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VIRTUAL BORDERS: ONLINE NOMINAL RIGIDITIES AND INTERNATIONAL MARKET SEGMENTATION

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Virtual Borders: Online Nominal Rigidities and International Market Segmentation
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ABSTRACT

Do prices respond to macro shocks? Does the mere presence of international frontiers hinder trade? We revisit these questions by studying a dataset of online book prices for a number of US and Canadian retailers. We believe our dataset is well suited to this task for a number of reasons: (1) data for multiple retailers are available; (2) the products sold are identical across retailers; (3) the sample spans a period of large fluctuations in the bilateral exchange rate; (4) the nature of the industry is such that physical distance is irrelevant beyond shipping costs which are observable; (5) nominal frictions in the form of menu costs are arguably minimal; and (6) proxies for sales are available for most retailers. Given the unique nature of our dataset, the first objective of the paper is to document the degree of price rigidity and price dispersion. Our main findings are: online book prices display significant stickiness; there is a large degree of heterogeneity across retailers in terms of price rigidity and pricing strategy; price dispersion is high both within and across borders. Also, price levels do not appear to respond to exchange rate fluctuations. Building on the predictions from a simple two-country, multi-firm model and by exploiting information contained both in prices and quantities, we show that market segmentation is probably behind this disconnect .

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1. Introduction

How quickly and to what extent do prices respond to market forces? These questions are central to our understanding of what drives macroeconomic fluctuations and of how to best mitigate them. Different assumptions lead to fundamentally different views of how the economy works and the actual scope for stabilization policies. Given the importance of these questions, it is not surprising that a large empirical literature has developed to investigate the behaviour of prices.

The recent micro evidence on price setting behaviour finds that prices are changed relatively frequently – compared to what is typically assumed in the macro literature – but also that there is considerable heterogeneity.[1] While this unconditional micro evidence is certainly useful for checking whether a specific friction – e.g. menu cost – is consistent with the behaviour of disaggregated prices, it is not clear that it addresses the fundamental questions stated at the outset. Our view regarding the sources of macroeconomic fluctuations and the role of stabilization policies depends not only on how frequently prices are changing, but also on how they are adjusting to market forces. For instance, firms could be implementing frequent price changes automatically through arbitrary rules of thumb without regard for the overall market conditions. Alternatively, firms might be changing prices quickly in the face of some shocks and slowly when faced with others.[2] It is therefore necessary to move

[1] Looking at disaggregated prices from the Consumer Price Index, Bills and Klenow (2005) find that the average duration for prices is 4.3 months, with considerable heterogeneity across sectors and types of goods and services. This evidence is inconsistent with the duration needed in a macro model to match the persistence of aggregate prices. Nakamura en Steinsson (2008) and Klenow and Kryvtsov (2008) find a longer duration of prices, somewhere between 7 and 9 months. But Nakamura and Steinsson (2008) find that prices changes are highly seasonal and that the hazard function is downward sloping, both facts being inconsistent with the typical menu cost models considered in the macro literature.

[2] For instance the evidence reported in Boivin, Giannoni and Mihov (2009) and Mackowiac, Moench and Wiederholt (2009) would be consistent with price setters responding more quickly to disturbances emanating from their sector than to economy wide forces.

beyond summary statistics on the frequency of price changes and to attempt to document whether and how prices are responding to particular developments.

For an open economy, one particularly important market force that should in principle affect the pricing decision is the exchange rate. For instance, in October of 2007, the Canadian dollar reached and went beyond parity against the US dollar for the first time in more than thirty years, having experienced a dramatic increase of about 30% against the US dollar over the previous three years. From the perspective of Canadian consumers, this rapid appreciation of the Canadian currency made many goods and services quite expensive at home compared to the US. This led to consumer uproar culminating on October 23rd with an explicit call by the Finance Minister for Canadian price setters to lower their prices, citing as an example the Harry Potter book, which at the time was selling for 20% less in the US. His argument was that "[t]here should not be large discrepancies between similar products just because they're being sold on different sides of [the] border."[3]

However, it may not be surprising for prices to react very little or not at all to exchange rate fluctuations if firms face constraints to price adjustment and/or there is a high degree of international market segmentation between the US and Canada. For example, we should expect that small frictions will prevent consumers from taking advantage of lower grocery prices across the border. In addition, products are often tailored to local markets, and may therefore not be perfect substitutes.[4]

In this paper we revisit the relationship between price adjustments and exchange rate fluctuations in the context of the US-Canada online book industry. This is a market in

[3] "Canadian retailers should lower prices 'as soon as possible': Flaherty", *www.cbc.ca*, October 23rd, 2007.

[4] This is why, for instance, in their empirical analysis, Burstein and Jaimovich (2009) and Gopinath et al. (2009) study wholesale prices where the scale of transactions should give firms a larger incentive to take advantage of deviations from the law of one price. One could argue, however, that while the benefits could be large, the costs for a retailer of switching wholesaler may also be sizeable.

which a priori we would expect nominal rigidities and trade frictions to be minimal. What are the features that make this market and our data set appropriate for this type of study? First, each product is identical across retailers, which makes our analysis immune to issues of quality, packaging, and size differences which are present in the data used in earlier studies (e.g. Broda and Weinstein, 2008). Second, price comparisons can be readily done online and so shopping or search costs should be orders of magnitude lower than for non-online items. Third, according to the NAFTA agreement, books are not subject to trade restrictions or tariffs and there are no constraints on buying books from foreign websites between these two countries. Fourth, the nature of the industry is such that the physical concept of distance is irrelevant: the consumer does not have to travel to purchase the good and rather must incur shipping costs, which we observe. Fifth, Canada and the US are among the most economically integrated countries in the world, with similar tastes and economic environments. Sixth, data for multiple retailers are available which is important for distinguishing between cross-country vs cross-retailer heterogeneity. Finally, for some websites, we have proxies for (relative) sales, which makes it possible to study the reaction of quantities to movements in international relative prices.

We collected data three times a week, between March 2008 and June 2009, from the websites of the main players in the online retail book market, both in the US (*Amazon.com* and *BN.com*) and in Canada (*Amazon.ca* and *Chapters.ca*). A book is added to our sample as soon as it appears on one of the New York Times Bestsellers Hardcover lists. The subsample we use for this study consists of more than 140,000 price quotes. In line with previous studies, we find very little evidence that exchange rate fluctuations influence local-currency prices.[5] As the value of the Canadian dollar versus its American counterpart fell by more

[5]For recent empirical evidence on this topic, see for example Burstein and Jaimovich (2009), Crucini and Shintani (2008) and Gopinath et al. (2009).

than 20% between June 2008 and March 2009, book prices moved from parity to being on average 22% cheaper in Canada.

Since price differences across countries may naturally arise from the presence of nominal rigidities (see Engel and Rogers, 1996), we first document the unconditional behaviour of prices in our data set. This part of the empirical investigation also allows us to shed further light on the micro evidence on the frequency of price adjustment, for prices that should not be subject to important menu costs. Looking at summary statistics for all books and retailers in our data set, we find that online book prices change considerably more frequently than anything reported in the literature before: the average price duration in the U.S. is about one month, whereas the median is about one week. However, such summary statistics are misleading as they mask considerable heterogeneity across retailers and countries. For example, the median price duration for *Amazon.ca* is four times greater than for *Amazon.com*. Differences across retailers also apply to most other pricing dimensions. Overall, despite the ease with which these prices can be changed online prices still display significant price stickiness.

Deviations from the law of one price (LOP) could also be consistent with the presence of a border effect: various frictions may lead to a *de facto* market segmentation across countries, which insulates prices from the need to respond to exchange rate movements.[6] In our dataset, deviations from the law of one price are widespread and sizeable, with cross-border discounts of the order of 10%-20% being quite common. However, before drawing conclusions about international market segmentation, we need to evaluate this variation in international prices in the context of the dispersion of online book prices within country. We find that price

[6] Such frictions could include: international transaction costs (such as those implied by the use of different monies), regulatory costs, differences in national tastes, market conditions, differences in local production, and shipping costs.

differences between the two US retailers are large: prices at *BN.com* are on average 20% higher than at *Amazon.com*, with more than 93% on the books in our data set being cheaper at *Amazon.com*. This is surprising if one comes from the view that the internet should reduce consumer search costs but is consistent with evidence previously documented in the industrial organization literature.[7] Nonetheless, the presence of such a high dispersion in the US highlights the challenge of attributing the dispersion in prices between Canada and the US to a border effect. Once a friction is introduced to explain the large dispersion of prices within country, it is not clear how the effect of this friction can be disentangled from a border effect, at least not without imposing the restrictions of a theoretical model.[8]

Since international price differences alone do not imply international market segmentation, to make further progress we use a simple two-country, multi-firm model in which retailers in the same country are assumed to be distributed in consumer preference space (for example as a result of their website design) and where buying from a foreign retailer represents a border cost leading to a form of home bias. This is a version of Salop (1979) where physical distance is re-interpreted as distance in the consumers' preference space. The model predicts that if markets are internationally integrated, retailers would react to the exchange rate for products whose prices are competitive relative to the foreign alternative. If markets are segmented, prices would not react. This result, however, is conditional on prices being flexible. In the presence of nominal rigidities, the task is more complex: the lack of response of prices to exchange rate fluctuations could be due to market segmentation or the fact that prices are sticky. To sort this out, we also look at the behaviour of (relative) quantities: if markets are completely segmented, quantities should not respond to the exchange rate.[9]

[7] Other studies have found similar evidence in various online markets. See for example Baye, Morgan and Scholten (2004), Clay et al. (2002), Ellison and Ellison (2007),

[8] See Gorodnichenko and Tesar (2009) for a formal discussion of this identification issue.

[9] In another context, Campbell and Lapham (2004) show that the number of retail establishments along

We test these predictions in our dataset. First, we find no significant relationship between cross-border price differentials and the timing of price changes: a book in violation of the law of one price is not more likely to be repriced. In addition, when prices do change, there is no conclusive evidence that they move in a direction consistent with the predictions of the model. In addition, the behavior of quantities does not seem to display any systematic relationship with the exchange rate. Overall, these results are consistent with the presence of international market segmentation.

The rest of the paper is organized as follows. Section 2 describes our dataset. Section 3 documents stylized facts about the frequency at which prices and reference prices are changing in our data set, while Section 4 describes the within and cross-country price dispersions. Section 5 presents a theoretical model that is consistent with the presence of both national and international price differences. Section 6 investigates the predictions of the model empirically, and Section 7 concludes.

2. Data

We collect data from websites of the main players in the online book market, both in the US (*Amazon.com* and Barnes and Noble's website, *BN.com*) and Canada (*Amazon.ca* and *Chapters.ca*). *Amazon.com* is by far the leader in terms of market share on the US market, while the Canadian market appears to be more evenly split.[10] Our main variable of interest is the price advertised, but we also collect additional information such as the list price, membership price, sales rank (when available), author, title, publisher and publishing date. A book is added to our sampling universe as soon as it appears on the New York Times

the US-Canada border responds to exchange rate movements.

