Exposure of Canadian Retailers to Cross-Border Shopping [*†]

Jen Baggs[‡] Loretta Fung[§] Beverly Lapham[¶]

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Abstract

This paper uses firm-level data from 1986 to 2007 to examine the effects of cross-border shopping on retailer performance. We used detailed geographic information to assess the degree to which these effects are influenced by the location of the retailer (i.e., distance to the closest land border post). We also investigate the role of other firm level characteristics. Previous studies have established that such border-crossing trips between Canada and the US are strongly related to changes in relative prices induced by exchange rate movements. This suggests the potential of significant demand fluctuations facing Canadian retailers induces by exchange rate changes. Our preliminary findings indicate that for the retail trade sector as a whole, trips by Canadian residents have a negative effect on sales while trips by US residents have a positive effect, and these effects diminish with distance to the border. We develop a preliminary model of retailers with heterogeneous firms and traveling consumers to better understand the observed empirical patterns and to guide our empirical specifications. Based on the model, we have constructed a measure of sensitivity of consumer travel/stay decision to exchange rate movements. We use it as an indicator of retailer exposure to cross-border shopping and quantify the exposure measure for Canadian cities with different proximities to the border under selected levels of the exchange rate.

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[‡]Faculty of Business, University of Victoria. E-mail: jenbaggs@uvic.ca.
[§]Department of Economics, National Tsing Hua University. E-mail: phfung@mx.nthu.edu.tw
[¶]Department of Economics, Queen's University. E-mail: laphamb@econ.queensu.ca.

1 Introduction

This paper uses firm-level data from 1986 to 2007 to examine the effects of same-day and multi-day trips across the border by Canadian and US residents on Canadian retailers' sales, profits, and probability of survival. Partially due to variation in institutions and policies, national borders are known to create market segmentation and persistent price differentials, causing persistent deviations from purchasing power parity (PPP) and the law of one price. While much of the discussion has focused on price differences across national borders (Engel and Rogers, 1996) and deviations from PPP and the law of one price (Atkeson and Burstein, 2008; Crucini, Telmer, and Zacharidas, 2005; Gopinath, Gourinchas, Hsieh, and Li 2011), fewer studies have examined the impact of these price differentials on consumer behavior and retail establishments. For countries with easy-to-access land borders (such as Canada and the United States), it has been documented that consumers compare prices and engage in cross-border shopping, making cross-border trips an economic decision (Chandra, Head, and Tappata 2013). This implies that real exchange rate changes (and other policy changes that influence international price differentials) can affect retailers by changing the number of consumers which shop at their store, which is a form of a demand shock. The degree of the demand shock and how it varies with proximity of a retailer to the border and other retailer characteristics is an important empirical question. Campbell and Lapham (2004) use county-level data to investigate the effect of real exchange rate movements on US retailers in four industries in border counties and find evidence of adjustment on both extensive and intensive margins. Asplund, Friberg, and Wilander (2007) find that relative price changes have a significant impact on Swedish alcohol sales and the effect lingers for several hundred kilometres. Using firm-level data, Baggs, Beaulieu, Fung, and Lapham (2013) also find a significant effect of real exchange rate changes on Canadian retailers, with effects that diminish with distance to the border.

To date, most studies on cross-border shopping and retailers have either focused on the determinants of cross-border shopping (Chandra, Head, and Tappata, 2013, Di Matteo and Di Matteo, 1996, Ferris, 2000 and 2010) or assessed the effect of real exchange rate or tax changes on retailers (Campbell and Lapham, 2004, Asplund, Friberg, and Wilander, 2007 and Baggs, Beaulieu, Fung, and Lapham, 2013). Using a particular measure of cross-border shopping activity, cross-border trips, makes it possible to assess the direct impact on retailers of cross-border trips (and barriers, such as the post-9/11 border control) and to take into account the shopping conditions on the other side of the border. In this paper, we use comprehensive firm-level data on Canadian retailers combined with cross-border trips data (both same-day and overnight) at the closest border-crossing to the firm from 1986 to 2007 for our empirical analysis. Our measures of adjustment include sales, profits and firm survival. Our findings suggest that, in general, Canadian cross-border trips have an adverse effect on Canadian retailers while US trips have a positive effect. On average, same-day trips have a stronger effect than overnight trips – possibly because overnight trips can be partially for vacation purpose – and cross-border trip effects (elasticities) diminish with distance to the border. We also construct a consumer search model based on Burdett and Judd (1983) to explain the empirical patterns found in this paper and in Baggs, Beaulieu, Fung, and Lapham (2013).

This paper contributes to the literature in at least two ways. First, we quantify the effects of cross-border travel on retailers, the rate at which the effects diminish with distance to the border, and differences across industries. Assessing the effects of cross-border shopping provides us with an excellent opportunity to observe how retailers react to demand shocks, which can be difficult to quantify in other situations. Secondly, we develop a theoretical model to better understand the predicted impact of exchange rate movements on retailers via cross-border shopping activities and to guide our future empirical specifications.

The rest of the paper proceeds as follows. Section 2 provides background information regarding cross-border shopping travel by both Canadians and Americans between Canada and the US. Section 3 describes the firm-level, regional, and aggregate data used for the analysis. Section 4 summarizes the preliminary results. Section 5 presents the theoretical model. Section 6 covers the empirical implementation and Section 7 concludes.

2 Background

With persistent deviations from PPP and a land border that is relatively easy to cross, some consumers are motivated to shop across the border to take advantage of price differences (and perhaps superior shopping opportunities). Although it is difficult to observe shopping expenditure, cross-border shopping can be approximated by same-day trips by automobile as the expenditure of same-day trips are more likely for shopping purposes while expenditure on overnight trips may also include vacation spending. Di Matteo and Di Matteo (1996) find that same-day trips by Canadians are responsive to exchange rate movements and the introduction of the goods and services tax in Canada in 1991.[1] Ferris (2000 and 2010) also examines the role of deregulation of Sunday shopping, the Canada-US free trade agreement,

[1]The Goods and Services tax (GST) was introduced on January 1, 1991. This is a Canadian federal tax and increased the sales tax rate in all Canadian provinces by 7 percentage points. The tax rate was then reduced to 6 percent in 2006 and to 5 percent in 2008.

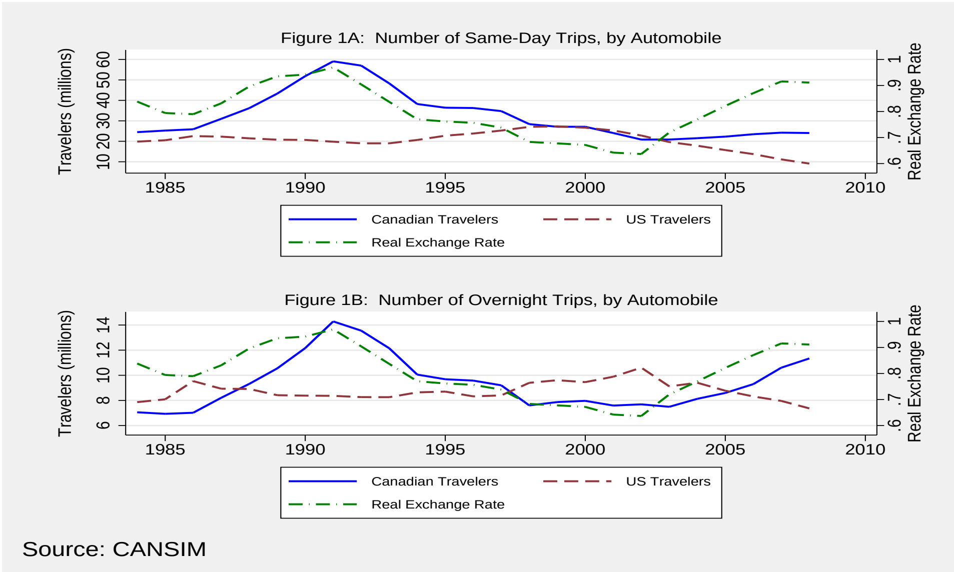


Figure 1: Cross-Border Trips and Real Exchange Rate (1984-2008)

and post-911 border control. Chandra, Head, and Tappata (2013) further study the responsiveness of both same-day and overnight trips, and provide an empirical and theoretical investigation of the cross-border shopping decision of consumers who reside at different distances from the border. Across these studies, the common findings are: (1) Canadian cross-border trips are positively related (and highly responsive) to the value of Canadian dollar; (2) Canadian cross-border trips are more responsive to exchange rate changes than are US trips; and (3) post-911 border control measures reduces the number of trips.

Figure 1 is suggestive of these patterns from 1984-2008. During this period, the Canadian dollar experienced a 23 percent real appreciation between 1985 and 1991, a 34 percent depreciation between 1991 and 2002, followed by a 43 percent real appreciation between 2002 and 2008. Figure 1A graphs same-day trips by automobile by Canadian and US travelers and the real exchange rate, measured as the nominal exchange rate times the US Consumer Price Index divided by the Canadian Consumer Price Index. Thus a rise in the real exchange rate in this figure represents a real appreciation of the Canadian dollar. Examining this figure, we observe that the number of Canadian travelers increases when there is Canadian real appreciation and decreases when there is a real Canadian depreciation. Note, however, that the positive relation is weakened since the year 2002, possibly attributable to the tightened border control after 911.[2]

Ford (1992) has summarized findings regarding cross-border shopping in various retail surveys. Based

[2]We further analyze the exchange rate elasticities in Section 4.1.

on those surveys, by driving time to the border and frequency of cross-border shopping trips, Canada can be divided into three shopping zones (or rings). The first ring comprises regions within 30 minute driving distance to the border.[3] Residents in this zone shop in the US on a weekly basis for less-durable goods such as gas and groceries. The second zone includes regions within 60 minutes driving distance to the border. Residents in this zone shop across the border on a monthly basis and purchase slightly more valuable goods such as clothing and small appliances. The third zone consists of regions within 90 minutes driving distance to the border. Residents in this zone are infrequent cross-border shoppers (four times a year) and acquire more expensive goods such as major appliances and electronics. In addition, Ford (1992) summarizes a survey on Ontario retailers regarding the impact of cross-border shopping. In border cities, about two-thirds of the retailers indicated that they are impacted by cross-border shopping with a lower positive response for retailers located farther away from the border. The fraction of affirmative responses also varies by business types: the fraction of retailers responding affirmatively is higher in general merchandise, furniture, eating and drinking places, and apparel and accessories.[4] In this paper, we expand this analysis to include *all* Canadian retailers located in different regions, and to *quantify* their response to both same-day and overnight trips.

