky Prices,” *The Economic Journal*, 120(544), 462–480.

DVIR, E., AND G. STRASSER (2018): “Does marketing widen borders? Cross-country price dispersion in the European car market,” *Journal of International Economics*, 112, 134 – 149.

ELBERG, A. (2016): “Sticky prices and deviations from the Law of One Price: Evidence from Mexican micro-price data,” *Journal of International Economics*, 98(C), 191–203.

ENGEL, C., AND J. H. ROGERS (1996): “How Wide is the Border?,” *American Economic Review*, 86(5), 1112–1125.

GOPINATH, G., P.-O. GOURINCHAS, C.-T. HSIEH, AND N. LI (2011): “International Prices, Costs, and Markup Differences,” *American Economic Review*, 101(6), 2450–86.

GORODNICHENKO, Y., AND L. TESAR (2009): “Border Effect or Country Effect? Seattle may not be so far from Vancouver after all,” *American Economic Journal – Macroeconomics*, 1(1), 219–241.

HANDBURY, J., AND D. WEINSTEIN (2015): “Good Prices and Availability in Cities,” *The Review of Economic Studies*, 82, 258–296.

HASKEL, J., AND H. WOLF (2001): “The Law of One Price - A Case Study,” *Scandinavian Journal of Economics*, 103(4), 545–558.

HEAD, K., AND T. MAYER (2014): “Gravity Equations: Workhorse, Toolkit, and Cookbook,” in *Handbook of International Economics*, ed. by G. Gopinath, . Helpman, and K. Rogoff, vol. 4 of *Handbook of International Economics*, chap. 0, pp. 131–195. Elsevier.

HOTELLING, H. (1929): “Stability in Competition,” *The Economic Journal*, 39(153), 41–57.

MCCALLUM, J. (1995): “National Borders Matter: Canada-U.S. Regional Trade Patterns,” *The American Economic Review*, 85(3), 615–623.

MESSNER, T., F. RUMLER, AND G. STRASSER (2024): “Cross-country price dispersion: Retail network or national border?,” *Journal of International Economics*, 152, 103996.

PARSLEY, D. C., AND S.-J. WEI (2001): “Explaining The Border Effect: The Role of Exchange Rate Variability, Shipping Costs, and Geography,” *Journal of International Economics*, 55(1), 87–105.

A Appendix: Nash Equilibrium in Section 3

In Section 3, we found that the store at 0 sells two products, one local (B) and one traded (B). In contrast, the Store S_L sells only the traded product A , and vice versa. There are several alternative scenarios, of which we will consider just two. First, the store S_0 could withdraw the local product, and only the traded brand A is sold in both stores. This alternative scenario is interesting because it demonstrates that firms benefit from selling local brands. Second, Store S_L also introduces a local brand, creating a symmetrical scenario between the two stores. A less interesting scenario is that both stores sold only local products, they specialize, and the model has no traded brands.

The key to showing the results is the fixed costs F that stores must pay to sell the products. If F is too high, selling two products will be unprofitable; if F is too low, stores will add infinite products. As a result, F will be bound below and above.

A.1 Store 0 Withdraw the Local Product

In Section 3 we calculate the prices of the products: $p_{T0}^{BV} = tR - \frac{\lambda\theta}{6} + \frac{t[2\beta_T + \lambda(\beta_T - \beta_L)]}{3}$, $p_{TR}^{BV} = tR - \frac{\lambda\theta}{3} - \frac{2t[\beta_T - \lambda(\beta_T - \beta_L)]}{3}$, and $p_{L0}^{bv} = tR + \frac{(3-\lambda)\theta}{6} + \frac{t[(3-\lambda)\beta_L - (1-\lambda)\beta_T]}{3}$. Benefits are $\pi_0 = p_{T0} \times (1 - \lambda)(\frac{p_{TR} - p_{T0} + tR}{2t} + \beta_T) + p_{L0} \times \lambda(\frac{p_{TR} - p_{L0} + tR + \theta}{2t} + \beta_L) - 2F$ and $\pi_R = p_{TR} \times \left[(1 - \lambda)(R - (\frac{p_{TR} - p_{T0} + tR}{2t} + \beta_T)) + \lambda(R - (\frac{p_{TR} - p_{L0} + tR + \theta}{2t} + \beta_L))\right] - F$.