[10] An interesting question is how distinct *Amazon.com* and *Amazon.ca* are in reality. In fact, the next sections will show that their pricing strategies are very different.

Bestsellers hardcover list, which includes four categories: Hardcover Fiction, Hardcover Non-Fiction, Hardcover Advice and Hardcover Business. Hardcovers are new to the market and don't have competing editions, while paperbacks may have multiple ISBN numbers for multiple editions. Bestsellers lists are released each week on Saturday, except once a month for Hardcover Business. A given book is uniquely identified by its ISBN, and is therefore identical in Canada and the US: there are no differences in packaging, size or content. This also precludes potential product substitution (e.g. for a paperback version), since this would lead to a new ISBN. The period studied is from March 2008 to June 2009, and information is retrieved three times a week, on Mondays, Wednesdays and Fridays. It should also be noted that most books in our sample are printed in the US.

For most of our empirical analysis, we start the sample on June 2, 2008 in order to get a set of books of significant size. The sampling period ends on June 29, 2009. Also, we restrict our attention to the 213 books for which price quotes are available on at least 95% of the sampling dates. This leaves us with a total of 141,646 price quotes. We also observe shipping costs for all retailers as well as sales rankings for *Amazon.com*, *BN.com* as well as *Amazon.ca*. Though the algorithms behind the rankings are proprietary, we will still use them as proxies for (relative) sales. All retailers offer international shipping, and shipping charges can be computed for any order size. This information will be used in subsequent analysis.

Books in our sample range in price from $4.59 to $40, with an average of $18.75 and a median of $18.39 (all local currency dollars). The average book price has experienced an inflation of 6.5% over the 13 months of our sample.

3. Facts on nominal rigidity

We first document the degree of price rigidity in our dataset, delaying the discussion on price dispersion to Section 4.. The main findings in this section are: online book prices are sticky, with a frequency of price changes of less than 4%; the duration of price spells appears lower than for books sold in brick-and-mortar stores; the sampling frequency can alter significantly the measure of price rigidity; small price changes are prevalent; and there is a tremendous degree of heterogeneity in pricing behavior across retailers.

As a first step, we compute the fraction of observations which are characterized by a price change over the period June 2, 2008 to June 29, 2009. At this point no attempt is made at purging our dataset of sales and temporary price changes. Therefore, for a given book, a price change occurs if the price of a given book/retailer is different than for the previous observation's price. Recall that there are three price quotes per week.

The first two columns of Table 1 show the presence of significant price stickiness in our dataset, with only 3.6% of observations characterized by price changes. In other words, on average 96.4% of prices do not change between two sampling dates (2 or 3 days). As evidenced elsewhere in the literature, price decreases account for a large fraction of price changes despite significant positive trend inflation over the sample: 48% and 52% of price changes are price decreases and increases respectively. There are, however, large differences across retailers: the frequency of price changes is above 8% for *BN.com* but barely 0.5% for *Chapters.ca*. One could hypothesize that firms with brick-and-mortar operations (Barnes and Noble and Chapters) may wish to limit price fluctuations because of the presence of menu costs or in order to avoid creating wedges between store and online prices. Yet, there is no evidence in this dataset that firms with physical stores have stickier prices than internet-only retailers.

We do not find any clear evidence that retailers change prices more frequently around Thanksgiving (November) and Christmas season. However, firms appear to have changed prices most in January 2009, with a maximum frequency of 6.5%, and the least in May 2009 (1.9%). Time variation in the frequency of price changes is even more pronounced for individual retailers. For example in 2008, 10.5% of *BN.com*'s price observations were price changes, but only 5.6% in 2009. Part of the explanation seems to be that Barnes and Noble puts newer books on sale more frequently. However, for *Amazon.com*, the pattern is reversed: prices are stickier in the first half of the sample (2.6% in 2008 versus 7% in 2009).

Table 1: Frequency of price changes.

Frequency (%)	All	US	Canada	Amz US	BN.com	Amz CA	Chapters.ca
Price change	3.62	6.43	0.82	4.58	8.26	1.05	0.58
Decrease	1.72	3.13	0.33	2.35	3.89	0.41	0.24
Increase	1.90	3.30	0.49	2.23	4.37	0.64	0.34
No change	96.38	93.57	99.18	95.43	91.74	98.95	99.41
Price change (weekly sampling)	5.44	9.09	1.84	7.88	10.25	2.41	1.26
Price change (monthly sampling)	6.83	10.27	3.38	10.52	10.02	4.26	2.50

Next, individual price series are arranged into price spells. A spell starts when a new price is implemented and ends when it is changed again by the retailer. The maximum length of a price spell in our dataset is therefore thirteen months (392 days). This in turn means that due to censoring, the mean duration results are lower-bound estimates. Figure 1 shows histograms of price spell durations across all retailers as well as for three of the firms in our sample. For *BN.com*, barely 0.5% of price spells hit the upper bound of thirteen months. At the other extreme, more than 20% of price spells of *Chapters.ca* last 392 days. On aggregate, around 70% of price spells have a duration of less than a month. Table 2 shows that the average and median price durations are 56.8 and 7 days respectively, from a

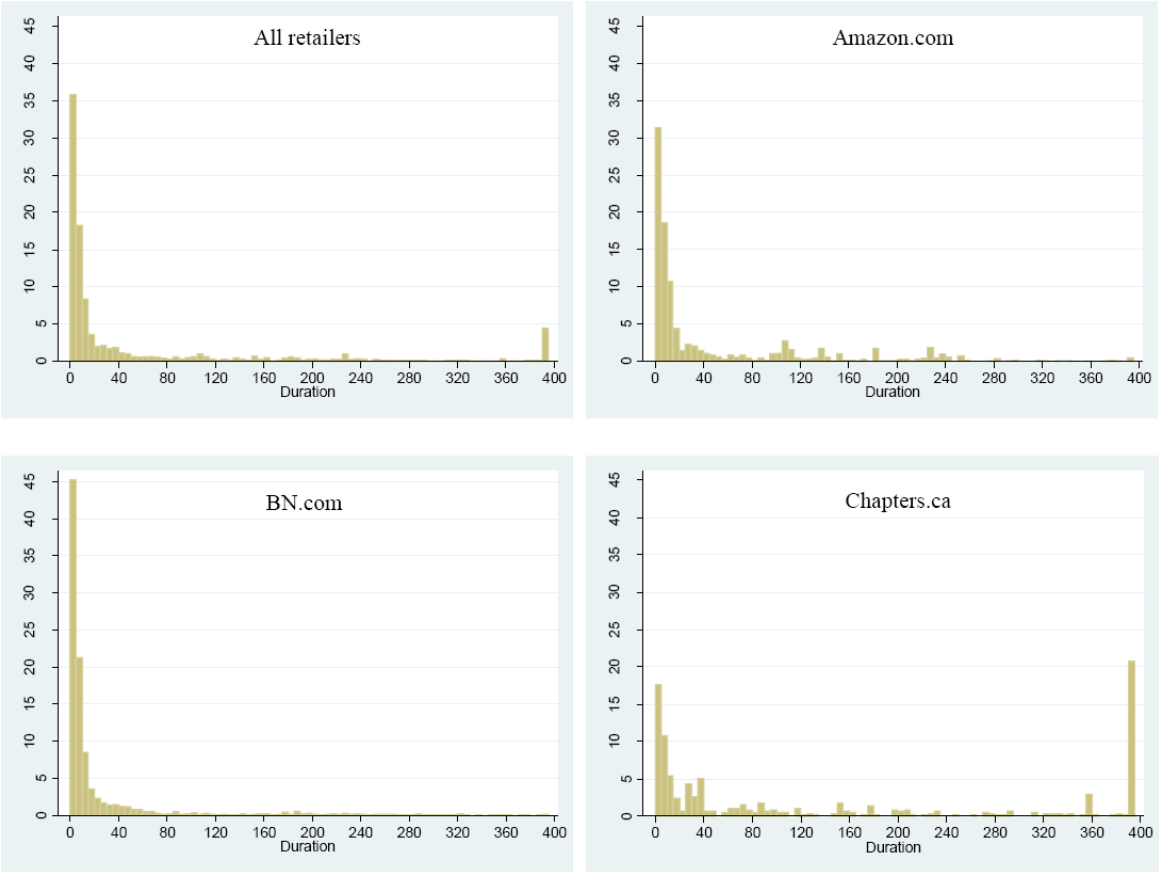

Figure 1: Histogram of price spell durations, in days.

minimum median duration of 5 days for Barnes and Noble to a maximum of 173 days for Chapters.

Comparisons with other findings in the literature are complicated by the fact that our dataset uses a much higher sampling frequency than most other studies.[11] For example, Nakamura and Steinsson (2008) using CPI monthly data find that the frequency of price changes is 5.4% per month for the category "Books not purchased through book clubs" over

[11] In addition, other databases may include non-internet retailers as well as a sample of books which is different than ours

Table 2: Duration of price spells. *Implied mean duration is equal to -1/log(1-f), where f is the price change frequency.*

Duration (days)	All	US	Canada	Amz US	BN.com	Amz CA	Chapters.ca
Mean duration	56.8	34.3	165.7	47.2	27.0	124.0	198.9
Implied duration	27.1	15.0	121.5	21.3	11.6	94.7	171.9
Median duration	7	7	96.5	10	5	47	173
Median duration (weekly sampling)	28	21	164.5	28	21	91	287
Median duration (monthly sampling)	120	90	300	90	90	210	360

the 1998-2005 period. The average implied duration, at 18 months, is almost twenty times higher than in our sample. However, by construction the duration of a price spell in their case is bounded below at one month. It is possible that by using a monthly frequency they miss a large number of price changes between sampling dates. A natural question therefore arises: would our results be significantly different with lower frequency data? The last two rows of Table 2 show the median duration when prices are instead sampled at weekly and monthly frequencies.[12] We find that the median duration is now four times higher at 4 weeks. Duration results rise for all retailers. For monthly sampling, the median and mean increase to 4 and 5.3 months respectively. The evidence therefore seems to show that the sampling frequency used can significantly alter the conclusions we reach about the degree of price rigidity present in the data. However, it remains that the monthly implied duration obtained using the frequencies from Table 4 is still only half that of Nakamura and Steinsson. This could be due to a number of factors: differences in pricing behaviour between online stores and physical retail outlets, variations in sets of books or retailers, differences in sample periods, etc.

[12]The weekly numbers are based on taking the Wednesday price observations. We obtain similar results when considering Mondays or Fridays instead. For the monthly durations, sampling is done using the observation closest to the 25th day of each month.