3 Data Description

3.1 Firm-Level Data

In this study we use a unique firm-level data set, T2LEAP data. It is created by linking two data sources: the corporate income tax file (the T2 file) and longitudinal employment analysis program (LEAP), which is derived from T4 payroll information. The T2 file includes financial variables and here we use sales, assets, equity, profits, and corporate type. Firm location can be identified by province and postal code. The LEAP file has information on employment, payroll, firm age (truncated in 1984) and industry classification (1980 Standard Industry Classification-Enterprise, SIC-E, and 2007 North American Industry Classification (NAICS)). Here, employment is measured by average labour units (ALU) which is defined as payroll divided by average wage in the same province, industry and size category. The corporate income tax file covers all incorporated firms in Canada and the LEAP file contains all firms that hire employees, the resultant linked data cover all incorporated enterprises in Canada that hire employees. The T2LEAP

[3]Here, we use Jokinsen's definition. Winter defines the first zone as 15 minute driving distance to the border (both were summarized in Ford, 1992).

[4]Ford (1992) pages 11 and 12.

data annually cover the period of 1984 to 2008. As the first and last years are partial years and 1985 is used as a lag, we use 1986 to 2007 in our empirical analysis. Our study covers a broad set of retail trade industries, food services, and accommodation.[5]

The T2LEAP database has two important advantages for studying retailers. First, it contains the universe of Canadian enterprises that hire employees, making it possible to study the behaviour of retailers of different sizes in different industries as well as firm entry and exit. This is particularly important for retailers as the vast majority of retailers are small enterprises with less than 10 employees (Baggs, Beaulieu, Fung, and Lapham 2013). Second, postal code information in the file makes it possible to connect firms to detailed regional characteristics in their local neighborhood and to the closest border counties in the United States.

Firm entry and exit in the T2LEAP file is identified using a method modified from Baggs (2005). The initial population of retailers are the ones in operation in 1986. The panel then is augmented by removing exits and adding entrants in each of the subsequent years. A firm is defined as an "exit" in year t if the year fits either of the following three criteria: the *last* year the files corporate income tax, has sales, OR hires employees. This firm is dropped in all subsequent years. A firm is defined as an "entrant" in year t is the first full year that the firm files corporate income tax, has sales and hires employees.[6]

In addition to the retail trade sector as a whole, we also examine the impact on selected industries that are expected to be affected by cross-border shopping activities: grocery stores, gasoline service stations, food services, accommodation, apparel and general retail, and furniture and appliances. Using the firm postal code information, we can calculate driving distance between a firm and the closest land border post.

3.2 Regional Data

3.2.1 Cross-border Trips

Data on border-crossing trips (head counts) from 1985 to 2007 are from the Tourism and the Centre for Education Statistics Division at Statistics Canada and CANSIM database. Here, we use the number of Canadian residents returning from the U.S. and the number of American residents entering Canada by automobile for same-day trips and for overnight trips.[7] The data are available at the level of border posts

[5] See Appendix A.1 for details on industry coverage and data cleaning process.

[6] A firm is considered exiting in year t if the firm does not reappear in subsequent years and a firm is considered entering in year t if the firm has never appeared before year $t-1$, making year t the first full year. Some firms have missing observations in some years (possibly due to late tax filing) but they are considered continuing firms.

[7] "Overnight" is the sum of one night and 2 and more night trips.

and we use the annual data from 107 land border posts with some posts combined due to data limitations (see Appendix A.2 for details). The closest land border post to a firm is determined by matching postal codes.[8]

3.2.2 International Traveler Survey

To identify possible origins of cross-border travelers from Canada, similar to Chandra, Head and Tappata (2013), we employ the International Traveler Survey (ITS) data from Statistics Canada. This database contains information on Canadian residents re-entered from the US by the Census Division where the resident lives and the length of their stay, we aggregate which to same-day and overnight trips. The database is available since 1990 and we use the data from 1990 to 2007.

3.2.3 Regional Characteristics

We account for local market conditions for a retailer (defined as a community) using population and median income by census division in 1986, 1991, 1996, 2001 and 2006.[9] The census division data is connected to the firm-level data by postal code and applied to the annual data two years before and after the census. We also account for economic activities in US border counties using data from County Business Patterns, 1986-2008. This data set contains the number of establishments, employment and payroll of all industries and sub-industries. Data on US border counties are linked to the Canadian retailer firm-level data by border posts.

3.2.4 Other Data

Industry and province specific consumer price indexes are used for deflating nominal variables and they are obtained from the CANSIM database. We also use gasoline prices at Canadian city centres to partially account for changes in travel costs facing consumers and these are taken from CANSIM.

[8] The driving distance is calculated using Google Api.

[9] As the census has been conducted every five years while our firm-level data is annual, we apply the population and median income values to two years before and two years after the census year.

4 Preliminary Empirical Findings

4.1 Cross-Border Trips

We first examine the effect of exchange rate movements on Canadian and American travelers. The equation estimated is similar to the one in Chandra, Head, and Tappata (2013) and can be specified as:

$$\ln n_{pt}^{rk} = \alpha + \beta_1^k \ln RER_t + \beta_2^k ctax_{pt} + \beta_3^k utax_t^r + \theta^k \ln P_{gas,t}^r + \gamma^k post911 + \delta^k \ln I_{pt}^r + \varepsilon_{pt}^{rk}, \text{where } k = C, U \quad (1)$$

where r indexes regions (defined as an area sharing the same closest land border post), p denotes provinces (a province is comprised of multiple regions). C denotes Canadian travelers and U denotes US travelers. Here n_{pt}^{rk} is the number of Canadian ($k = C$) or US travelers ($k = US$) crossing at the border post closest to region r, and RER is real exchange rate (expressed as US dollar per Canadian dollar). During the period studied, in addition to exchange rate movements, another important change that may have affected consumers' cross-border shopping decisions was the introduction of the Goods and Services Tax (GST) on January 1, 1991. To account for this, we include the Canadian sales tax, $ctax$, which is a combination of provincial sales taxes (PST) and federal sales taxes (GST). We also include sales taxes in adjacent states as this may affect the final relative price of goods and consumer's crossing decision. In addition, we include gasoline prices at the province level to control for changes in the cost of driving trips,[10] a post-911 dummy ($post911$) to account for the effect of tightening border control after 911, and provincial and adjacent state real GDPs (denoted as I) to include the effects of local and neighboring income and general economic activity. We also control for border post fixed effects and include a time trend. Finally, ε_{pt}^{r} is an error term.

The results of estimating equation (1) is reported in Table 1. Columns 1 and 2 report results for same-day trips and columns 3 and 4 for overnight trips. The results in columns 1 and 2 show that a real appreciation of the Canadian dollar is associated with increases in the number of trips by Canadians to the US and a reduction in trips by Americans to Canada. We also note that the magnitude of the real exchange rate effect for Canadian travelers is larger and significant which is consistent with the larger response by Canadian travelers shown on Figure 1 and the results of Chandra, Head, and Tappata (2013).

In addition to the exchange rate effects, we find cross border same-day trips are negatively related to our post-911 border control dummy and positively associated with border county business activities.

[10]Here the provincial gasoline price is the average of gasoline prices in major cities in the province and it is deflated using CPI of all items except food and energy at the province.

Table 1: Exchange Rate Effect on Cross-border Trips

	Same-Day Trips		Overnight Trips	
	Canadian	US	Canadian	US
	(1)	(2)	(3)	(4)
lnRER	1.933**	-0.765	1.991**	-0.325
	(0.526)	(0.469)	(0.593)	(0.627)
Cdn Sales Tax	3.647	-0.783	3.259	-0.340
	(2.896)	(2.548)	(3.492)	(3.769)
US State Sales Tax	19.347**	11.916**	6.142	1.952
	(4.400)	(3.854)	(5.464)	(5.453)
Post 911 Dummy	-0.326**	-0.099	-0.101	0.073
	(0.124)	(0.123)	(0.179)	(0.197)
Real Gasoline Price	-0.856	-0.594	-0.774	-0.313
$= \ln P_{gas}$	(0.666)	(0.581)	(0.592)	(0.680)
Provincial Real GDP	-1.025	-0.329	0.254	0.937
	(1.442)	(1.375)	(1.826)	(1.851)
State Real GDP	-0.065	0.049	-0.053	-0.076
	(0.062)	(0.063)	(0.099)	(0.117)
Border County Business Activities	0.320**	0.369**	0.442**	0.229+
	(0.108)	(0.098)	(0.103)	(0.120)
Time Trend	Yes	Yes	Yes	Yes
Provincial Fixed Effects	Yes	Yes	Yes	Yes
R-squared	0.941	0.952	0.975	0.983
Observations	2,288	2,288	2,288	2,288

Newey-West standard errors (robust to serial correlation to 5 years maximum) in parentheses
$**$p <0.01, $*$ p<0.05, + p<0.1

Turning our attention to the overnight trip results reported in columns 3 and 4, most of the findings are similar to the same-day trips results. In particular, a real appreciation of the Canadian dollar is associated with an increase in overnight trips by Canadians while having little effect on trips by Americans. In addition, overnight trips are positively related to border county business activities and, interestingly, there is little effect of post 9/11 border control.