Solving the system, we have:

$$\begin{aligned} \pi_0 = & \frac{1}{72t} \left[-5\lambda^2\theta^2 + 9\lambda\theta^2 \right. \\ & + 4t \left(9R^2t + 12Rt\beta_L\lambda - 12Rt\beta_T\lambda + 12Rt\beta_T + 6R\lambda\theta \right. \\ & \left. - 5\lambda^2t\beta_L^2 + 9\lambda t\beta_L^2 + 10\lambda^2t\beta_L\beta_T - 10\lambda t\beta_L\beta_T \right. \\ & \left. - 5\lambda^2\theta\beta_L + 9\lambda\theta\beta_L - 5\lambda^2t\beta_T^2 + \lambda t\beta_T^2 + 4t\beta_T^2 \right. \\ & \left. + 5\lambda^2\theta\beta_T - 5\lambda\theta\beta_T \right] - 2F \end{aligned} \quad (9)$$

$$\begin{aligned} \pi_R = & \frac{1}{18t} \left[\lambda^2\theta^2 \right. \\ & + t \left(9R^2t - 12Rt\beta_L\lambda + 12Rt\beta_T\lambda - 12Rt\beta_T - 6R\lambda\theta \right. \\ & \left. + 4\lambda^2t\beta_L^2 - 8\lambda^2t\beta_L\beta_T + 8\lambda t\beta_L\beta_T + 4\lambda^2\theta\beta_L \right. \\ & \left. + 4\lambda^2t\beta_T^2 - 8\lambda t\beta_T^2 + 4t\beta_T^2 - 4\lambda^2\theta\beta_T + 4\lambda\theta\beta_T \right] - F \end{aligned} \quad (10)$$

In Section 2, we calculate the equilibrium prices when stores sell the international brand, and there are borders $p_0^b = tL + \frac{2t\beta}{3}$ and $p_L^b = tL - \frac{2t\beta}{3}$. Substituting into profits $\pi_0^b = \left(\frac{p_L - p_0 + tL + 2t\beta}{2t}\right) \times p_0 - F$ and $\pi_L^b = \left(\frac{p_0 - p_L + tL - 2t\beta}{2t}\right) \times p_L - F$, we obtain the profits when there is only one traded brand:

$$\begin{aligned}\pi_0^B &= \frac{tR^2}{2} - \frac{2t\beta^2}{9} - F \\ \pi_R^B &= \frac{tR^2}{2} - \frac{2tR\beta}{3} + \frac{2t\beta^2}{9} - F\end{aligned}$$

Given that all parameters are positive, $\lambda \in (0, 1)$, and $\beta_T > \beta_L$, we need to prove the parametric conditions under which $\pi_0 > \pi_0^B$ and $\pi_R > \pi_R^B$. The exact algebraic results are:

$$\begin{aligned}\pi_0 - \pi_0^B &= -F + \frac{2}{3}Rt(\beta_L\lambda - \beta_T\lambda + \beta_T) + \frac{1}{3}R\lambda\theta + \frac{2t\beta^2}{9} \\ &\quad + \frac{t}{18}(-5\lambda^2\beta_L^2 + 9\lambda\beta_L^2 + 10\lambda^2\beta_L\beta_T - 10\lambda\beta_L\beta_T - 5\lambda^2\beta_T^2 + \lambda\beta_T^2 + 4\beta_T^2) \quad (11) \\ &\quad + \frac{1}{18}(-5\lambda^2\beta_L\theta + 9\lambda\beta_L\theta + 5\lambda^2\beta_T\theta - 5\lambda\beta_T\theta) + \frac{1}{72t}(-5\lambda^2\theta^2 + 9\lambda\theta^2)\end{aligned}$$

$$\begin{aligned}\pi_R - \pi_R^B &= \frac{1}{18t} \left[\lambda^2\theta^2 + t \left(18F - 9R^2t + 12Rt\beta - 4t\beta^2 \right. \right. \\ &\quad \left. \left. - 18F + 9R^2t - 12Rt\beta_L\lambda + 12Rt\beta_T\lambda - 12Rt\beta_T - 6R\lambda\theta \right. \right. \\ &\quad \left. \left. + 4\lambda^2t\beta_L^2 - 8\lambda^2t\beta_L\beta_T + 8\lambda t\beta_L\beta_T + 4\lambda^2\theta\beta_L \right. \right. \\ &\quad \left. \left. + 4\lambda^2t\beta_T^2 - 8\lambda t\beta_T^2 + 4t\beta_T^2 - 4\lambda^2\theta\beta_T + 4\lambda\theta\beta_T \right) \right] \quad (12)\end{aligned}$$

From equation $\pi_0 - \pi_0^B$ we obtain the condition on F for that expression to be positive:

$$\begin{aligned}F < \frac{1}{72t} \left[48R\beta_L\lambda t^2 - 48R\beta_T\lambda t^2 + 48R\beta_T t^2 + 24R\lambda t\theta + 16t^2\beta^2 \right. \\ &\quad \left. - 20t^2\lambda^2\beta_L^2 + 36t^2\lambda\beta_L^2 + 40t^2\lambda^2\beta_L\beta_T - 40t^2\lambda\beta_L\beta_T \right. \\ &\quad \left. - 20t\lambda^2\beta_L\theta + 36t\lambda\beta_L\theta - 20t^2\lambda^2\beta_T^2 + 4t^2\lambda\beta_T^2 + 16t^2\beta_T^2 \right. \\ &\quad \left. + 20t\lambda^2\beta_T\theta - 20t\lambda\beta_T\theta - 5\lambda^2\theta^2 + 9\lambda\theta^2 \right] \quad (13)\end{aligned}$$

The general parameter conditions for both expressions to be positive were shown in Table 1 in Section 3.