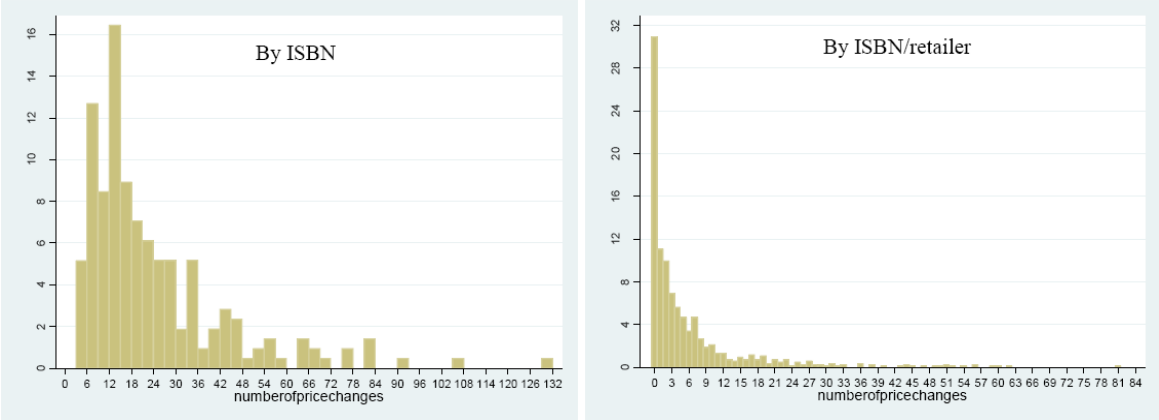

Figure 2: Distribution of the number of price changes

The plot on the left in Figure 2 shows the distribution of the number of price changes across books (ISBN), irrespective of retailers. There is actually no book whose price has not been changed by any retailer over the whole sample. The median is equal to 17, the mode is 14, and the maximum 131 price changes over thirteen months. There is a non-negligible set of books for which the number of price changes is greater or equal than 25 times over the sample period. However, this once again hides a large degree of retailer heterogeneity. The second plot in Figure 2 instead depicts the distribution of price changes across book-retailer pairs; in this case, slightly more than 30% of book-retailer pairs experienced no price changes. This confirms that price fluctuations are largely driven by a few retailers.[13]

A look at Figure 3 shows the size of price changes varies widely across firms. Barnes and Noble, for example, generally changes its prices by -14% or 12%, and almost never by less than 10%. Conversely, *Amazon.ca* implements numerous small price changes.

It is debatable whether price changes due to temporary, short-lived sales are particularly relevant to understand lower frequency macroeconomic phenomena. For this reason, most

[13]The median for the number of price changes by ISBN ranges from 0 for Chapters and Amazon.ca, to 8 for Barnes and Noble.

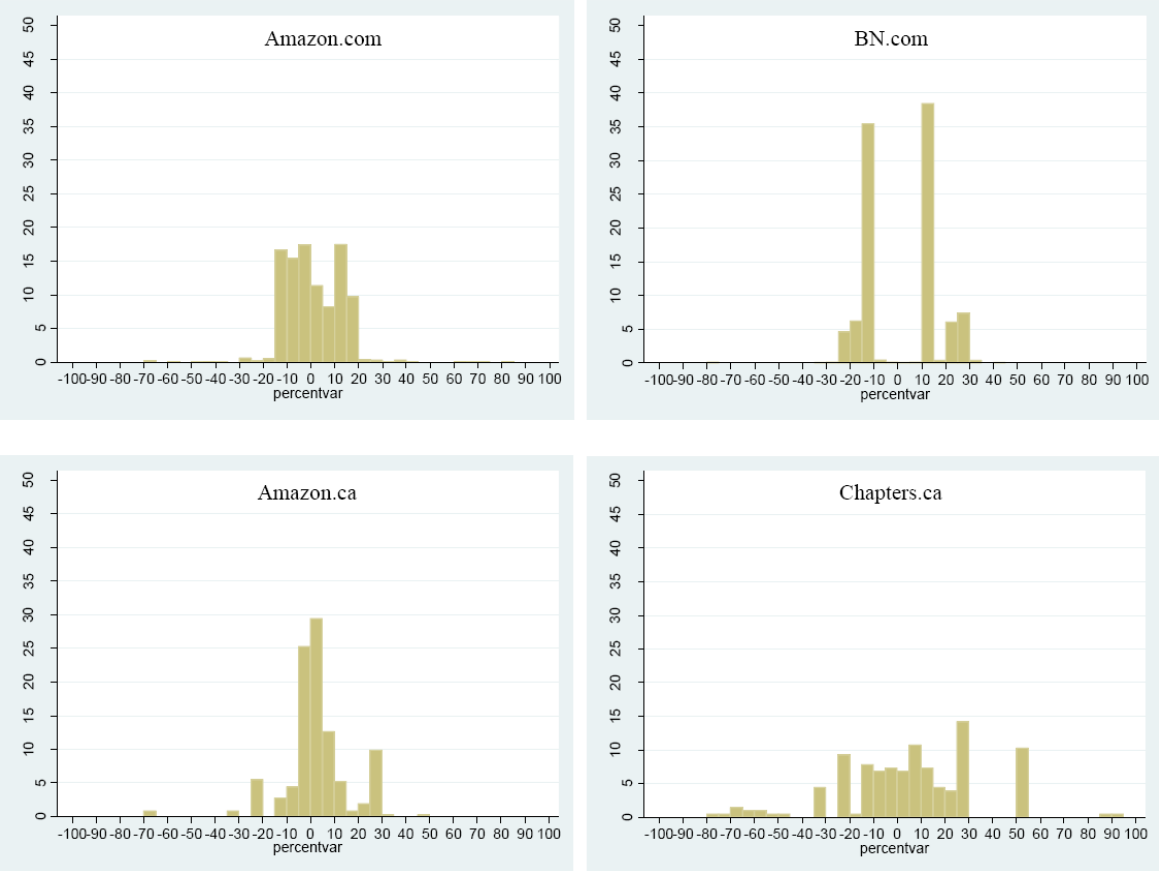

Figure 3: Distribution of the size of price changes, by retailer.

macro studies on price data at the micro level discuss separately the behavior of "regular prices", i.e. prices purged from sales (see Nakamura and Steinsson, 2008, or Klenow and Kryvtsov, 2008). What "regular price" means is not always clear however: there is generally no clear marker for temporary sales.[14] In this context, we adopt a concept similar to the *reference price* of Eichenbaum, Jaimovich and Rebelo (2008) to filter out temporary price fluctuations. Conceptually, the reference price corresponds to the price most often observed over a given time period. For a product that experiences occasional temporary discounts, the reference price would therefore coincide with the "regular" price that the consumer generally faces.

Table 3 summarizes our findings for reference prices computed on a bi-weekly basis. The average duration of a reference price is 138 days in our sample, and the median is 84 days (versus 7 days for posted prices). The probability that a reference price changes on a bi-weekly basis is 5.6%, and ranges from 1.7% for *Chapters.ca* to 8.8% for *Amazon.com*. Notice that unlike posted prices, reference prices at *BN.com* and *Amazon.com* behave very similarly.

Table 3: Reference prices.

	All	US	Canada	Amz US	BN.com	Amz CA	Chapters.ca
				Bi-weekly frequency (%)			
Ref. price change	5.55	8.68	2.41	8.78	8.58	3.16	1.67
Decrease	2.20	2.20	0.75	4.15	3.14	0.94	0.55
Increase	3.35	3.35	1.67	4.63	5.44	2.22	1.12
				Duration (days)			
Mean	138	105	201	105	105	201	211
Median	84	42	168	42	42	168	182
Implied mean	245	154	574	152	156	436	831

How stable are the prices faced by online book consumers? One way to answer this

[14] One may consider that the list price is a form of regular price which is likely very sticky. In our sample, a little more than 17% of online prices are equal to the posted price. But this number varies a lot across retailers: it is equal to 0% for *Amazon.ca*, 0.7% for *Amazon.com*, 13.6% for *BN.com* and 78% for *Chapters.ca*.

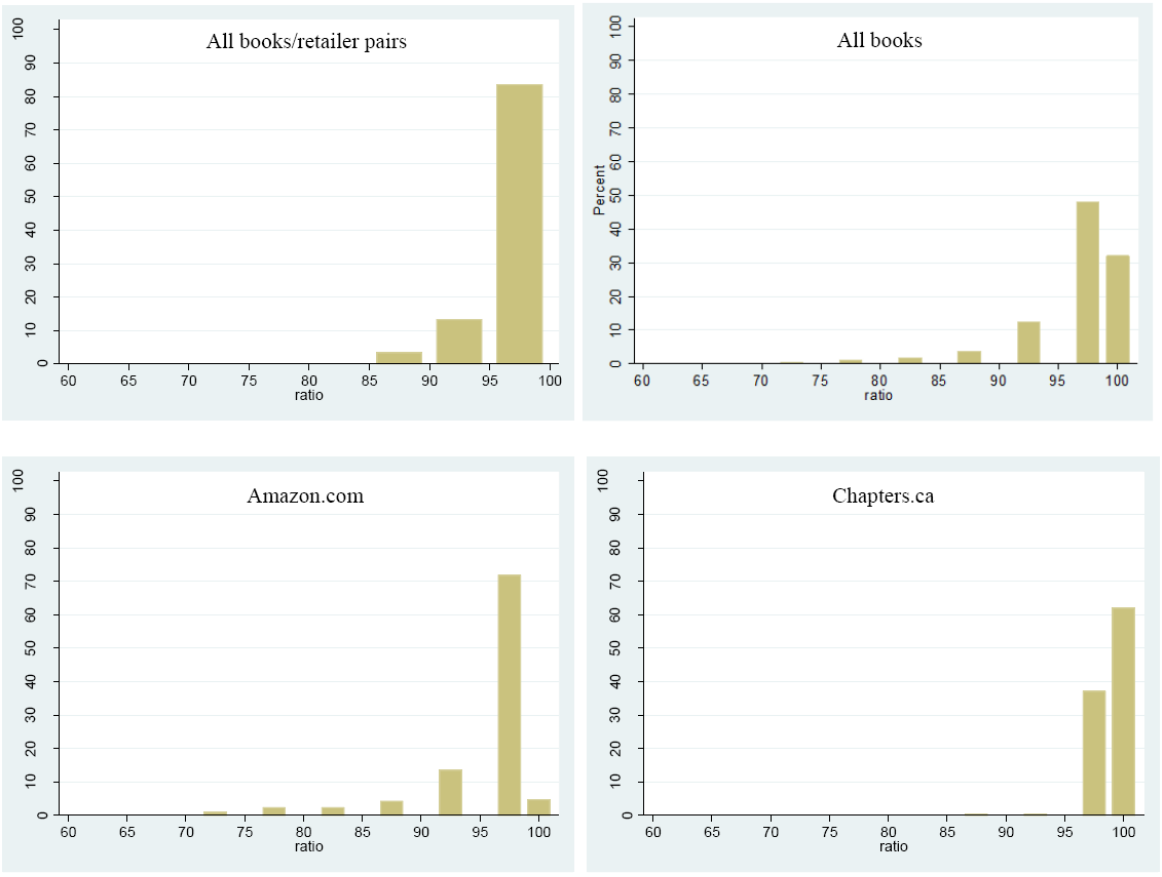

Figure 4: Prevalence of reference prices. *Fraction of price quotes within a two-week period that are equal to that period's reference price. For "All books/retailers", each observation is a book-retailer pair. For the other histograms, each observation is a book.*

question is to look at the fraction of price observations within a two-week period that are equal to that period's reference price. Figure 4 shows the distribution of this statistic in the aggregate as well as for all books two retailers. Across all book/retailer pairs, one third of the books have not experienced any deviation from the bi-weekly reference prices over the sample period. However, the top-right histogram shows that no single ISBN has been consistently equal to its bi-weeklyy reference price, once aggregated across all four retailers. Deviations have also been more frequent at *Amazon.com* than *Chapters.ca*, for example.