4.2 Firm Sales

We now turn to an analysis of the impact of cross-border shopping (approximated by cross border trips) on Canadian retailers. We start by investigating the sales of Canadian retailers. The equation estimated is specified as:

$$\ln y^r_{fict} = \sum_{k=C,U} [(\beta^k_1 + \beta^k_{13} \ln d_{ft}) \ln same^{rk}_t + (\beta^k_2 + \beta^k_{23} \ln d_{ft}) \ln overnight^{rk}_t] + \phi \ln d_{ft} + \gamma x_{ft-1} + \delta z^r_{ict-1} + \varepsilon^r_{fict} \tag{2}$$

Table 2: Firm Sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	All	Grocery	Accomm.	Food	Gasoline	Apparel & GR	Appliances
Cdn Same Day	-0.036**	-0.056**	-0.029	-0.034**	-0.079+	-0.043*	-0.022
	(0.006)	(0.021)	(0.024)	(0.011)	(0.041)	(0.019)	(0.017)
*Dist	0.008**	0.017**	0.007	0.007**	0.013	0.008*	0.003
	(0.001)	(0.004)	(0.005)	(0.002)	(0.008)	(0.004)	(0.003)
US Same Day	0.038**	0.066**	0.042	0.033**	0.075+	0.066*	0.016
	(0.006)	(0.025)	(0.026)	(0.011)	(0.042)	(0.026)	(0.018)
*Dist	-0.006**	-0.018**	-0.007	-0.006*	-0.011	-0.009+	0.002
	(0.001)	(0.005)	(0.005)	(0.002)	(0.008)	(0.005)	(0.004)
Cdn Overnight	-0.013	-0.093**	-0.072*	-0.037+	-0.001	-0.024	0.047+
	(0.009)	(0.028)	(0.030)	(0.019)	(0.056)	(0.026)	(0.025)
*Dist	0.001	0.013*	0.011+	0.006+	-0.005	0.005	-0.011*
	(0.002)	(0.005)	(0.006)	(0.004)	(0.010)	(0.005)	(0.005)
US Overnight	0.011	0.005	0.022	0.032*	0.031	-0.009	-0.036+
	(0.007)	(0.021)	(0.025)	(0.015)	(0.041)	(0.018)	(0.020)
*Dist	-0.002+	0.001	-0.001	-0.007*	-0.003	0.000	0.006
	(0.001)	(0.004)	(0.005)	(0.003)	(0.008)	(0.004)	(0.004)
Observations	2,192,308	214,404	108,984	489,962	109,246	147,283	181,832
R-squared	0.147	0.112	0.114	0.108	0.125	0.206	0.233
Number of Firms	219,164	22,309	10,370	56,377	11,090	15,632	17,522

Robust standard errors (adjusted for clustering at the firm level) in parentheses

** $p<0.01$, * $p<0.05$, + $p<0.1$

Industry, community and regional level controls are included. Industry, province and year fixed effects are also controlled.

where f indexes firms, i industries, c communities and r regions. Here a region is comprised of multiple communities which vary in their population and distance to the border. y is either firm sales or profits. *Same* denotes same-day trips by Canadian ($k = C$) or US travelers ($k = U$), *overnight* overnight trips and d_{ft} driving distance between firm f and the closest land border post. x_{ft-1} represents a vector of (lagged) controls for firm characteristics and they include firm age, size (measured by assets) and leverage (debt-asset ratio). Firm leverage is used to control for the impact of firm financial conditions on sales. Furthermore, $z^r_{ict-1}$is a vector of industry, community and regional controls. Here, we use lagged industry sales (excluding the firm f itself) and industry concentration (measured by the Herfindahl-Hirschman index) to take into account industry size and concentration. We also account for local income and market size by including median income and population in the relevant Canadian census division and control for economic activity in border counties by including the number of establishments in adjacent border counties.

Equation (2) is estimated using panel regressions with firm fixed effects. We also include year fixed effects to control for changes in the macroeconomic environment that are common to all firms and the results are reported in Table 2. Here, we only report coefficient estimates for the main variables of interest but full sets of lagged firm, industry, community and regional level controls are included in the regressions.

Complete regression tables are available upon request. Column 1 reports results for the entire retail trade sector. Coefficient estimates for Canadian same-day trips is negative and significant while the coefficient estimate for the US same-day trips is the opposite, suggesting that Canadian travelers have a negative effect while US travelers have a positive effect on firm sales. The coefficient estimates for the terms interacting distance with same-day trips have signs opposite to the direct effects and both significant, implying that the effects of cross-border same-day trips diminishes with distance to the border. When examining the effects of overnight trips, we find that they are overall insignificant for the entire retail trade sector.

Turning our attention to industry sub-samples reported in columns 2 to 7. We find that for grocery stores, both Canadian and US same-day trips as well as Canadian overnight trips play a significant role and their effects diminish with distance to the border. For food services, both same-day and overnight trips have an impact on firm sales and the size of effect also reduces with distance to the border. For the apparel and general retail sub-sample (column 6), only same-day trips influence firm sales and the effect is mitigated by distance to the border. For the gasoline service stations (column 5), only same day trips have effects and distance to the border has little impact on the size of effects. For accommodations (column 3), only overnight trips by Canadians have an adverse effect and it diminishes with distance to the border. Finally, border-crossing trips have little effect on firm sales in the appliances and furniture sub-sample as cross-border shopping at this sub-group may be limited by warranty considerations and the transportability of products.

5 Theoretical Model

Combining the findings in Baggs, Beaulieu, Fung, and Lapham (2013) and the empirical results of the previous section, we have seen the following empirical patterns. First, the sales and profits of Canadian retailers are adversely affected by a real currency appreciation and the elasticities of each of these variables with respect to real exchange rates changes diminish with distance to the border. This patterns suggest the presence of a demand side effect resulting from cross border shopping. Second, we find that cross-border trips, especially by Canadian travelers are highly responsive to exchange rate changes, supporting the theory that increases in relative prices in Canada motivates some Canadian consumers to engage in cross-border shopping (see also, Chandra, Head, and Tappata (2013)). Finally, cross-border trips by Canadians have an adverse effect on Canadian retailers' sales, profits and survival while trips by US residents have a positive effect, with elasticities that diminish with distance to the border. In this section, we begin to develop a model to explain these patterns and to provide a framework for our future empirical work.

5.1 General Description of Environment

Suppose there are two countries, H and F, each with their own currency. There are multiple retail sectors in each country producing and selling goods and we index the sectors by $z \in [0, \bar{z}]$. The goods within a sector are homogeneous but goods are differentiated across sectors. We assume that due to cross-country technological and wage differences, that in some sectors, the average price of the good in that sector is higher in H than in F when converted to the same currency and in other sectors it is the opposite. For now, we will think of H as Canada and will focus on a single sector for which the same currency average price of the good in H is higher than in F so the flow of shoppers for that good will be from H to F. The nominal exchange rate, s, is stochastic and exogenous and denotes units of F currency per unit of H currency – hence, an increase in s is a nominal appreciation of H currency.

Each country is comprised of multiple regions and each region is comprised of multiple communities. All communities within a region share a common border crossing (this is what defines a region). Regions are indexed by $r = 1, 2, ...N$ and are characterized by income per capita, I^r, a parameter which affects the per capita gross benefits of cross-border shopping from that region, β^r, and a parameter which affects the cost of cross-border travel from that region, γ^r, such as the price of gasoline. We denote the vector of region characteristics by $\theta^r \equiv (I^r, \beta^r, \gamma^r)$. Each region is divided into C communities according to the distance of the community from the region's border crossing. Communities within each region are indexed by $c = 1, 2, ..., C$ and a community is characterized by its distance to the nearest border crossing, D_c, (which is common across regions) and its population, ω_c^r, (which varies across regions). We denote the vector of community characteristics in region r by $\Psi_c^r \equiv (D_c, \omega_c^r)$.

5.2 Retailers

Each retail sector is modeled using an industry structure based on that described in Burdett and Judd (1983) but with firms which differ in their productivity. We focus on a single representative retail sector. Community c has a continuum of firms of endogenous measure N_c in the representative sector selling a homogeneous good. The technology for a retailer with productivity parameter a in Country j is given by the following:

$$y_j(a) = \left(\frac{1}{a}\right) (m_j^H)^{\alpha_j^H} (m_j^F)^{\alpha_j^F} (l_j)^{1-\alpha_j^H-\alpha_j^F}, \tag{3}$$

where y_j is output, a is the firm-specific technology parameter, m_j^H is input of intermediates produced in H, m_j^F is input of intermediates produced in F, and l_j is input of labor. A retailer must pay a fixed cost, f_E to enter and draw its productivity parameter from a common distribution in Country j given by $J_j(a)$ with support $[0, \bar{a}_j]$.

The wage in Country j is w_j, is denoted in Country j currency, is exogenous, and is common across all communities in Country j. The price of the intermediate produced in Country H is p_H^m and is denoted in Country H currency while the price of the intermediate produced in Country F is p_F^m and is denoted in Country F currency. The intermediate goods' prices are treated as exogenous and are common across all communities in both countries. We do not model the production of intermediates nor do we model the labour market.

Solving the cost minimization problem of a retailer with cost parameter a in each country gives the following unit cost functions in each country's currency as a function of the nominal exchange rate, s:

$$a\phi_H(s) = \Upsilon_H \left(p_m^H\right)^{\alpha_H^H} \left(\frac{p_m^F}{s}\right)^{\alpha_H^F} (w_H)^{1-\alpha_H^H-\alpha_H^F}\,, \tag{4}$$

and

$$a\phi_F(s) = \Upsilon_F \left(sp_m^H\right)^{\alpha_F^H} \left(p_m^F\right)^{\alpha_F^F} (w_F)^{1-\alpha_F^H-\alpha_F^F}\,, \tag{5}$$

where

$$\Upsilon_j \equiv \left((\alpha_j^H)^{-\alpha_j^H} (\alpha_j^F)^{-\alpha_j^F} (1-\alpha_j^H-\alpha_j^F)^{\alpha_j^H+\alpha_j^F-1}\right). \tag{6}$$

Throughout the paper, let $\epsilon_y^x(\cdot)$ denote the elasticity of variable x with respect to variable y. Thus, for all firms we have

$$\epsilon_s^{\phi_H} = -\alpha_H^F < 0 \qquad\qquad \epsilon_s^{\phi_F} = \alpha_F^H > 0. \tag{7}$$

As expected with Cobb-Douglas technology, the absolute value of the elasticity of a retailer's unit (marginal) cost with respect to the nominal exchange rate equals the expenditure share on the imported input. We see that an increase in s which is a H currency appreciation decreases the unit cost of H retailers as it decreases the H currency price of their imported input. Of course, an increase in s increases the unit cost of F retailers as it increases the F currency price of their imported input.

Each period, incumbents and new retailers observe the nominal exchange rate, and choose a price to post. The (endogenous) equilibrium distribution of posted prices in Country j is denoted $G_j(p; s)$ with support $(\underline{p}_j(s), \tilde{p})$, where $\tilde{p}$ is the constant reservation price which is common across all consumers. Hence

$G_j(p;s)$ denotes the fraction of firms in Country j in a particular retail sector which charge a price no greater than p. The price distribution depends on the nominal exchange rate because s affects the unit cost of retailers which affects the price distribution (see below). Firms which have marginal cost above the consumers reservation price will not operate so the maximum cost parameter for operation in Country j is given by $\tilde{a}_j(s) = \frac{\tilde{p}}{\phi_j(s)}$. For convenience, we define the cost distribution conditional on producing:

$$\tilde{J}_j(a;s) = \frac{J_j(a)}{J_j(\tilde{a}_j(s))} \tag{8}$$

Consumers know the distribution of prices across the retailers in a sector in each country but do not know which firm is charging which price. Thus, consumers know the average price in each country which we denote as $\bar{p}_H(s)$ and $\bar{p}_F(s)$. Consumers cannot shop for the same good in both countries and they optimally choose in which country to shop for each good. After they choose the country where they will shop for a good, they search a subset of the firms selling that good in that country to obtain price quotes. A price quotation from retailers in Country j is a random draw from $G_j(p;s)$. There will be two types of H consumers: Stayers who shop in H and draw price quotes from $G_H(p;s)$ and Travelers who shop in F and draw price quotes from $G_F(p;s)$. In the description of the consumers in the next section, we analyze the consumers' optimal decisions regarding in which country they will shop (that is, their decision to be a Stayer or a Traveler). The number of price quotes observed by any one consumer is random and we let q_k denote the probability that an arbitrary consumer will observe k price quotes for $k \in \{1, 2, ...\infty\}$ with $\sum_{k=1}^{\infty} q_k = 1$ (there is zero probability of observing zero quotes). These probabilities are the same in every market. Note that q_k will also be the fraction of buyers in a market who observe k prices. After a consumer has observed his random number of price quotes, he spends all of the income that he has allocated for purchases in that sector and will purchase at the lowest observed price.