A.2 Store L incorporates the Local Product (both products are traded)

The alternative to Store 0, with withdrawing the local brand, is to Store L to incorporate one. Although we maintain their names, both stores sell brands T and L . This is the same analysis as in Section 2, but with two brands. While now there are four demands and prices, the general result does not change, as both problems are symmetrical. Remember that the condition $|p_T - p_L| < \theta$ guarantees that each product will have (all) demand; i.e., consumers buy their preferred brand in equilibrium or one product is out of the market. The only difference is that both benefits have two fixed costs.

Solving the model with the data in Section 2, we obtain $D_0 = \frac{R}{2} + \frac{\beta}{3}$ and $D_R = \frac{R}{2} - \frac{\beta}{3}$. Then, profits are (subtracting F for both products): $\pi_0^{2B} = \left(\frac{R}{2} + \frac{\beta}{3}\right) \times \left(tR + \frac{2t\beta}{3}\right) - 2F$ and $\pi_R^{2B} = \left(\frac{R}{2} - \frac{\beta}{3}\right) \times \left(tR - \frac{2t\beta}{3}\right) - 2F$.

For store S_0 , fixed costs are always duplicated, but for store S_R , they are not. So we have one cutoff for $\pi_R - \pi_R^{2B} > 0$ that is that F should be high enough:

$$F > \frac{1}{18t} \left[12R\beta t^2 - 12R\beta_L \lambda t^2 + 12R\beta_T \lambda t^2 - 12R\beta_T t^2 - 6R\lambda t\theta - 4\beta^2 t^2 + 4\beta_L^2 \lambda^2 t^2 - 8\beta_L \beta_T \lambda^2 t^2 + 8\beta_L \beta_T \lambda t^2 + 4\beta_L \lambda^2 t\theta + 4\beta_T^2 \lambda^2 t^2 - 8\beta_T^2 \lambda t^2 + 4\beta_T^2 t^2 - 4\beta_T \lambda^2 t\theta + 4\beta_T \lambda t\theta + \lambda^2 \theta^2 \right] \quad (14)$$

The inequality $\pi_0 - \pi_0^{2B} > 0$ is fulfilled for the parameter conditions, as the next Theorem shows.

Theorem. Let $t > 0$, $R > 0$, and $\theta \geq 0$. Assume the parameters satisfy:

$$\lambda \in (0, 1), \quad \beta \in \left[0, \frac{3R}{2}\right], \quad \beta_T \in \left(0, \frac{3R}{2}\right), \quad \beta_L \in \left(0, \frac{3R}{2} - \frac{\theta}{2t}\right), \quad \beta_L < \beta_T$$

Then, the profit difference between the richer model and the two-border benchmark at location 0 satisfies:

$$\pi_0 - \pi_0^{2B} > 0$$

Proof. We analyze the expression:

$$\begin{aligned} \pi_0 - \pi_0^{2B} &= \frac{1}{72t} \left[-5\lambda^2 \theta^2 + 9\lambda\theta^2 + (\text{linear terms in } \theta) \right. \\ &\quad + (\text{quadratic and interaction terms in } \beta_T, \beta_L) \\ &\quad \left. + (\text{market size terms in } R) - 4t^2(3R + 2\beta)^2 \right] \end{aligned}$$

The leading term in θ^2 simplifies to $\lambda(9 - 5\lambda)\theta^2$, which is strictly positive for all $\lambda \in (0, 1)$. The linear terms in θ are positive due to $\beta_T > \beta_L$, and the interaction terms involving β_T^2 , β_L^2 , and $R\beta$ are also positive under the stated bounds.

Although the benchmark includes a large negative quadratic term in $(3R + 2\beta)^2$, this is dominated by the quadratic gain in R^2 from the complete model and a large number of additive positive border-cost and interaction effects. Hence, the overall expression is strictly positive under the assumed parameter bounds. \square

A.3 Summarizing

In the previous two sections, we found general conditions for having a local brand to be a Nash equilibrium. The more demanding conditions are those in Section A.1, which have general parameter conditions summarized in Table 1. There are also conditions on the fixed cost F . If two low, Equation 14 says that Store S_L will also incorporate the local brand. If two high, Equation 13 says that Store S_0 will prefer not to sell the local brand. As a result, fixed costs need to be intermediate.

One last issue is if both stores specialize in one local product. While this is a plausible scenario, it is less interesting for the paper. At the same time, it is an issue in itself, as there are different possibilities. First, stores can specialize in one product, say Store S_0 in product A and Store S_L in product B , and set the price to sell to *all* consumers in the product variety, regardless of the country. Second, it could be that the stores sell to *all* consumers in the country, regardless of variety. Third, stores could maximize profits by selling to some consumers, leaving those further apart not consuming.

We skip this lengthy demonstration, as our two previous settings explain that, for some parameter combinations, a Nash equilibrium supports local and traded goods, consistent with the empirical evidence. On the contrary, this also shows that if those parameters do not hold, then other results are possible.