It is well known that for many products, prices tend to oscillate between two values: a regular and a sale price. To investigate the prevalence of such pricing behavior in our dataset, we compute the percentage of price changes which are of size similar (in absolute value) to the previous price change. If prices generally oscillate between two constant values, this percentage should be close to 100%. Results show that once again, heterogeneity is the norm: for *BN.com*, this number is equal to 94.4% over the whole sample. In other words, most price changes are temporary sales with the price returning to exactly its original level. For *Amazon.com* and *Chapters.ca*, the percentages are 59.3% and 50.8% respectively. In the case of *Amazon.ca*, however, oscillation is a less prevalent feature of their pricing strategy: only 28.7% of price changes are implemented to return the price to its original level.

4. Evidence on price dispersion

A number of studies have discussed whether the advent of internet has led to a reduction in the dispersion of prices, possibly by lowering consumer search costs. Our dataset includes a total of four retailers, two in each country, which allows us to study the topic of price dispersion in the context of online book retailing.

4.1. Within-country price dispersion

First, Figure 5 compares average book prices across retailers and time in each country. A striking finding is that price differences are large, particularly in the US: prices at *BN.com* are about 20% higher than at *Amazon.com* on average. In Canada, differences between the two main retailers are not as pronounced, with *Chapters.ca* being on average 5-6% more

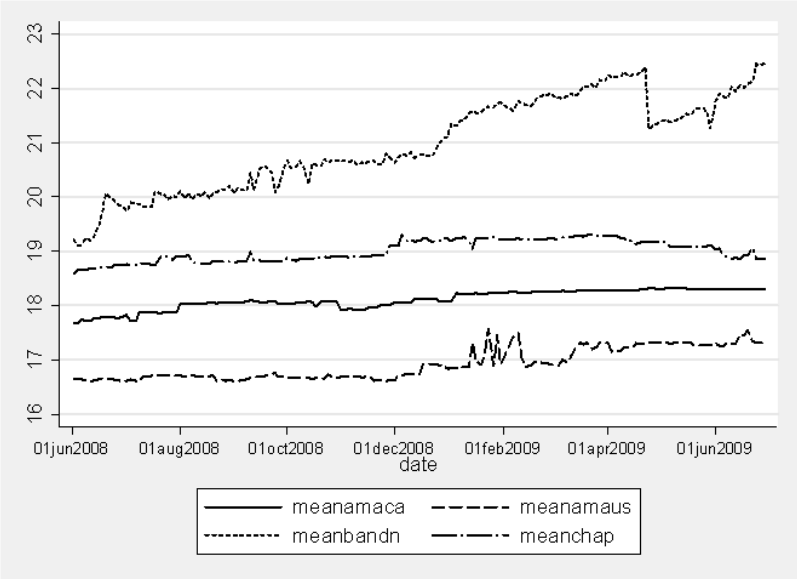

Figure 5: Average prices in local currency. *Evolution of the average price of a book, over time, by retailer. All prices are posted prices in local currency.*

expensive.[15] Prices at *BN.com* experienced visible inflation over thirteen months before a substantial drop towards the end of the sample. The other retailers have maintained more stable prices on average.

The observed price dispersion does not appear to be the product of a few outliers having a large impact on the average price. Figure 6 plots the fraction of books that are cheaper at retailer x than retailer y. Clearly, price differences are widespread for the books in our sample and not specific to a few titles. Using base posted prices, between 93% and 99% of books are cheaper at *Amazon.com* than at *BN.com*. This number goes down somewhat when member prices for *BN.com* are instead used for price comparisons. In Canada, this figure

[15] Two retailers offer membership programs which, for an annual fee of $25 in local currency, give rebates of 5% (*Chapters.ca*) or 10% (*BN.com*) on posted online prices. Participants in those programs also periodically receive discount coupons that can be redeemed online. It is unclear how popular those membership programs are.

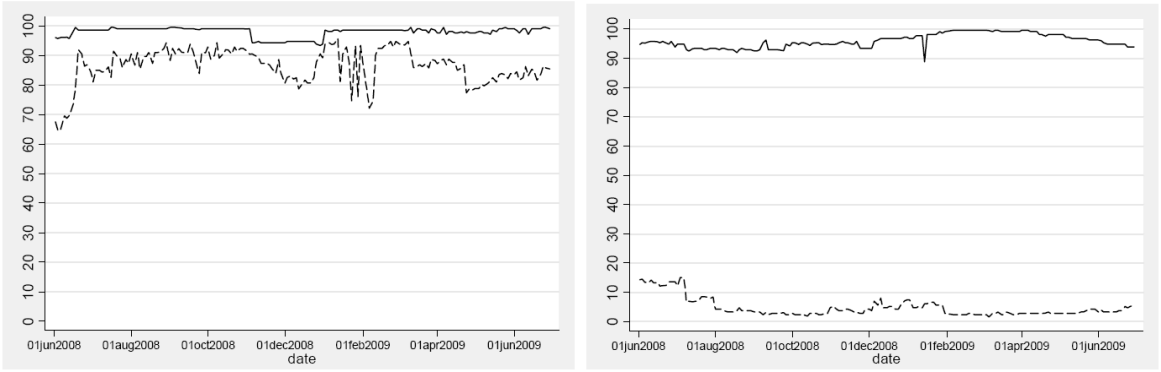

Figure 6: Fraction of books that are cheaper at retailer x than retailer y. Solid lines are based on comparisons of base prices; dotted lines use membership prices for *BN.com* and *Chapters.ca*.

oscillates between 92% to 100%, with a declining trend in the last two months. However, price dispersion virtually disappears once member prices are used: *Chapters.ca* tends to set its member price a few cents lower than *Amazon.ca*'s.

Even once shipping costs are taken into account, the conclusions remain unchanged: price dispersion, at least in the US, is high and mainly due to differences in pricing strategies at the retailer level. This is in line with the findings by Clay, Krishan and Wolff (2001). In the context of a product as homogenous as books, it seems particularly challenging to explain what may lie behind such price dispersion.[16]

4.2. Inter-country price dispersion

The evidence on price dispersion presented in the previous section was only concerned with local currency prices. However, a large literature has studied the behavior of international prices in various contexts. In particular, a number of studies have been interested in

[16] Some have put forward branding (Clay et al., 2001) or differentiated features such as reviews and loyalty programs (Clay et al., 2002).

the following questions: Does the mere presence of international frontiers hinder trade? To what extent do borders lead to market segmentation? Our dataset is particularly well suited for analyzing these issues: both US retailers and both Canadian retailers ship internationally, products are homogenous, international transactions can be done without leaving one's home, websites are similar in design and shipping costs are observable. Unlike other retail goods, trade frictions are not obvious in our context: consumers do not have to physically cross the border to take advantage of lower-priced goods. Consequently, deviations from the law of one price would arguably be more surprising in an online environment.

The main finding from our dataset is that there is very little evidence of an impact of exchange rate fluctuations on local-currency prices. This was already evident from Figure 5 in the previous sub-section: despite a 20% depreciation of the Canadian dollar between June and November 2008, and a significant appreciation afterwards, there was no visible impact on average prices at *Amazon.ca* and *Chapters.ca*. This in turn implies that prices expressed in a common currency (US dollars) must have fluctuated significantly: the left-hand plot in Figure 7 shows that Canadian retailers moved from being similarly priced to their US competitors over the first third of the sample, to being relatively cheap afterwards. In fact, over the span of seven months, books went from being on average 2-3% more expensive in Canada than in the US to more than 22% cheaper (right-hand side plot). This price difference mirrored almost perfectly the evolution of the exchange rate over our sample. This property is studied more systematically in Section 6.

While these price differentials may seem substantial, in order to determine whether cross-border shopping can be advantageous, shipping costs need to be added to posted book prices.[17] In this context, however, bundling issues are relevant: per-book costs are a function

[17] Books are not subject to custom duties under NAFTA.

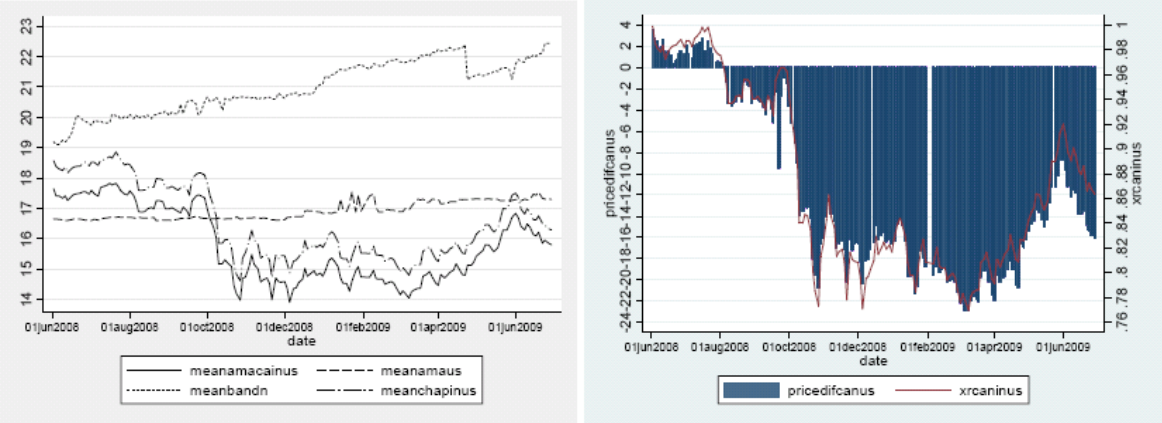

Figure 7: International prices. *Left: Average prices by retailer, in common currency (USD). Right: Exchange rate and average price difference between US and Canadian retailers.*

of the number of items ordered. For this reason, results for various order sizes are analyzed.