Now we turn to the determination of the equilibrium price distribution in Country j in a representative retail sector. We will see below that all communities will have the same equilibrium price distribution. This is because all retailers draw from the same cost distribution and face the same wage and prices of intermediates and all consumers have the same reservation price and those are the only variables that affect the equilibrium price distribution (in particular, the measure of buyers and measure of retailers does not affect the price distribution).

We begin by deriving the expected number of buyers who will buy from a retailer located in Country j posting an arbitrary price p expressed in the currency of Country j. Let $\lambda_j(s, \Psi_c^r, \theta^r)$ denote the measure of buyers in community c in region r in Country j. This measure is endogenous and is determined from the consumers' traveling decisions as described in the next section. Importantly, this measure of buyers depends on the exchange rate because the exchange rate affects the differences in average prices across countries which affects the fraction of consumers who cross-border shop.

The expected measure of buyers who observe $k \geq 1$ prices and buy from a retailer located in community c in region r in Country j posting price p equals $[\lambda_j(s, \Psi_c^r, \theta^r)q_k]\,[k]\,\left[(1 - G_j(p; s))^{k-1}\right]$. The first term in this expression is the measure of buyers who observe k prices, the second term is the number of prices they observe, and the third term is the probability that the posted price p is the lowest price they observe. Hence, the total expected measure of buyers in community c in region r in Country j who will purchase at price p is given by

$$\lambda_j(s, \Psi_c^r, \theta^r) \sum_{k=1}^{\infty} kq_k(1 - G_j(p; s))^{k-1} = \lambda_j(s, \Psi_c^r, \theta^r) A(G_j(p; s)), \tag{9}$$

where $A(G_j(p; s)) \equiv \sum_{k=1}^{\infty} kq_k(1 - G_j(p; s))^{k-1}$.

Henceforth, we focus on a retailer in Country H who is only selling to consumers who reside in the retailer's community. This would be a retailer who is either unaffected by cross-border shopping so is selling to all consumers in the community or who is located in a community where some of the consumers from the community are cross-border shopping and the retailer is only selling to consumers who reside in the community who are not cross-border shopping. All consumers who purchase from such a retailer will spend the same amount – the amount of their income that they have allocated to purchases from this sector. Denote the expenditure by a consumer on the good in this sector in region r as $E(I^r)$. Hence, a buyer who purchases the good at price p will purchase $\frac{E(I^r)}{p}$ units of the good. Thus, the expected output, revenue (i.e. sales), employment, and profit of an H retailer posting price p located in community c in region r with measure N_c of retailers, and only selling to local consumers are given by

$$y_H(p; s, \Psi_c^r, \theta^r) = \left(\frac{E(I^r)}{p}\right)\left(\frac{\lambda_H(s, \Psi_c^r, \theta^r) A(G_H(p; s))}{N_c}\right). \tag{10}$$

$$R_H(p; s, \Psi_c^r, \theta^r) = p y_H(p; s, \Psi_c^r, \theta^r) \tag{11}$$

$$l_H(p; s, \Psi_c^r, \theta^r) = \left(1 - \alpha_H^H - \alpha_H^F\right) \Upsilon_j (p_m^H)^{\alpha_H^H} \left(\frac{p_m^F}{s}\right)^{\alpha_H^F} (w_H)^{-(\alpha_H^H + \alpha_H^F)} y_H(p; s, \Psi_c^r, \theta^r) \tag{12}$$

$$\pi_H(p, a; s, \Psi_c^r, \theta^r) = \Big(p - a\phi_H(s)\Big) y_H(p; s, \Psi_c^r, \theta^r) \tag{13}$$

We now derive the equilibrium pricing functions in a representative community so we drop the c subscripts and r superscripts and drop the explicit dependence on the exchange rate for now. An H retailer with cost parameter a chooses p to maximize profits given by

$$\pi(p,a) = (p - a\phi_H)\left(\frac{\lambda_H A(G_H(p))}{N}\right)\left(\frac{E}{p}\right), \tag{14}$$

where the first term is the difference between price and unit cost, the second is the ratio of the measure of buyers to the measure of sellers, and the last term is the quantity each buyer purchases. This gives rise to the following first-order condition:

$$\left(1 - \frac{a\phi_H}{p_H(a)}\right)\left(\frac{\lambda_H A'(G_H(p_H(a)))G'_H(p_H(a))}{N}\right)E + \left(\frac{a\phi_H}{p_H(a)^2}\right)\left(\frac{\lambda_H A(G_H(p_H(a)))}{N}\right)E = 0. \tag{15}$$

Now note that assuming that $J_H(a)$ is differentiable and conjecturing that the equilibrium price distribution $G_H(p)$ and the equilibrium pricing function $p_H(a)$ are differentiable, we know that $G_H(p(a)) = \tilde{J}_H(a)$ and $G'_H(p_H(a))p'_H(a) = \tilde{J}'_H(a)$. Hence, we can rewrite the first-order condition above as

$$\left(1 - \frac{a\phi_H}{p_H(a)}\right)\left(\frac{A'(\tilde{J}_H(a))\tilde{J}'_H(a)}{p'_H(a)}\right) + \left(\frac{a\phi_H}{p_H(a)^2}\right)\left(A(\tilde{J}_H(a))\right) = 0, \tag{16}$$

or

$$p'_H(a) = \left(\frac{A'(\tilde{J}_H(a))\tilde{J}'_H(a)}{A(\tilde{J}_H(a))}\right)p_H(a) - \left(\frac{A'(\tilde{J}_H(a))\tilde{J}'_H(a)}{a\phi_H A(\tilde{J}_H(a))}\right)p_H^2(a). \tag{17}$$

Now this is a Bernoulli equation and can be solved to derive the equilibrium pricing function by an H retailer where we again make the dependence on s explicit:

$$p_H(a;s) = \frac{A(\tilde{J}_H(a;s))\tilde{p}}{A(1) - \left(\frac{\tilde{p}}{\phi_H(s)}\right)\int_a^{\frac{\tilde{p}}{\phi_H(s)}}\left(\frac{A'(\tilde{J}_H(t;s))\tilde{J}'_H(t;s)}{t}\right)dt} \tag{18}$$

Now, recall that $\tilde{J}_H(a;s) = \frac{J(a)}{J(\frac{\tilde{p}}{\phi_H(s)})}$ and this implies that $\tilde{J}_H(a;s)$ is affected by the nominal exchange rate only through its effect on $\phi_H(s)$. Hence, from this and the pricing equation above, we can see that all firms in the same sector will follow the same pricing rule, regardless of their location, and that those prices will depend on s only through its effect on $\phi_H(s)$ (i.e. prices are independent of the measure of buyers and sellers). Thus, this model has the important feature that the "size" of the market (i.e. the measure of buyers and the measure of sellers) does not affect the price distribution nor the average posted price. Hence, changes in s will affect prices only through its effect on retailers' costs but will affect the measure of buyers facing a retailer (and, hence their output, revenue, employment, and profits) as captured by $\lambda_H(s, \Psi_c^r, \theta^r)$ and the equilibrium measure of sellers given by $N_H(s)$ and these will vary across communities and regions. This makes this model particularly tractable for examining the elasticities of the retailers' performance measures (output, sales, profits, etc.) with respect to the exchange rate.

We now turn to the free entry condition which determines the equilibrium measure of retailers. That condition is as follows:

$$\left(\frac{1}{N_H(s)}\right)\int_0^{\frac{\tilde{p}}{\phi_H(s)}} \pi_H(a;s)d\tilde{J}_H(a;s) = f_E, \tag{19}$$

which states that average profits must equal the cost of entry. This gives us the following equation in $N(s)$:

$$\left(\frac{\lambda_H(s)E}{N_H(s)^2}\right)\int_0^{\frac{\tilde{p}}{\phi_H(s)}} \left(1 - \frac{a\phi_H(s)}{p_H(a)}\right) A(\tilde{J}_H(a;s))d\tilde{J}_H(a;s) = f_E \tag{20}$$

or

$$N_H(s) = \left(\frac{\lambda_H(s)E\int_0^{\frac{\tilde{p}}{\phi_H(s)}} \left(1 - \frac{a\phi_H(s)}{p_H(a)}\right) A(\tilde{J}_H(a;s))d\tilde{J}_H(a;s)}{f_E}\right)^{.5} \tag{21}$$

We also note that the equilibrium measure of entrants in a community, $\bar{N}_H(s)$ must satisfy

$$N_H(s) = \bar{N}_H(s)J_H\left(\frac{\tilde{p}}{\phi_H(s)}\right) \tag{22}$$

We now examine the elasticities of firm-level variables of interest with respect to the nominal exchange rate. Recall that output of a firm with cost parameter a are given by

$$y_H(a;s) = \left(\frac{E}{p_H(a;s)}\right)\left(\frac{\lambda_H(s)A(\tilde{J}(a;s))}{N(s)}\right). \tag{23}$$

Letting ϵ_x^y denote the elasticity of y with respect to x, we can derive the following:

$$\epsilon_s^{y_H(a;s)} = -\epsilon_s^{p_H(a;s)} + \epsilon_{\tilde{J}}^{A(\tilde{J}(a;s))}\epsilon_s^{\tilde{J}(a;s)} + \epsilon_s^{\lambda_H(s)} - \epsilon_s^{N(s)}. \tag{24}$$

Now the first two terms in this expression depend only on the elasticity of $\phi_H(s)$ with respect to s, i.e. on the exogenous parameter $-\alpha_F^H$. The third term is determined by the consumer side as it reflects the responsiveness of the number of cross-border shoppers to changes in the exchange rate. The final term above depends on both of these things.

The elasticity of expected sales is given by

$$\epsilon_s^{R_H(a;s)} = \epsilon_s^{p_H(a;s)} + \epsilon_s^{y_H(a;s)} = \epsilon_{\tilde{J}}^{A(\tilde{J}(a;s))} \epsilon_s^{\tilde{J}(a;s)} + \epsilon_s^{\lambda_H(s)} - \epsilon_s^{N(s)}. \tag{25}$$

The elasticity of expected employment equals:

$$\epsilon_s^{l_H(a;s)} = \epsilon_s^{y_H(a;s)} + \epsilon_s^{\phi_H(s)}. \tag{26}$$

The elasticity of expected profits equals:

$$\epsilon_s^{\pi_H(a;s)} = \frac{p_H(a;s)\epsilon_s^{p_H(a;s)} - a\phi_H(s)\epsilon_s^{\phi_H(s)}}{p_H(a;s) - a\phi_H(s)} + \epsilon_s^{y_H(a;s)} = \frac{a\phi_H(s)\left(\epsilon_s^{p_H(a;s)} - \epsilon_s^{\phi_H(s)}\right)}{p_H(a;s) - a\phi_H(s)} + \epsilon_{\tilde{J}}^{A(\tilde{J}(a;s))} \epsilon_s^{\tilde{J}(a;s)} + \epsilon_s^{\lambda_H(s)} - \epsilon_s^{N(s)}. \tag{27}$$

We now turn to the consumer side of the model which will provide insights on the measure of consumers facing a given H retailer, $\lambda_H(s, \Psi_c^r, \theta^r)$, and allow us to characterize the elasticity of this with respect to the exchange rate.

5.3 Consumers

Our specification of consumers is similar to that in Chandra, Head, and Tappata (2013). Each consumer purchases a positive quantity from each sector. They may purchase a good in the community in which they reside or they may travel across the border to purchase a good in the other country. A consumer may purchase goods in some sectors in their own community and goods in other sectors abroad, depending on expected relative prices. A consumer will never purchase from another community within their own country because it is costly to travel to that community and the expected price is the same as in their own community.

We let $T(D_c, \gamma^r)$ denote the utility cost of traveling across the border for any consumer who resides in community c in region r. We assume that $T(\cdot)$ is increasing in distance of the consumer from the border, D_c, because the consumer has to travel farther to cross-border shop. We also assume that $T(\cdot)$ is increasing in its second argument, the region-specific parameter which affects the cost of cross-border travel (such as gasoline prices or the severity of border controls). Note that travel costs are the same across all consumers within a community but differ across communities.

Consumers within a community share a common, region-specific component to the gross benefit of traveling across the border to shop and the form of the common benefit function will depend on the underlying structure of preferences over consumption of the different retail goods. It will also depend on the relative prices of goods when converted to the same currency and since the average price of each good in each country depends on the nominal exchange rate, we capture this dependence by writing the common benefit function as a function of the nominal exchange rate. Let this common component of the gross benefit of cross-border traveling which is common across all communities in a region be given by $B(s, I^r, \beta^r)$, recalling that I^r is per-capita income in region r and β^r is a region-specific variable, such as shopping opportunities directly across the border from the region. At this point, we do not impose a functional form on $B(\cdot)$ but we assume that $B(s, I^r, \beta^r)$ is increasing in s and in β^r and is convex in its first argument to be consistent with the empirical evidence presented in Chandra, Head, and Tappata (2013).

Finally, as in Chandra, Head, and Tappata (2013), we incorporate an individual-specific benefit from cross-border travel. We denote this by ζ_i for consumer i and assume it has distribution $K(\zeta)$ with support $[\underline{\zeta}, \bar{\zeta}]$. Note that we have assumed that this distribution is the same across all communities and regions.

Putting these altogether gives the net benefits of cross-border travel for consumer i who resides in community c in region r:

$$W(\zeta_i, s, \Psi_c^r, \theta^r) \equiv B(s, I^r, \beta^r) - T(D_c, \gamma^r) + \zeta_i. \tag{28}$$

Note that we assume that $W(\underline{\zeta}, s, \Psi_c^r, \theta^r) < 0 \ \forall s$ to ensure that some consumers (those with relatively a low ζ will optimally choose not to travel across the border).

The cutoff ζ for traveling across the border from community c in region r is denoted $\zeta^*(s, \Psi_c^r, \theta^r)$ and it satisfies $W(\zeta^*, s, \Psi_c^r, \theta^r) = 0$:

$$\zeta^*(s, \Psi_c^r, \theta^r) \equiv T(D_c, \gamma^r) - B(s, I^r, \beta^r). \tag{29}$$

Hence, consumers with $\zeta > \zeta^*(\cdot)$ will travel and cross-border shop (Travelers) while those with $\zeta \leq \zeta^*(\cdot)$ will not travel and will buy from retailers in their own community (Stayers). We note that under the assumption that $T(D_c, \gamma^r)$ is increasing in both of its arguments, and that $B(s, I^r, \beta^r)$ is increasing in s and in β^r, we know that $\zeta^*(\cdot)$ is increasing in D_c and γ^r (variables which increase travel costs) and decreasing in s and β^r (variables which increase travel benefits).

Now the fraction of consumers from community c in region r which are Travelers is given by

$$x(s,\Psi_c^r,\theta^r) \equiv 1 - K\Big(\zeta^*(s,\Psi_c^r,\theta^r)\Big) = 1 - K\Big(T(D_c,\gamma^r) - B(s,I^r,\beta^r)\Big). \tag{30}$$

recalling that the population of community c in region r equals ω_c^r.

Finally, the measure of buyers in a sector in Country H in a community where a positive measure of consumers travel and where the average H price is higher than the average F price in a sector is the measure of Stayers in that community and is given by

$$\lambda_H(s,\Psi_c^r,\theta^r) = \omega_c^r K\Big(\zeta^*(s,\Psi_c^r,\theta^r)\Big). \tag{31}$$

Note that this is the same variable used above to denote the measure of buyers in the description of retailers.

Recall from the retailer description that the output, revenue, employment, and profit elasticities with respect to the nominal exchange rate all depend on the elasticity of $\lambda_H(\cdot)$. We now derive that elasticity for community c in region r in Country H using equation (31):

$$\epsilon_s^{\lambda_H}(s,\Psi_c^r,\theta^r) = \left[\frac{dK(\zeta^*(s,\Psi_c^r,\theta^r))}{K(\zeta^*(s,\Psi_c^r,\theta^r))}\right]\left[\zeta^*(s,\Psi_c^r,\theta^r)\epsilon_s^{\zeta^*}(s,\Psi_c^r,\theta^r)\right], \tag{32}$$

where from equation (29) we have

$$\epsilon_s^{\zeta^*}(s,\Psi_c^r,\theta^r) = \left(\frac{B(s,I^r,\beta^r)}{\zeta^*(s,\Psi_c^r,\theta^r)}\right)\left(-\epsilon_s^B(s,I^r,\beta^r)\right). \tag{33}$$

Substituting equation (33) into equation (32) gives

$$\epsilon_s^{\lambda_H}(s,\Psi_c^r,\theta^r) = \left[\frac{dK(\zeta^*(s,\Psi_c^r,\theta^r))}{K(\zeta^*(s,\Psi_c^r,\theta^r))}\right]\left[-B(s,\beta^r,I^r)\epsilon_s^B(s,\beta^r,I^r)\right] < 0, \tag{34}$$

We note that this elasticity is negative if the common gross benefit from traveling is increasing in the exchange rate. That is, when the H currency appreciates, more H consumers travel and the measure of buyers shopping from an H retailer falls.

Now, we want the theoretical model to tell us something about how this elasticity depends on its arguments so that this will guide us in the form of the regressions we perform with firm-level performance measures. The first item to note is that the properties of the first term in equation (34) will depend on the properties of the distribution function of the unobservable idiosyncratic component of the benefits of travelling. We would expect for most distributions that this term will be decreasing in ζ^* (it will be decreasing for uniform, Pareto, and normal distributions).

If $\frac{dK(\zeta)}{K(\zeta)}$ is decreasing in ζ, we have the following two results. Since $\zeta^*(\cdot)$ is increasing in D_c and θ^r (variables which increase the costs of travel), then:

$$\frac{\partial \left|\epsilon_s^{\lambda_H}(s, \Psi_c^r, \theta^r)\right|}{\partial D_c} < 0 \qquad\qquad \frac{\partial \left|\epsilon_s^{\lambda_H}(s, \Psi_c^r, \theta^r)\right|}{\partial \theta^r} < 0. \tag{35}$$

Recall that the elasticities of firm-level performance measures with respect to the exchange rate are positive functions of this elasticity. This implies that the model predicts that output, revenue, employment, and profit elasticities for a retailer will be decreasing functions of the distance of the retailer from the border and decreasing in the level of other variables which increase the cost of travel, such as the price of gasoline. Of course, the quantitative relationship between changes in D_c and θ^r and these elasticities will depend on the functional forms assumed for $K(\zeta)$, $B(s, I^r, \beta^r)$, and $T(D_c, \theta^r)$.

Let us now examine the relationship between $\epsilon_s^{\lambda_H}(\cdot)$ and s under the assumption that $\frac{dK(\zeta)}{K(\zeta)}$ is decreasing in ζ. An increase in s increases the common benefit from traveling and so will decrease ζ^*, thereby increasing $\frac{dK(\zeta)}{K(\zeta)}$. If the common benefit function $B(s, I^r, \beta^r)$ is convex in s (as argued in Chandra, Head, and Tappata (2013)), then an increase in s will increase $\zeta^* \left|\epsilon_s^{\zeta^*}\right|$. Thus, under these two assumptions, we have

$$\frac{\partial \left|\epsilon_s^{\lambda_H}(s, \Psi_c^r, \theta^r)\right|}{\partial s} > 0. \tag{36}$$

Furthermore, if $B(s, I^r, \beta^r)\epsilon_s^B(s, I^r, \beta^r)$ is increasing in β^r, then we also have

$$\frac{\partial \left|\epsilon_s^{\lambda_H}(s, \Psi_c^r, \theta^r)\right|}{\partial \beta^r} > 0. \tag{37}$$

So, under certain restrictions, the model implies that firm-level output, revenue, profits, and employment elasticities are increasing in the level of the exchange rate and in some proxy for β^r, such as the shopping opportunities just across the border.