Figure 8 plots over time the fraction of the 213 books in our sample that are cheaper in Canada than in the US, from the perspective of American consumers. A few things are worth highlighting. First, a significant number of products can be found for cheaper across the border, even once shipping costs are factored in. This is particularly true for larger orders, since domestic shipping costs fall to zero once the consumer spends more than $25. When comparing prices at *Amazon.com* and *Amazon.ca*, up to 40% of items turn out to be cheaper in Canada based on bundles of four books. This fraction reaches 96% for the *BN.com-Amazon.ca* pair, based on a 4-book order. Hence, and this is our second point, whether it is profitable for a US consumer to order books in Canada depends highly on which retailers are compared. As will become clear in the next section, the implication is that it is difficult to identify a border effect based on international price differences alone.

Third, in line with the previous evidence, the availability of cross-border deals is directly tied to the exchange rate: books in Canada were almost always more expensive than in the

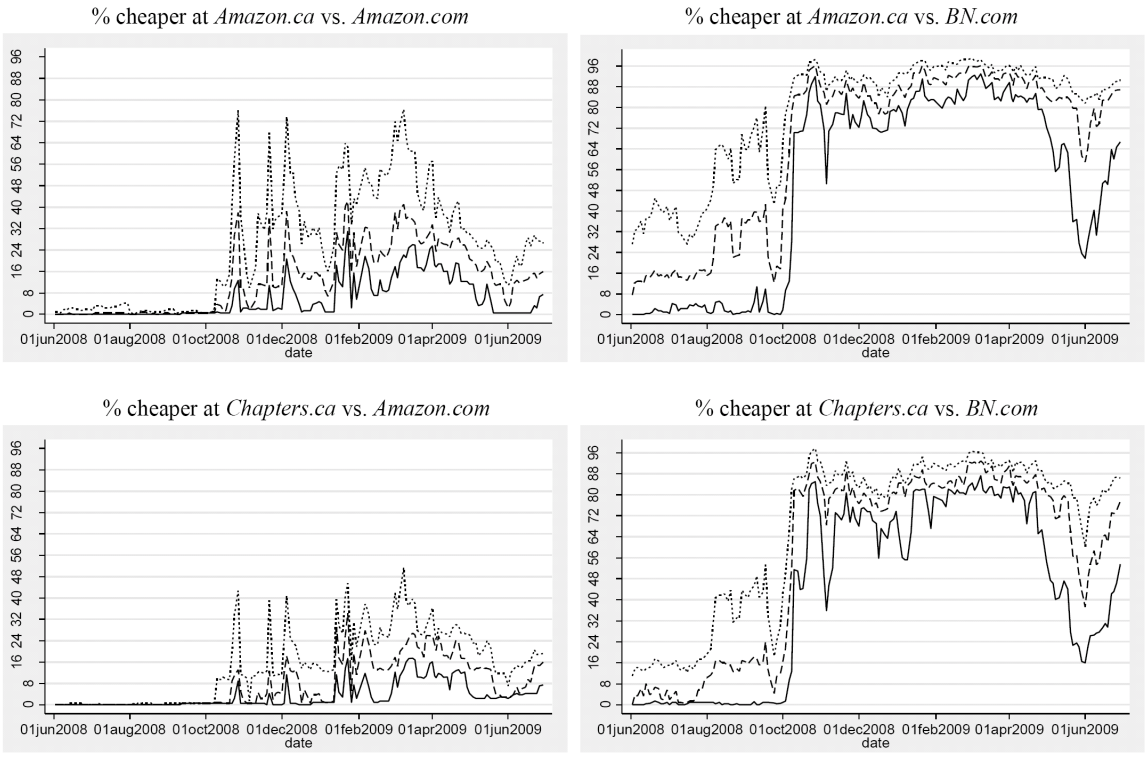

Figure 8: Percentage of books which are cheaper in Canada, for a US resident, by pairs of retailers (including shipping costs). *Various bundle sizes: 1 book (solid line), 4 books (dashed) and 8 books (dotted).*

US in June 2008 when the Canadian dollar was at its peak, and again later in mid-2009. The opposite was true in late 2008 and early 2009.

Finally, deviations from the law of one price can be sizable. Figure 9 plots the distribution of discounts from shopping on Canadian websites, conditional on the book price being higher in the US (shipping costs are included). Discounts in excess of 10% are quite common, particularly for larger orders, and can be as high as 50% in some cases.[18]

From the perspective of a Canadian consumer, occasions to find books at a lower price in the US are scarcer over our sample. At the peak, 8% of books were cheaper at *Amazon.ca* than *Amazon.com*. It goes up to 65% when comparing *Amazon.ca* and *BN.com*. However, most of these deals are observed only around mid-2008, before the depreciation of the Canadian dollar. Also, they apply mainly to single-book orders; for larger orders, differences in posted prices are compensated by shipping cost disparities. For this reason, the rest of the paper will focus on cross-border price differentials from the perspective of US consumers.

5. A model of international pricing

Section 4.2. demonstrated that the law of one price was often violated in our sample. In an online environment where trade frictions are few and search costs are low, are these seemingly arbitrage opportunities evidence of the presence of a border effect?[19] To answer this question we develop a two-country model of price competition very similar to that of Gopinath et al. (2009). The setup is along the lines of the Salop (1979) circular city model of product differentiation and is depicted in Figure 10. A border splits the circle into two

[18] These non-trivial price differences cannot therefore be explained by the fees of 1% to 2.5% charged by most credit cards for foreign currency transactions.

[19] Blum and Goldfarb (2006) show that Americans are more likely to visit websites from nearby countries even controlling for language, income, etc. They conclude that distance proxies for taste differences. In our case, since most of the books are bestsellers in both countries at the same time, taste differences are unlikely to explain price dispersion.

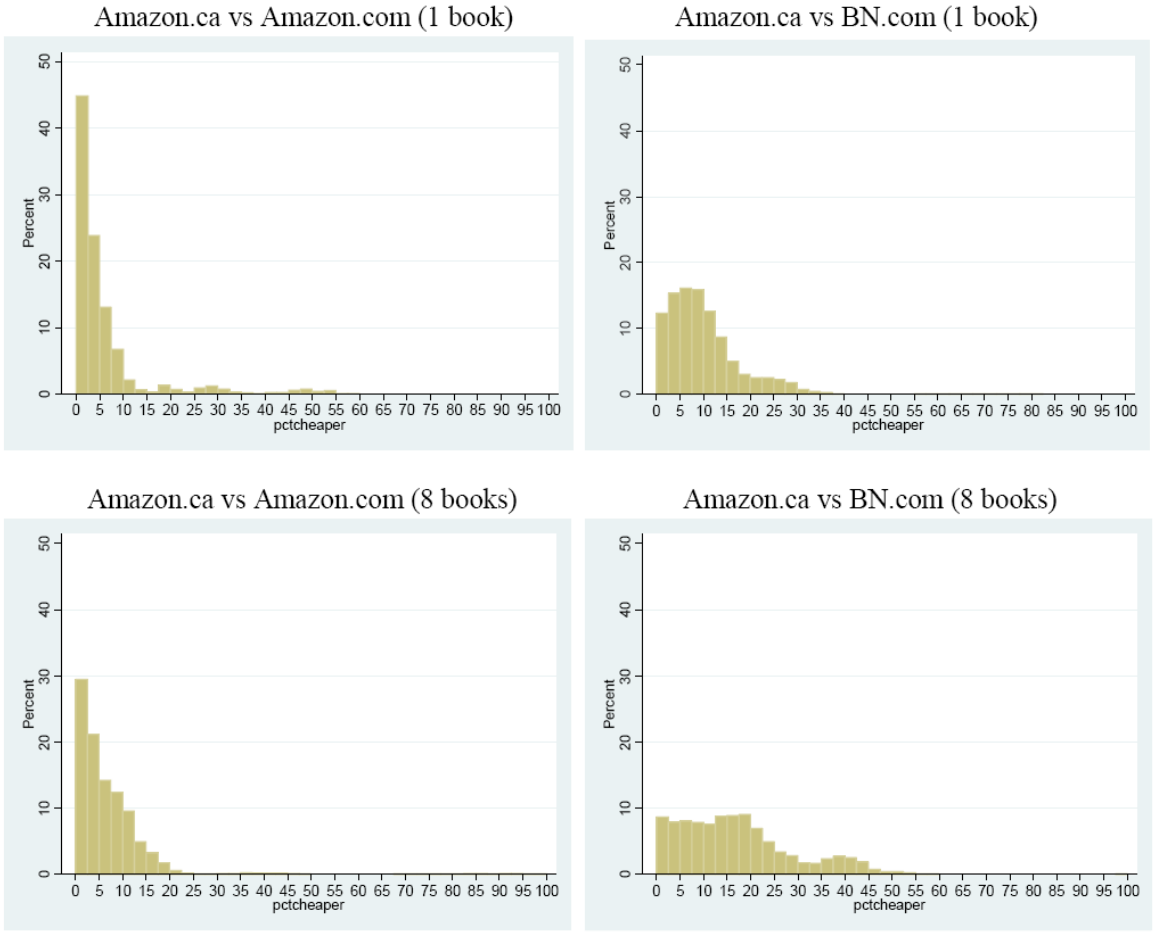

Figure 9: Discounts from buying in Canada, for various pairs of retailers and order sizes. Shipping costs are included.

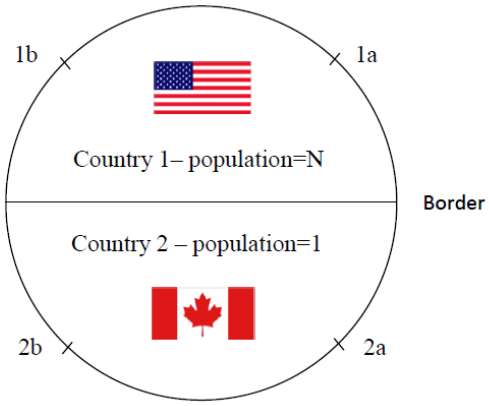

Figure 10: Two-country circular city model

countries (country 1 and country 2) with consumers and firms from country 1 located along the circle on one side of the border and consumers and firms from country 2 along the other side. We suppose that the circle is of unit length and that the border runs from 1/4 to 3/4. For simplicity and also because it is consistent with the dataset at hand, we focus on the situation in which there are just two firms in each country: *1a* and *1b* in country 1 and *2a* and *2b* in country 2. We assume maximal differentiation and place 1a and 1b at 1/8 and 7/8 respectively and 2a and 2b at 3/8 and 5/8.

We suppose that there is a firm-specific local variable cost that is in domestic currency: c_{ja} and c_{jb} for $j = 1, 2$. In our context, it is also reasonable to assume that there is another variable cost associated with the wholesale production of books. Most books are printed in country 1 (the US) and so there is a variable cost in U.S. dollars that is common across sellers. This cost is denoted by k.