5.4 Real Exchange Rates

The analysis above focused on a representative retail sector. Recalling that there are multiple retail sectors indexed by $z \in [0, \bar{z}]$, we denote the average price in sector z in Country j denominated in that country's currency as $\bar{p}_j(z;s)$. This average price is calculated as

$$\bar{p}_j(z;s) \equiv \int_{\underline{p}_j(z;s)}^{\tilde{p}(z)} p dF_j(p,z;s), \tag{38}$$

where $F_j(p,z;s)$ is the equilibrium price distribution in sector z in Country j with support $[\underline{p}_j(z;s), \tilde{p}(z)]$.

Suppose we assume that all consumers have the same optimal expenditure shares and we denote that share in sector z as $\sigma(z)$ with $\int_0^{\bar{z}} \sigma(z)dz = 1$ (this would be the case under identical and homothetic preferences). Under this assumption we can construct a consumer-based price index in each country as follows:

$$P_j(s) \equiv \int_0^{\bar{z}} \sigma(z)\bar{p}_j(z;s)dz. \tag{39}$$

Finally, we define the real exchange rate as follows:

$$q(s) \equiv s\left(\frac{P_H(s)}{P_F(s)}\right). \tag{40}$$

Recall that in this environment, a change in the nominal exchange rate, s, will change the average price in each sector only through its effect on the costs of firms selling in that sector. Recall also that an increase in s will decrease the costs of retailers in Country H and increase the costs of retailers in Country F. Thus, we expect that an increase in s will decrease the ratio of the countries' price indexes in brackets in the above expression. This suggests that the net effect on the real exchange rate of an increase in the nominal exchange rate is ambiguous. However, the change in the nominal exchange rate will be only partially passed through to costs (recall that $-1 < -\alpha_F^H < 0$ and $0 < \alpha_H^F < 1$ are the cost elasticities) and those cost changes will be only partially passed through to prices (because firms in this model of consumer search have some market power). Thus, we do not expect the relative price index to fall as much as the rise in the nominal exchange rate (in percentage terms) and hence we expect that an increase in the nominal exchange rate will be accompanied by a rise in the real exchange rate. This is consistent with the observed high positive correlation between real and nominal exchange rates in the data. We will verify that our economy can exhibit this property in a numerical exercise in the next section.

5.5 Numerical Example

In this section we impose functional forms on the theoretical economy described above and provide results from numerical simulations designed to clarify the properties of the model. For simplicity, we assume there is a single retail sector and a single region and examine the response of equilibrium variables in that sector to an exogenous appreciation of the home currency. We begin by describing how we define communities and the functional forms that we use in this exercise.

Following the population distribution data in Chandra, Head and Tappata (2013), we assume that each region is comprised of 35 communities and that the maximum distance of a community from the border is 300 kms. The distance of community c for $c \in \{1, 2, ..., 35\}$ is then given by $D_c = c\left(\frac{300}{35}\right) \approx 18.57c$. We use the Canadian population distribution data by distance from the border given in Chandra, Head, and Tappata (2013) and an arbitrary value for the total region population (which we henceforth denote as Ω^r) to calculate the population values for each community within a region, ω_c^r.

We let the cost of travel be specified as a linear- log function of distance, D_c^r and the regional specific parameter γ^r:

$$T(D_c^r, \gamma^r) = \tau_0 + \tau_1 \ln(D_c^r) + \tau_2 \ln(\gamma^r), \tag{41}$$

where all coefficients are positive. Similarly, we let the common travel benefit function depend on the log of the nominal exchange rate, s, and the regional specific benefit parameter β^r:

$$B(s, I^r, \beta^r) = \rho_0 + \rho_1 \ln(s) + \rho_2 \ln(\beta^r) + \rho_3 \ln(s)^2 + \rho_4 \ln(s) \ln(\beta^r), \tag{42}$$

where all coefficients are positive. Note that this specification imposes that the benefit function is convex in the nominal exchange rate. We assume that the distribution for the individual-specific component of travel benefit is given by a truncated normal distribution with support $(0, 5)$, mean μ, and variance σ^2. The truncated normal distribution can be specified as:

$$K(\zeta) = \frac{\Phi\left(\frac{\zeta-\mu}{\sigma}\right) - \Phi\left(\frac{\underline{\zeta}-\mu}{\sigma}\right)}{\Phi\left(\frac{\bar{\zeta}-\mu}{\sigma}\right) - \Phi\left(\frac{\underline{\zeta}-\mu}{\sigma}\right)} \tag{43}$$

where $\Phi(\cdot)$ is a standard normal cumulative distribution function.

We further assume that the probability distribution over the number of price quotes received by a searching consumer is a truncated Poisson distribution with support $k = \{1, 2, ...\}$ given by

$$q_k = \frac{e^{-\eta}\eta^k}{(1 - e^{-\eta})k!}, \tag{44}$$

where $\eta > 0$ is the exogenous arrival rate. The expected number of price quotes with this distribution is

$\frac{\eta}{1-e^{-\eta}}$.

We now specify the particular values we use for the exogenous economy parameters. For the firms' technologies, we use the following parameters:

$$\alpha_H^H = \alpha_F^H = \alpha_H^F = \alpha_F^F = 0.1 \qquad\qquad A_H = 0.6 \quad A_F = 1.0, \tag{45}$$

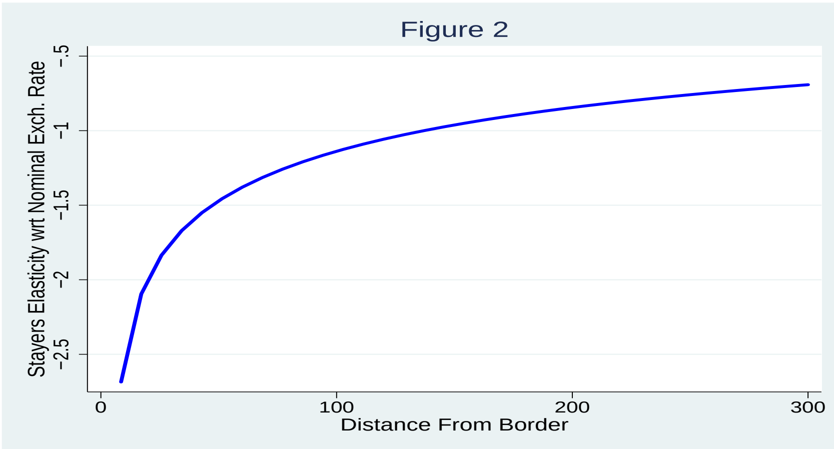
so we see that the F technology is more productive than the H technology which will lead to a lower average price in F. We set the prices of both intermediate goods and both wages to 1.0. These parameters imply the following cost functions:

$$\phi_H(s) = 3.16s^{-\alpha_F^H} \qquad\qquad \phi_F(s) = 1.90s^{\alpha_H^F}. \tag{46}$$

On the consumer side, we set the arrival rate of price quotes equal to $\eta = 1.0$ and the reservation price equal to $\tilde{p} = 5.0$. We set the parameters in the utility travel cost function as follows: $\tau_0 = 2.0$, $\tau_1 = 0.5$, and $\tau_2 = 0.3$. The parameters of the common gross benefit from travel function are given by $\beta_0 = 1.0$, $\beta_1 = 1.5$, $\beta_2 = \beta_3 = \beta_4 = 0.2$. These values guarantee that $B(s, I^r, \beta^r) - T(D_c, \gamma^r) < 0 \; \forall D_c$ to ensure that some H consumers will shop in H (see equation 28). We begin with the travel cost shifter parameter equal to $\gamma^r = .1$ and the travel benefit shifter parameter equal to $\beta^r = 2.0$ and consider the effects of changes in these two parameters on our variables of interest. We set the mean and variance of the truncated normal distribution for the individual component of the benefit of travel to $\mu = 1.8$ and $\sigma^2 = 1.0$. We set the total population in the region equal to 1000.

We begin by examining the response of endogenous variables when the nominal exchange rate increases by 20% from $s_l = 1.0$ to $s_h = 1.2$. Marginal costs in H fall by approximately 2% from $\phi_H(s_l) = 3.16$ to $\phi_H(s_h) = 3.10$ while costs in F rise by approximately 2%. This causes the average price in H to fall from $\bar{p}_H(s_l) = 4.15$ to $\bar{p}_H(s_h) = 4.11$, a .96% decrease while the average price in F rises by .93% from $\bar{p}_F(s_l) = 3.24$ to $\bar{p}_F(s_h) = 3.27$. This results in a decrease of 1.74% in the price ratio of the average price in H to the average price in F and a 17.9% increase in the real exchange rate. Thus we see that a nominal appreciation leads to a real appreciation and the nominal and real exchange rate will be perfectly correlated in this economy.

We now turn to the elasticity with respect to the nominal exchange rate of the number of consumers who do not travel – that is, the elasticity of the number of buyers who purchase from the H retailers when the H currency appreciates. The total number of consumers who shop in H falls from 615 when $s = 1.0$



to 505 when $s = 1.2$ which is an elasticity equal to -.89. Figure 2 plots this elasticity for each community (i.e. each distance category) and we see that the absolute value of these elasticities decline with distance from the border as we expect as travel costs are increasing in distance (see equation (35)). From the analysis above we know that this result implies that revenue, employment, and profits elasticities will be negative and will decrease in absolute value with distance from the border.

Figures 3-5 demonstrate this result for profit elasticities. These figures also illustrate the effects of the level of the nominal exchange rate, the travel cost shift parameter, and the travel benefit shift parameter on the elasticities. In particular, Figure 3 demonstrates that the elasticities will be higher in absolute value when the initial value of the H currency is higher. Recall that we obtain this result because we have assumed that the benefit function is convex in s. Figure 4 shows that profits are more responsive to movements in the exchange rate when the benefits from crossing are higher resulting from more U.S. stores (i.e. when β^r is larger). Finally, Figure 5 indicates that profits are more responsive when the cost of travel is lower resulting from lower gas prices (i.e. when γ^r is lower).

While these results from the theoretical model are preliminary, they are instructive in that they suggest that our future empirical specifications should include a role for variables other than distance as influencing the elasticities of firm performance levels with respect to exchange rate movements.

Figure 3

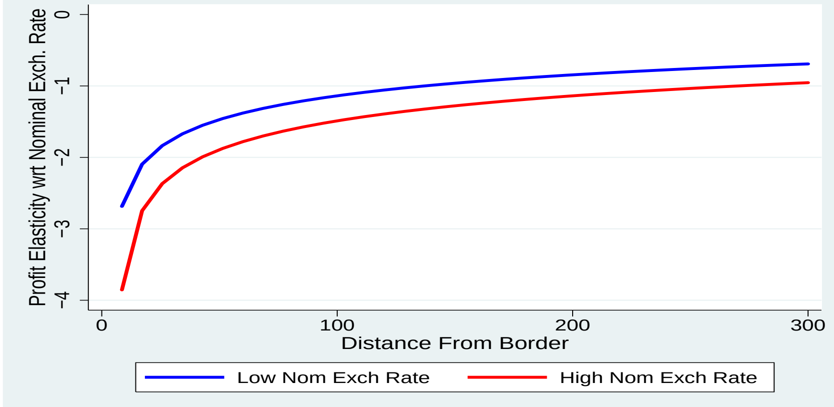
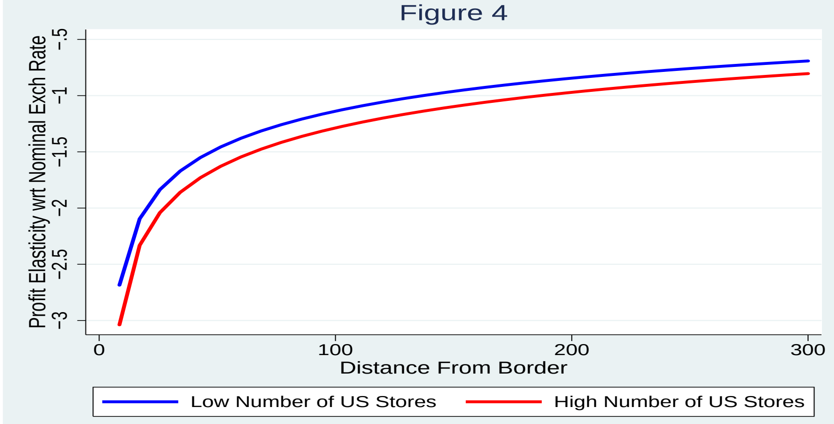
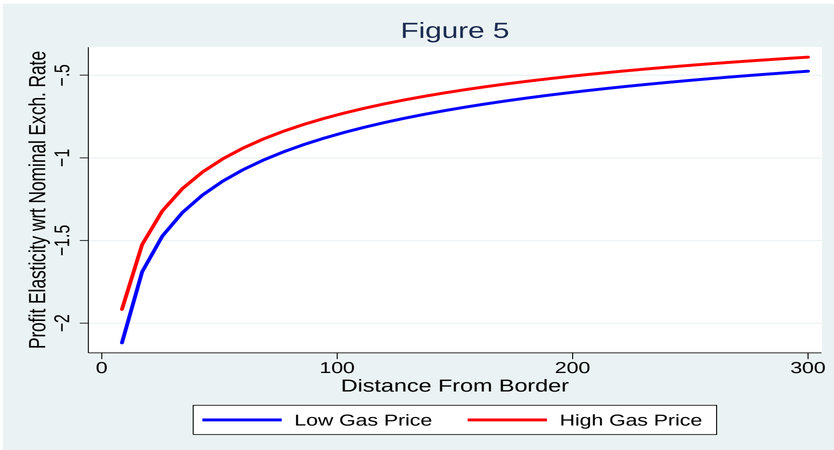


Figure 4





6 Empirical Implementation

6.1 Propensity to Cross the Border

We begin the empirical implementation with estimating parameters of the cost and benefit of cross-border trips based on equation (30). We continue assume that the individual component of net benefit, $K(\zeta)$, follows a truncated normal distribution with mean as μ and variance as σ^2. In this case, the propensity to cross equation can be estimated using a fractional probit model (Papke and Wooldridge, 1996) as indicated in Chandra, Head and Tappata (2013).

$$x_{ct}^r = \Phi\big(\theta_0 + \theta_1 \ln D_c + \theta_2 \text{post } 9/11 + \theta_3 \ln s_t + \theta_4 ctax_t^r + \theta_5 utax_t^r + \theta_6 \ln I_{ct}\big) \tag{47}$$

where a region, r, is defined by border post while a community, c, is defined by Census Division. Here, the crossing rate in each community, x_{ct}^r, is calculated in two steps based on the method developed by Chandra, Head and Tappata (2013). The first step is to estimate the share of crossers from each community c based on the International Traveler Survey (ITS) and then use these shares to portion crossers in each associated border post. The second step is to compute the propensity to cross as the estimated number of crossers

Table 3: Same-Day and Overnight Crossing Rates

	Same Day	Overnight	Combined
	(1)	(2)	(3)
Nominal Exchange Rate	1.081**	0.709**	1.026**
= ln(Nominal ER)	(0.105)	(0.050)	(0.088)
Canadian Sales Tax	3.086**	2.071**	3.008**
= ln(1+PST+GST)	(0.533)	(0.277)	(0.461)
State Sales Tax	2.065	2.915*	2.604
= ln(1+State Sales Tax)	(2.312)	(1.222)	(1.964)
Median Community Income	-0.192**	0.260**	-0.039
= ln(median income)	(0.070)	(0.033)	(0.059)
Median Community Distance	-0.383**	-0.071**	-0.343**
= ln(median distance)	(0.009)	(0.004)	(0.007)
Post 9/11 Dummy	-0.186**	-0.028	-0.151**
= 1 if year $\geq$ 2002; = 0 otherwise	(0.039)	(0.019)	(0.033)
Time Trend	Yes	Yes	Yes
Border Post Fixed Effects	Yes	Yes	Yes
Log-Likelihood	-310.867	-101.732	-376.078
Observations	13,216	13,216	13,216

$**$ p<0.01, $*$ p<0.05, + p<0.1.

Robust standard errors (adjusted for clustering at the border post level) in parentheses.

from each community divided by the potential number of trips per year (population at census division c times 365 days).[11] Here, we have computed both same day and overnight crossing rates. Distance, $\ln D_c$, is measured by the median of network distance from a census division to the closest land border post and the other factors affecting the cost of cross-border trips is approximated by a post-9/11 dummy which captures increased border-waiting time following 9/11. $\ln s_t$ is the logarithm of nominal exchange rate.[12] In addition, we also include sales tax rates in Canada and adjacent US states. Income ($\ln I_{ct}$) is measured by median income by Census Division.

Note that with truncated normal distribution, coefficient estimates are cost and benefit function parameters scaled by $1/\sigma$ (Chandra, Head and Tappata, 2013). For instance, $\theta_1 = \tau_1/\sigma$. As σ is not observable, we assume $\sigma = 1$ in subsequent calculations. Here, we drop the price of gasoline as the price of gasoline has insignificant coefficient estimates across specifications. We also drop business activities at the border counties as counties with more business activities are adjacent to more populated communities in Canada, making the propensity to cross difficult to interpret. Table 3 reports the results of estimating equation (47). Column 1 presents results for same-day crossing rate. Consistent with predictions from the theoretical model that both of the cost determinants, distance and post 9/11 indicator, have negative effects on propensity to cross while exchange rate and Canadian sales tax have positive effects. At the

[11] Refer to Appendix B for a detailed description.

[12] Here we use nominal exchange rate to be consistent with the theoretical model. In unreported results, we use real exchange rate and the results are very similar.

same time, median income has a negative effect. This may indicate that lower income households are more keen on cross-border arbitrage. Column 2 summarizes results for overnight crossing rate. Comparing column 2 to column 1, we observe that the magnitude of exchange rate, Canadian sales tax, and median distance effects are smaller for overnight trips. Smaller distance effect may because longer stay makes distance less costly per day. Here, community median income has a positive and significant effect. As overnight trips may be primarily for the purposes of vacation and visiting relatives, cost saving from shopping in the US become less important, and higher income households may be more likely to bear the cost of these trips. Interestingly, the post 9/11 indicator has little effect on overnight crossing rate. This may suggest that longer length of stay makes increased border waiting time after 9/11 less costly on average as compared to same-day trips or travelers may take fewer and longer trips because of longer border waiting time.

6.2 Exposure to Cross-Border Shopping

We then can apply the parameter estimated from equation (47) to the elasticity to stay with respect to exchange rate (ϵ_s^λ) to measure how sensitive community c in region r is to exchange rate changes. Under truncated normal distribution specified in equation (43), it can be specified as:

$$\epsilon_s^\lambda = \frac{dK(\zeta^*)}{K}(-B\epsilon_s^B) = \frac{-\phi(\frac{\zeta^*-\mu}{\sigma})(\theta_1)}{\Phi\left(\frac{\zeta^*-\mu}{\sigma}\right) - \Phi\left(\frac{\underline{\zeta}-\mu}{\sigma}\right)} \tag{48}$$

where $\phi(\cdot)$ is a standard normal distribution function, and $(\frac{\zeta^*-\mu}{\sigma}) = -(\theta_0+\theta_1 \ln D_c+\theta_2 \text{post } 9/11+\theta_3 \ln s_t+\theta_4 ctax_t^r + \theta_5 utax_t^r + \theta_6 \ln I_{ct})$. Note that as the coefficients are estimated from the propensity to cross equation, the sign of coefficients has to be reversed when applied to the decision to stay. As discussed in the previous subsection, all the coefficients estimates are the cost and benefit function parameters scaled by $1/\sigma$. We can then substitute distance to the closest border post, sales tax rates, median income of different communities in equation (48) and compute their elasticity of staying with respect to the exchange rate. To interpret the meaning of magnitude, we compare elasticities of different communities to a hypothetical community located 1 km away from the border, before 9/11 and with all other variables at means. As it measures the relative sensitivity of consumers decision to stay (and shop) at the community with respect to the exchange rate, this can be regarded as the degree of exposure to cross border shopping facing Canadian retailers. We then refer to this as an exposure measure.[13]

[13] In the computation, we assume that $\underline{\zeta} = 0$, $\mu = 1.8$ and $\sigma = 1$.

Table 4: Exposure Measure of Selected Canadian Cities

Year	Nominal ER	Saint Catharines (21 KM)	Vancouver (48 KM)	Montreal (62 KM)	Saint John, NB (113 KM)	Ottawa (95 KM)	Toronto (130 KM)
		(1)	(2)	(3)	(4)	(5)	(6)
1991	0.873	0.342	0.210	0.210	0.162	0.130	0.109
2002	0.637	0.149	0.091	0.073	0.046	0.042	0.035
2006	0.882	0.244	0.158	0.134	0.087	0.083	0.073
Year	Nominal ER	Winnipeg (113 KM)	Quebec City (144 KM)	Regina (164 KM)	Calgary (257 KM)	Saskatoon (419 KM)	Edmonton (549 KM)
		(7)	(8)	(9)	(10)	(11)	(12)
1991	0.873	0.126	0.118	0.078	0.033	0.037	0.017
2002	0.637	0.040	0.035	0.020	0.008	0.008	0.003
2006	0.882	0.078	0.067	0.045	0.018	0.020	0.008

The nominal exchange rate is expressed as US dollar per Canadian dollar. Source: CANSIM.
Driving distance to the closest land border posts are reported in the parentheses.