Consumers are uniformly distributed along the circle, but there are potentially different sized masses on each side of the border. We normalize the mass of consumers in country 2 to be 1 and let the mass of consumers in country 1 (the US) be N. We suppose that

each consumer buys one unit of the product of their most preferred firm. A consumer from country j located at x who buys from firm i located at x_i gets utility

$$u_i^j(x) = v - p_i - s_i^j - t|x_i - x| - b_j I(x_i, x). \tag{1}$$

s_i^j denotes the cost of shipping charged by firm i for delivery to a consumer in country j. For physical stores, it is natural to interpret t as a transportation cost. In the context of online retailing, this parameter encompasses all of the factors affecting the cost for a consumer of consuming something other than his most preferred level of a particular characteristic, e.g. website layout, range of shipping options, availability of customer reviews, etc. I is an indicator function for whether the consumer and firm are in different countries, and b_j is the border cost that must be paid in this case. Here, the border cost includes the uncertainty related to international transactions (e.g. currency exchange rate or extra fees charged by credit card company, shipping times, ease to return articles, etc.), as well as other factors that discourage consumers from buying from foreign sources.[20]

First, we are interested in finding demand at each of the four firms. Note that each firm faces demand on two segments: one that is strictly domestic (ie. between 1b and 1a, and between 2a and 2b), and one that is international (ie. between 1a and 2a, and between 2b and 1b). Further note that there are three possibilities for the international segment: i) full market segmentation such that the indifferent consumer is right at the border (country 1 consumers buy from the country 1 firm and country 2 consumers from the country 2 firm),

[20] The border cost could even encompass informational frictions on the consumer side. For example, a buyer may be simply unaware of the availability of cross-border deals. As price differentials rise, such deals become better known either through word of mouth or media reports. Such an interpretation would be observationally equivalent to a preference-based friction.

ii) partial segmentation such that the indifferent consumer is in country 2 (all country 1 consumers buy from the country 1 firm, as do some country 2 consumers), and iii) partial segmentation such that the indifferent consumer is in country 1 (all country 2 consumers buy from the country 2 firm, as do some country 1 consumers).

Based on the utility function (1) and the setup of the model, it is possible to characterize the indifferent consumer on each segment of the circle (for instance, the indifferent consumer on the $1b$-$1a$ segment is $\widetilde{x}^1_{1_b1_a}$ such that $u^1_{1_a}(\widetilde{x}^1_{1_b1_a}) = u^1_{1_b}(\widetilde{x}^1_{1_b1_a})$). Then for the domestic markets, demands are given by

$$d^{1_b}_{1_b1_a} = \widetilde{x}^1_{1_b1_a} = \frac{p_{1a} - p_{1b} + s^1_{1a} - s^1_{1b}}{2t} + \frac{1}{8},$$

$$d^{1_a}_{1_b1_a} = \frac{1}{4} - \widetilde{x}^1_{1_b1_a} = \frac{p_{1b} - p_{1a} + s^1_{1b} - s^1_{1a}}{2t} + \frac{1}{8},$$

$$d^{2_a}_{2_a2_b} = \widetilde{x}^2_{2_a2_b} = \frac{p_{2b} - p_{2a} + s^2_{2b} - s^2_{2a}}{2t} + \frac{1}{8},$$

$$d^{2_b}_{2_a2_b} = \frac{1}{4} - \widetilde{x}^2_{2_a2_b} = \frac{p_{2a} - p_{2b} + s^2_{2a} - s^2_{2b}}{2t} + \frac{1}{8}$$

where the superscript refers to the firm and the subscript indicates which segment the demand refers to. Prices are in local currency, and for expositional purposes shipping costs are not included.

The task is a little bit more complex for the international segments ($1a$-$2a$ and $1b$-$2b$). For the $1a$-$2a$ segment, the indifferent country 1 and country 2 consumers are respectively

$$\widetilde{x}^1_{1a2a} = \frac{p_{2a}e + b_1 - p_{1a} + s^1_{2a}e - s^1_{1a}}{2t} + \frac{1}{8}$$

$$\widetilde{x}^2_{1a2a} = \frac{p_{2a} - b_2 - p_{1a}(\frac{1}{e}) + s^2_{2a} - s^2_{1a}(\frac{1}{e})}{2t} + \frac{1}{8}.$$

where e is the number of country 1 currency units that can be obtained from one unit of country 2 currency. Note that because of the discontinuity created by the border, $\widetilde{x}^1_{1a2a} \leq \frac{1}{8}$ and $\widetilde{x}^2_{1a2a} \geq \frac{1}{8}$. That is, we can never be in a situation where the indifferent country 1 consumer is bigger than $\frac{1}{8}$ since then he would be located in country 2, in which case we should look at the problem from the perspective of a country 2 consumer. The reverse is also true: the indifferent country 2 consumer must be larger or equal to $\frac{1}{8}$.

Further note that we assume that all consumers must buy at least one unit of the product. Therefore, there are three possible cases:

1. Full segmentation: $\widetilde{x}^1_{1a2a} = \frac{1}{8}$ and $\widetilde{x}^2_{1a2a} = \frac{1}{8}$

   If the border costs are such that

$$\begin{aligned} b_1 &\geq \left(p_{1a} + s^1_{1a}\right) - \left(p_{2a} + s^1_{2a}\right) e \\ &\quad \textit{and} \\ b_2 &\geq \left(p_{2a} + s^2_{2a}\right) - \left(p_{1a} + s^2_{1a}\right) \frac{1}{e}, \end{aligned}$$

   then the indifferent agent is at the border and the markets are fully segmented.

2. Partial segmentation with indifferent agent in country 1: $\widetilde{x}^1_{1a2a} < \frac{1}{8}$ if

$$b_1 < \left(p_{1a} + s^1_{1a}\right) - \left(p_{2a} + s^1_{2a}\right) e.$$

3. Partial segmentation with indifferent agent in country 2: $\widetilde{x}^2_{1a2a} > \frac{1}{8}$ if

$$b_2 < \left(p_{2a} + s^2_{2a}\right) - \left(p_{1a} + s^2_{1a}\right) \frac{1}{e}.$$

The conditions on the other international segment ($2b$-$1b$) are similar.

Next we derive predictions about how prices should adjust in response to the exchange rate and show that in order to identify international price segmentation, information from price and quantities needs to be used.

We assume that firms maximize local currency profits by choosing the optimal price for a given product. Without any loss of generality, we focus on firms $1a$ and $2a$.

We consider two cases:

1. Markets are fully segmented

   The firms' maximization problems are:

$$\begin{aligned}
\max_{p1a} \pi &= (p_{1a} - c_{1a} - k) N \left(\frac{1}{8} + d^{1_a}_{1_b 1_a} \right) \\
&= (p_{1a} - c_{1a} - k) N \left(\frac{1}{4} + \frac{p_{1b} - p_{1a} + s^1_{1b} - s^1_{1a}}{2t} \right), \\
\max_{p2a} \pi &= (p_{2a} - c_{2a} - k\frac{1}{e}) \left(\frac{1}{8} + d^{2_a}_{2_a 2_b} \right) \\
&= (p_{2a} - c_{2a} - k\frac{1}{e}) \left(\frac{1}{4} + \frac{p_{2b} - p_{2a} + s^2_{2b} - s^2_{2a}}{2t} \right).
\end{aligned}$$

   Demand on the international segments is $\frac{1}{8}$ for each firm because of full segmentation. Not surprisingly, only domestic prices enter the demand functions, and sales are scaled by N for country 1 (though the relative size of the markets plays no role in the full segmentation case). The exchange rate only plays a role through movements in the

cost of imported inputs for country 2 firms. Optimization leads to the following prices

$$\begin{aligned} p_{1a} &= \frac{t}{2} + k + \frac{2c_{1a} + c_{1b} + s^1_{1b} - s^1_{1a}}{3}, \\ p_{2a} &= \frac{t}{2} + \frac{k}{e} + \frac{2c_{2a} + c_{2b} + s^2_{2b} - s^2_{2a}}{3}. \end{aligned}$$

This in turn implies that the elasticities of prices with respect to the exchange rate are respectively

$$E_{p_{1a},e} = \frac{\partial p_{1a}}{\partial e}\frac{1}{p_{1a}} = 0,$$

$$E_{p_{2a},e} = \frac{\partial p_{2a}}{\partial e}\frac{1}{p_{2a}} = -\frac{6k}{e(3te + 6k + 2c_{2b}e + 4c_{2a}e + 2s^2_{2b}e - 2s^2_{2a}e)} < 0.$$

The price of a country 1 firm is not affected by exchange rate fluctuations when markets are fully segmented. In contrast, country 2 firms react as long as a portion of their costs are denoted in foreign currency ($E_{p_{2a},e} = 0$ if $k = 0$). A sufficient condition for the sign of this elasticity to be negative as expected is for domestic shipping costs to be equal; ie for $s^2_{2b} = s^2_{2a}$. In practice, domestic shipping costs are very similar across retailers.

2. Partial segmentation with the indifferent agent located in country 1

$$\begin{aligned} \max_{p1a} \pi &= (p_{1a} - c_{1a} - k)N(d^{1_a}_{1_b 1_a} + \widetilde{x}^1_{1a2a}) \\ &= (p_{1a} - c_{1a} - k)N\left[\frac{1}{4} + \frac{p_{1b} + s^1_{1b} - p_{1a} - s^1_{1a}}{2t} + \frac{(p_{2a} + s^1_{2a})\,e + b_1 - p_{1a} + s^1_{1a}}{2t}\right], \\ \max_{p2a} \pi &= (p_{2a} - c_{2a} - k\frac{1}{e})\left[d^{2_a}_{2_a 2_b} + \frac{1}{8} + N\left(\frac{1}{8} - \widetilde{x}^1_{1a2a}\right)\right] \\ &= (p_{2a} - c_{2a} - k\frac{1}{e})\left[\frac{1}{4} + \frac{p_{2b} - p_{2a} + s^2_{2b} - s^2_{2a}}{2t} + N\left(\frac{p_{1a} + s^1_{1a} - (p_{2a} + s^1_{2a})\,e - b_1}{2t}\right)\right]. \end{aligned}$$

In this case, optimal prices and elasticities are complex expressions which are difficult to analyze. Our main interest is in determining the sign of $E_{p_{2a},e}$. To do so, we first derive the elasticity expressions at two extremes: when $b_1 = 0$ (no border cost) and $b_1 = b_1^*$ (upper bound on the border cost that ensures partial segmentation). We can show that under plausible parameter restrictions:[21]

$$\begin{aligned} E_{p_{2a},e}|_{b_1=0} &< 0, \\ E_{p_{2a},e}|_{b_1=b_1^*} &< 0, \end{aligned}$$

and

$$E_{p_{2a},e}|_{b_1=0} > E_{p_{2a},e}|_{b_1=b_1^*}.$$

3. In other words, a country 2 (Canadian) retailer finds it optimal to raise its local currency price following an appreciation of the US dollar for any value of the border cost such that markets are not fully segmented. The size of the price reaction is inversely proportional to the degree of market segmentation.[22] When expressed in US dollars, the model predicts that prices of Canadian retailers will fall but by less than the full movement in the exchange rate; that is, there is incomplete pass-through of exchange rate fluctuations into prices. There are two forces at play behind this prediction: the appreciation of the US dollar means that US retail prices become less competitive, and that USD-denominated marginal costs rise.

[21] These are mostly restrictions on the marginal costs, the shipping costs, and the exchange rate: common-currency costs cannot be too different, either through a large dispersion in c's or an exchange rate very different than 1, and similarly for shipping costs. In the context of our empirical study, it is reasonable to assume that the necessary conditions are satisfied.

[22] We can also show that for the parameter space under consideration, the (absolute) elasticity is a monotonically increasing function of the border cost b.

In contrast, the exchange rate elasticity is positive for country 1 firm prices: as the value of their currency rises, American consumers find it more attractive to buy from Canadian retailers. US firms respond by lowering their prices (in domestic currency) to remain competitive.

In the next section, we test whether the model predictions about prices are supported by our dataset. Any discussion on the behavior of quantities is postponed to Section 6.1.

6. Testing for international market segmentation

Earlier evidence already showed that average local currency prices did not seem to react to the large fluctuations of the exchange rate over the sample. Figure 11 goes one step further: it plots the distribution of the correlations between the prices in Canadian dollars and the exchange rate, for the two Canadian retailers. Under partial market segmentation, one would expect to see a majority of negative correlations: as the US dollar appreciates (e falls), Canadian firms become relatively more competitive and respond by raising their prices. Looking at the plots in the left column, there does not seem to be much evidence of such behaviour for the books in our dataset. For *Amazon.ca*, close to 60% of books have a correlation of virtually zero, while for *Chapters.ca* it is 42%. In light of the evidence on price rigidity from Section 3., this may not be surprising: by construction, products which seldom experience price changes will have low correlation. While there is some evidence that negative correlations are more frequent, this could be due to the fact that over the sample period, prices have displayed an inflationary trend while the Canadian dollar depreciated.

The model of the previous section predicts that retailers will react to exchange rate fluctuations for products whose prices are competitive relative to foreign alternatives. The plots in the second column of Figure 11 report similar correlations, but for booksthat werecheaper

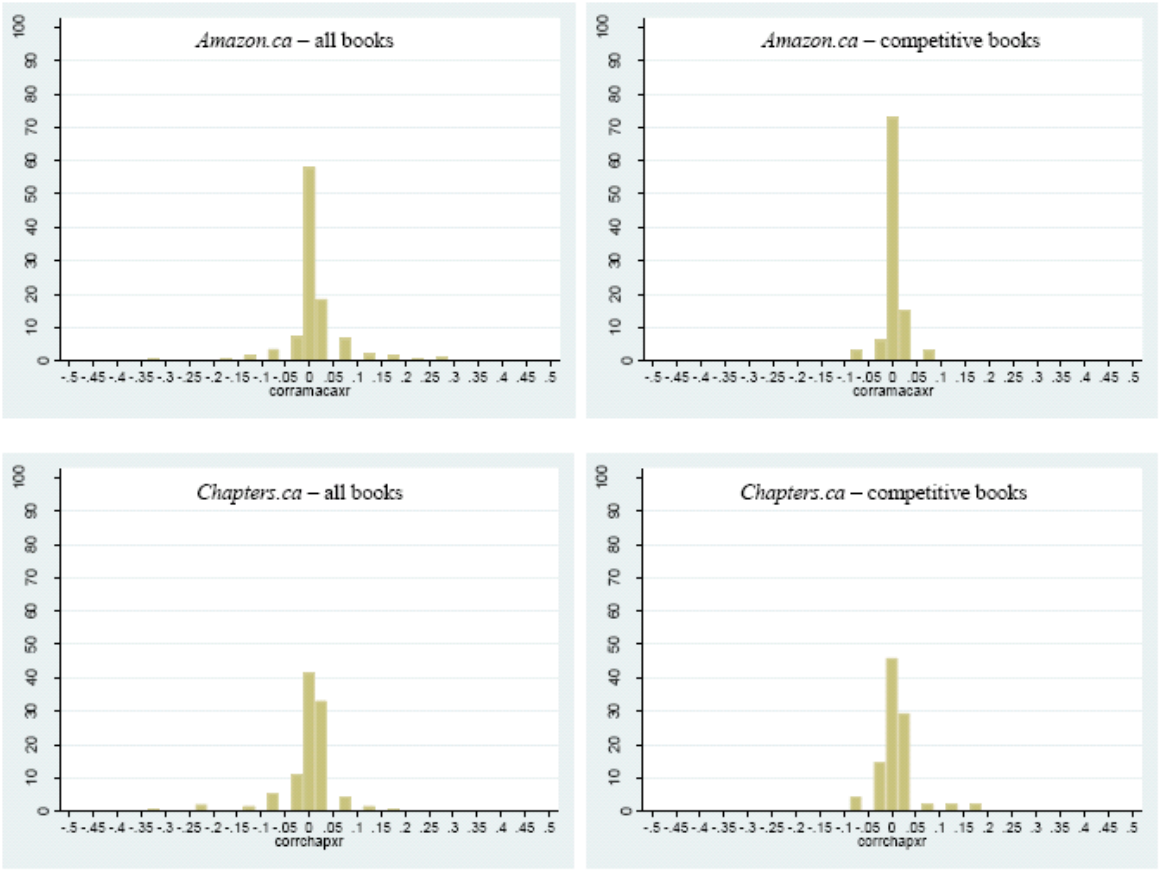

Figure 11: Correlations between local prices of Canadian retailers and exchange rate. *Each observation is a book. "Competitive books" refers to items which are cheaper in Canada than at Amazon.com for at least 8 weeks (perspective of a US consumer).*

in Canada (from the perspective of a US consumer) for at least 8 weeks over the sample. There does not appear to be any significant difference with the full sample; in fact, an even larger portion of books have prices uncorrelated with the exchange rate. In other words, there is no evidence that Canadian online retailers react to changes in the relative price of their goods on the North American market.

Alternatively, one can look at how prices in a common currency react to exchange rate movements. If markets are integrated, exchange rate pass-through is expected to be incom-

plete: for example, a 1% appreciation of the US dollar leads to a smaller-than-1% fall in the prices of Canadian retailers, expressed in USD. In other words, a portion of the currency fluctuations are absorbed in markups due to the presence of foreign competition. To determine whether this happens in the online book market, a regression of the log price on its own lags and the log of the exchange rate is run for Canadian retailers. Figure 12 reports the average response over time of prices (in USD) to a permanent 1% appreciation of the US dollar.[23] Impulse responses tend to be more stable for *Amazon.ca*, and there is no sign of incomplete pass-through: on impact, at $t = 1$, prices react fully to the 1% change in the exchange rate. Notice that this is true for the full sample as well as for books which were cheaper in Canada on at least twelve occasions over the sample period: *Amazon.ca* does not appear to react differently based on how competitive their prices are versus foreign firms.[24] For *Chapters.ca*, prices react one-for-one on impact. There is some evidence of a reversal in the first few periods following the shock for books which are cheaper than in the US. However, this may be an artifact of small sample bias: as was clear from Figure 8, Chapters has a smaller portion of products which are cheaper than at *Amazon.com*.

These results may not however be a sign of market segmentation; instead, they could be an artifact of the pervasive price stickiness in our dataset. If retailers seldom reset prices, movements in a highly volatile variable such as the exchange rate will lead to large fluctuations in international relative prices. In fact, even if markets were integrated, if retailers face costs of changing prices they may find it optimal to avoid repricing items following exchange rate fluctuations.

The detailed nature of our dataset allows us to go a step further by taking into account

[23] An implicit assumption in computing the impulse responses is that shocks to prices and the exchange rate are orthogonal.

[24] Choosing other tresholds does not alter the conclusions. However, impulse responses become noisier as the subsample gets smaller.

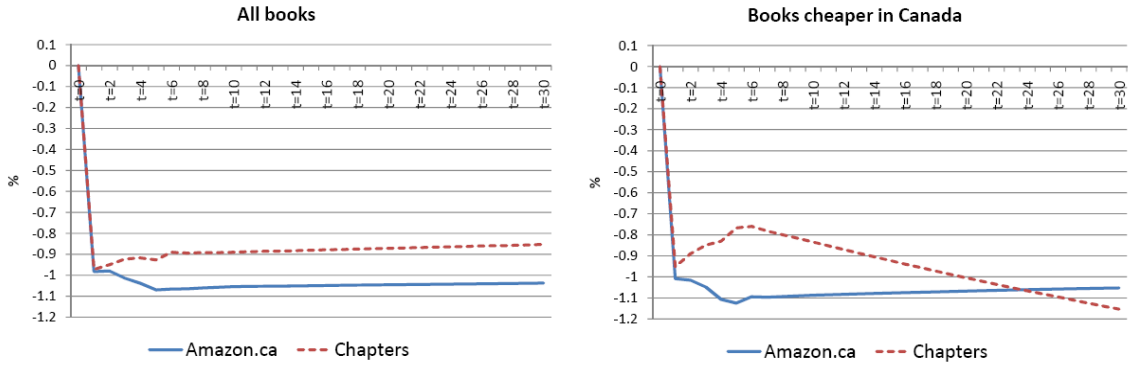

Figure 12: Average reaction of book prices to a 1% appreciation of the US dollar. *Prices of Canadian retailers expressed in USD. Left: all books. Right: only books which are cheaper in Canada than at Amazon.com, for a US resident (4-book bundle).*

the presence of price stickiness while testing for the presence of market segmentation. In particular, we are interested in answering the following questions: (1) Are prices more likely to be adjusted for books which are in violation of the law of one price (LOP)? (2) When prices of books are reset, is it in a direction that restores parity? (3) Is the size of price changes related to the degree of deviation from LOP? The underlying idea is simple: if international markets are integrated to some degree, large cross-border price differentials should represent an additional incentive for retailers to change prices. In addition, even if a firm's actions are limited by the presence of menu costs, we should expect that conditional on modifying its price it does so optimally. Our dataset is ideal for answering these questions: price quotes are sampled at high frequency for a large number of items, and a control group is available since the sample includes books both cheaper and more expensive across the border.