Table 4 reports the exposure measure for selected cities based on their distance to the border, median income, sales tax rates and exchange rate faced in three representative years – 1991, 2002 and 2006. In the last three decades, the Canadian dollar has experienced large and persistent appreciations and depreciations. The value of Canadian dollar was climbing in the late 1980s and reached one of the highest levels in 1991. It then experienced a 10-year currency depreciation and reached the lowest level in 2002. After 2002, the Canadian dollar appreciated again and reached the 1991 level in year 2006. Column 1 shows that for a border community like Saint Catharines (about 20 km from the border), the consumers are 34% as sensitive to exchange rate changes as compared to a hypothetical community at 1 km from the border when the exchange rate is at the 1991 level. When the exchange rate arrive the 2002 level, it was reduced to 15%, suggesting that retailers face less responsive consumers. When the exchange rate swang back to the 1991 level in year 2006, the exposure measure increased to 24%, which is about 10 percentage points smaller than 1991. This can be primarily attributable to the post-9/11 border control, making crossing the border more difficult. For communities located moderately farther away from the border, such as Vancouver and Montreal, the exposure measure becomes around 30% smaller. The magnitude of exposure measure diminishes sharply with distance from the community to the border. For a community located about 145 km away from the border, such as Quebec City, the size of exposure measure is one-third the size as compared to Saint Catherine. For communities located far away from the border, such as Calgary and Edmonton, the exposure measure becomes close to zero.

7 Conclusions and Future Work

Consistent with the findings of Chandra, Head, and Tappata (2013), we find that cross-border trips, especially by Canadian travelers are highly responsive to exchange rate changes, supporting the theory that increases in relative prices in Canada motivates some Canadian consumers to engage in cross-border shopping. Our empirical analysis using firm-level data for Canadian retailers from 1986 to 2007 suggests that cross-border trips by Canadians have an adverse effect on Canadian retailers' sales while trips by US residents have a positive effect. Our results also indicate that these effects diminish with distance of the retailer to the border. Furthermore, the magnitude of these effects varies considerably across the retail industries that we study.

We have developed a theoretical model of retailers with variable mark-ups and consumers who make a cross-border travel decision. The model provides predictions regarding the relationships between firm and regional characteristics and the magnitude of the effects of real exchange rate changes and resulting cross-border travel activity on the sales, employment, and profits of retailers. We are taking the theoretical model to data. Our preliminary results suggest that consumer propensity to cross the border is responsive to the exchange rate and smaller for communities located farther from the border. We also use the estimated parameters to measure the degree of exposure to cross-border shopping for Canadian cities. As the impact of community travel decision on retailers depend not only on consumer travel decision but also on the transportability of goods in cross-border trips and firm/industry characteristics. Guided by the theoretical model, we will investigate the effect of consumer travel on retailer performance for different industries in our future work.

Appendix

A Data

A.1 Firm-level Data

In this paper, the retail trade industries and food & accommodation industries include the union set of the industries in 1980 SIC-E and 2007 NAICS classifications reported in Table A.1.

We have converted 1980 SIC-E used in earlier years to 2007 NAICS. Generally speaking, using the 2007 NACIS, the grocery store sub-sample include industries 4451 and 4452, accommodation, 721, food services, 722, gasoline service stations, 447, apparel & general retail, 448 and 452, appliances & furniture, 442 and 443.

As discussed in Baggs et. al. (2009), in the T2LEAP database, a small fraction of firms have some years missing possibly due to late filing and reappeared in later years. In this case, the missing years where removed from the analysis but the firms are still classified as continuing firms. In the data cleaning process, we remove observations with profit-sales ratio in the top and bottom 0.5 percentile or leverage below the 99^{th} percentile as these can be considered extreme values. We also removed observations with negative value in sales or assets. Before empirical analysis, we deflate sales using industry and province specific CPI (2002 = 100), and deflate assets as well as profits using province specific CPI. The CPI data are obtained from the CANSIM database

Table A.1: Industry Classification

1980 SIC-E	Description	2007 NAICS	Description
60	Food, Beverage and Drug, Retail	441	Motor Vehicle and Parts Dealers
61	Shoe, Apparel, Fabric and Yarn, Retail	442	Furniture and Home Furnishings Stores
62	Household Furniture, Appliances and Furnishings, Retail	443	Electronics and Appliance Stores
63	Automotive Vehicles, Parts and Accessories, Sales and Service	444	Building Material and Garden Equipment and Supplies Dealers
64	General Retail Merchandising Industries	445	Food and Beverage Stores
65	Other Retail Store Industries	446	Health and Personal Care Stores
69	Non-Store Retail Industries	447	Gasoline Stations
91	Accommodation Service Industries	448	Clothing and Accessories Stores
92	Food and Beverage Service Industries	451	Sporting Goods, Hobby, Book and Music Stores
		452	General Merchandise Stores
		453	Miscellaneous Store Retailers
		454	Non-Store Retailers
		721	Accommodation Services
		722	Food Services and Drinking Places
		8111	Automotive Repair and Maintenance

A.2 Cross-Border Trips

Traveler data are from the CANSIM database and from the Tourism and the Centre for Education Statistics Division (TCESD). In total, 107 border posts are included in our analysis. They are either land border posts or ferry docks. In the data, some border posts were reported together before 1990, and Windsor Bridge and Tunnel were reported together for confidentiality reason. For this reason, we combine the traveler data for the following border post groups: Lacolle Route 15, 221 and 223; Rock Island Rt 55 and 143 (Stanstead); Emerson East and Emerson West Lynne; Armstrong and Ste Aurelie; Windsor Tunnel and Ambassador Bridge; Pacific Highway and Douglas.

B Consumer Propensity to Cross

Consumer propensity to cross is constructed using Chandra, Head and Tappata's (2013) method. It involves two stages. The first stage is to estimate the number of trips from each census division, it is computed using the following formula:

$$\hat{n}^r_{ct} = \frac{T^r_{ct}}{\sum_{c \in r} T^r_{ct}} n^r_t,$$

where $\hat{n}^r_{ct}$ is the estimated number of trips from community c, T^r_{ct} is the number of trips from community c based on the International Traveler Survey (ITS). We use the share of trips from community c in trips from all Census Divisions close to region r to portion the total number of trips going through post r from CANSIM. As the ITS is available only after 1990 while the cross-border trips data can be extended to 1986, we use the 1990 share of trips to portion cross-border trips data before 1990.

The second stage is to compute the propensity to cross as the number of trips divided by the number of potential trips. The number of potential trips is the number of population in community c times 365 days as each resident can potentially take multiple trips in a year and the maximum number of trips a resident can take is 365 trips. That is:

$$x^r_{ct} = \frac{\hat{n}^r_{ct}}{365 \times \text{population}^r_{ct}}.$$

When defining communities and regions, we encounter the case of one census division has firms close to different border posts. In this case, we use the fraction of firms in community c and region r to portion population from a Census Division to different communities. Here, the distance between each community

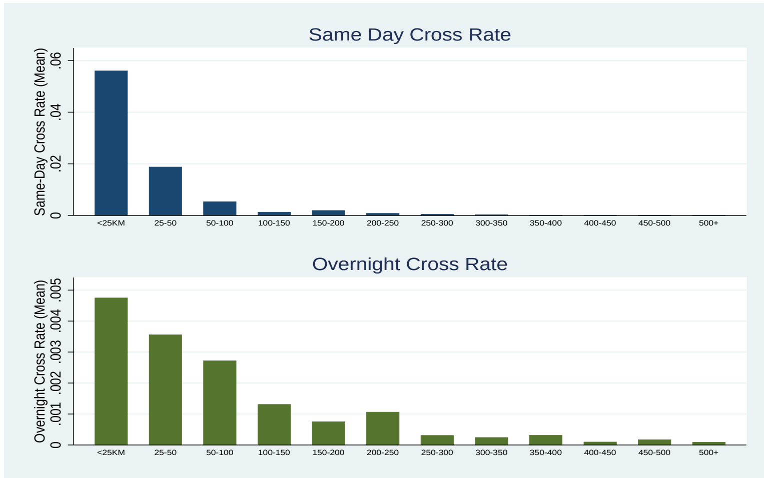


Figure A.1: Propensity to Cross the Border and Distance, 1986-2007

and the closest land border post is the median distance among all firms in this community.

Figure A.1 shows the relation between same-day crossing rate, overnight crossing rate and distance. Overall, the pattern suggest that there is a higher propensity to take same-day trips as compared to overnight trips and that same-day crossing rate diminishes quickly with distance while overnight trips diminishes at a slower speed. The average same-day crossing rate is close to zero for communities located beyond 300 km from the border. Figure A.2 summarizes the relation between same-day crossing rate and the real exchange rate and it suggests a positive relation between same-day crossing rate and the value of Canadian dollar. Interestingly, this positive relation is weakened after 2002 – when the value of the Canadian dollar climbed back to the 1991 level, the crossing rate did not take off as much as in the early 1990s.

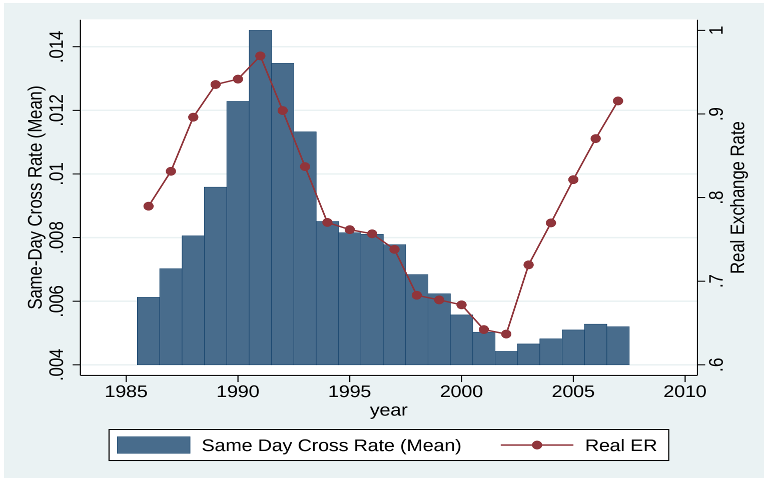


Figure A.2: Propensity to Cross the Border and the Exchange Rate, 1986-2007

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