Recall that from the point of view of a Canadian retailer j, in each period their products can be sorted into three categories:

- books which are cheaper than in the US for a US consumer;

$$e\left(p_{it}^{CA,j} + s^{CA \to US,j}\right) < \min\left\{p_{it}^{US,k} + s^{US \to US,k}\right\}_{k \in \{Amazon.com, BN.com\}}$$

- books which a Canadian consumer can find for less at a US store;

$$e\left(p_{it}^{CA,j} + s^{CA \to CA,j}\right) > \min\left\{p_{it}^{US,k} + s^{US \to CA,k}\right\}_{k \in \{Amazon.com, BN.com\}}$$

- all others.

If markets are not fully segmented and firms internalize cross-country price differences when making their pricing decisions, one would expect more frequent price changes for the first two categories of books (those in violation of the law of one price). The top half of Table 4 compares the frequencies of price changes using all price quotes. Only results for the first and third categories are presented: there are too few books which are cheaper for a Canadian resident to buy from a US retailer (maximum of 164 across pairs). Results are reported for each pair of retailers. In general, it does not seem that deviations from the law of one price make Canadian retailers more likely to change prices. However, there are some intriguing results: *Amazon.com* implements price changes more often for books which can be found for less in Canada. Yet, the opposite seems to be true for *BN.com*. In fact, these differences are likely due to the changes in pricing strategies documented in Section 3.. For the books in our dataset, *Amazon.com* implemented more frequent sales in the second half of the sample while *BN.com* did the opposite. This is also when the Canadian dollar was at its lowest point against the US dollar. Results from the bottom half of Table 4 are consistent with such bias. Two-week reference prices are constructed and price change

frequencies computed.[25] As previously discussed, this is likely to filter out most temporary sales. The use of reference prices does not alter significantly our ealier conclusions. It does however yield more similar frequencies across categories for the two US retailers.

Table 4: Frequencies of price changes for books in violation of the law of one price. *Probability of a price change at $t+1$ conditional on a violation of the law of one price at t. Number of observations are in brackets.*

	All observations			
	Amazon.ca	*Amazon.com*	*Chapters.ca*	*Amazon.com*
Cheaper in Canada (US consumer)	1.05% (4458)	7.72% (4458)	0.90% (2672)	9.58% (2672)
Others (not in violation of LOP)	1.06% (29361)	4.05% (29361)	0.52% (30881)	4.03% (30881)
	Amazon.ca	*BN.com*	*Chapters.ca*	*BN.com*
Cheaper in Canada (US consumer)	0.70% (22652)	3.58% (22652)	0.54% (19457)	4.90% (19457)
Others (not in violation of LOP)	1.78% (11320)	13.59% (11320)	0.58% (14386)	12.51% (14386)
	2-week reference prices			
	Amazon.ca	*Amazon.com*	*Chapters.ca*	*Amazon.com*
Cheaper in Canada (US consumer)	5.22% (670)	11.49% (670)	2.06% (389)	11.83% (389)
Others (not in violation of LOP)	3.04% (5260)	8.69% (5260)	1.66% (5498)	8.73% (5498)
	Amazon.ca	*BN.com*	*Chapters.ca*	*BN.com*
Cheaper in Canada (US consumer)	2.85% (3825)	6.69% (22720)	1.49% (3299)	6.76% (3299)
Others (not in violation of LOP)	4.03% (2133)	12.80% (2133)	1.93% (2641)	11.36% (2641)

Next, we study more carefully and methodically whether the decision to reset a price is a function of the deviation from the law of one price, controlling for a host of other factors. Unfortunately, the prevalence of temporary sales for some retailers involves a potential bias in the estimation. Consider this simple illustrative example: *Amazon.ca* normally sells a book for a price 5% higher than in the US, from the perspective of an American consumer. Suppose that it randomly implements one-period, 10% sale on this item, making it 5%

[25] Recall that the reference price corresponds to the mode of the price quotes for a given two-week period.

cheaper than in the US. Mechanically, the probability of a price change conditional on being initially in violation of the law of one price is 100%. In this example, the econometrician will mistakenly be led to conclude that *Amazon.ca*'s re-pricing decision is sensitive to foreign competition. The bias towards partial market segmentation is similar for US retailers.

To minimize this bias, one could focus on reference prices. However, because of their lower frequency, these series leave us with too few price changes in the sample. Instead, we filter out temporary sales from our dataset: we drop price changes which are preceded or followed within a given time window (here one week) by another price change of similar magnitude but opposite sign.[26] This technique leaves us with enough observations to carry out the empirical analysis.

Table 5 presents the results for the first set of regressions. Here, the question is whether retailers are more likely to change prices for books in deviation from the law of one price. For example, for *Amazon.ca*, the following relationship is estimated using our dataset:

$$P\left(\Delta P_{it}^{AMACA} \neq 0\right) = \Phi\left[e\tilde{P}_{it-1}^{AMCA} < \tilde{P}_{it-1}^{AMUS}, \left|\log\left(\frac{P_{it-1}^{AMACA}}{P_{it-1}^{CH}}\right)\right|, X_{it}\right] \tag{2}$$

where $\tilde{P}_{it-1}^{AMCA} = P_{it-1}^{AMACA} + s^{AMCA \to US}$ is the price (in domestic currency) of book i sold by *Amazon.ca* at time t including Canada-to-US shipping cost; $\tilde{P}_{it-1}^{AMUS} = P_{it-1}^{AMAUS} + s^{AMUS \to US}$ is the price of *Amazon.com*, including domestic shipping. Results are reported based on shipping charges for four-book bundles. We also include the (lagged absolute) price difference with the local competitor to control for repricing due to domestic competition. The controls $X_{it}^{j,CA}$ include month dummies, the number of months since first publication of book i, one lag of the log price level, as well as lagged *Amazon.com* sales rankings. Similar regressions

[26] By similar magnitude, we mean plus-or-minus 10%. Our results are quite robust to the use of wider time windows or stricter definitions of sales. Also, while we report here only results based on the filtered series, it turns out that conclusions are generally very similar if one instead relies on the raw data.

are also run for US retailers.

Table 5: Law of one price and probability of changing price. *Probit regressions. Robust standard errors allowing for correlation within clusters (ISBN) are in brackets. *, ** and *** indicate significance at the 10, 5 and 1 percent level respectively.*

	Amazon.ca $P\left(\Delta P_{it}^{AMCA} \neq 0\right)$		*Chapters.ca* $P\left(\Delta P_{it}^{CH} \neq 0\right)$	
	(2)	(3)	(2)	(3)
$e\tilde{P}_{it-1}^{CA} < \tilde{P}_{it-1}^{AMUS}$	0.22		−0.14	
	(0.15)		(0.12)	
$\log\left(\frac{e\tilde{P}_{it-1}^{CA}}{\tilde{P}_{it-1}^{AMUS}}\right)$		−0.58		5.41**
		(0.82)		(2.60)
$\left\lvert\log\left(\frac{P_{it-1}^{AMCA}}{P_{it-1}^{CH}}\right)\right\rvert$	1.64***	1.56***	1.03***	0.53
	(0.22)	(0.39)	(0.20)	(0.84)
Pseudo-R^2	0.15	0.29	0.11	0.12
Obs.	34358	3977	34358	1992
	Amazon.com $P\left(\Delta P_{it}^{AMUS} \neq 0\right)$		*BN.com* $P\left(\Delta P_{it}^{BN} \neq 0\right)$	
	(2)	(3)	(2)	(3)
$e\tilde{P}_{it-1}^{AMCA} < \tilde{P}_{it-1}^{US}$	0.18**		−0.23***	
	(0.07)		(0.07)	
$\log\left(\frac{e\tilde{P}_{it-1}^{AMCA}}{\tilde{P}_{it-1}^{US}}\right)$		−0.18		0.21
		(0.48)		(0.40)
$\left\lvert\log\left(\frac{P_{it-1}^{AMUS}}{P_{it-1}^{BN}}\right)\right\rvert$	0.70**	0.86***	−1.03***	−0.48
	(0.28)	(0.21)	(0.35)	(0.34)
Pseudo-R^2	0.07	0.07	0.04	0.03
Obs.	34358	4458	34358	22361

Results from a probit estimation of (2) for each retailer are reported in Table 5. For conciseness, coefficients for the control variables X_{it} are not reported. Notice that the price difference between a firm and its domestic competitor is generally significant and of the right sign, with the exception of *BN.com*. However, coefficients for the LOP dummy are only marginally significant, if at all. In fact, for *Chapters.ca* and *BN.com*, the coefficients are of the *wrong* sign: for example, *Chapters.ca* is less likely to reprice a book in violation of the law of one price.

The lack of clear results for regression 2 may be due to the fact that the LOP dummy is correlated with some unobserved characteristic. It could also be that the threshold is wrongly defined: for example, a bookseller may only find it worthwhile to react to large deviations from LOP. Next, we focus on the instances when there is violation of the law of one price and run the following probit regression, using *Amazon.ca* as an example:

$$P\left(\Delta P_{it}^{AMCA} \neq 0 \left| e\tilde{P}_{it-1}^{AMCA} < \tilde{P}_{it-1}^{AMUS} \right.\right) = \Phi\left[\log\left(\frac{e\tilde{P}_{it-1}^{AMCA}}{\tilde{P}_{it-1}^{AMUS}}\right), \left|\log\left(\frac{P_{it-1}^{AMCA}}{P_{it-1}^{CH}}\right)\right|, X_{it}\right]. \quad (3)$$

In other words, the probability of a price change is estimated as a function of the difference in price with the least expensive foreign competitor, using only the observations for which there is violation of the law of one price. From Table 5, it appears that for most retailers, the decision to reset a price is not significantly affected by the relative prices of foreign competitors. The only exception is *Chapters.ca*, but the coefficient is of the wrong sign. The marginal effects are also of little economic significance: setting all other independent variables to their mean values, a book which is equally priced at *Amazon.com* and *Amazon.ca* has a 1.2% probability of being repriced in any given period by *Amazon.com*. If this book becomes 20% cheaper at *Amazon.ca*, the price change probability only rises to 1.3%.[27]

Even if the timing of price changes does not seem to be affected by law of one price deviations, this is not necessarily evidence of international market segmentation. For example, firms may have time-dependent repricing rules (e.g. review prices once a year), and yet take into account cross-border price differentials when choosing a new price. We study this hypothesis next. The first question we aim to answer using our dataset is the following: are books in large violation of the law of one price more likely to be repriced in a direction that

[27] These price change frequencies are significantly different than the ones reported in Section 3. for two main reasons: temporary sales have been filtered out, and only observations in violation of LOP are kept.

restores parity? Once again, due to data availability, the focus is on instances when a US consumer can find a book for less in Canada than the US. In these cases, the theoretical model implies that under partial market segmentation, Canadian retailers should have an incentive to increase prices, while US booksellers find it optimal to lower theirs in order to remain competitive.

Taking *Amazon.com* as an example, the following probit regression is run for observations in violation of LOP:

$$P\left(\Delta P_{it}^{AMUS} < 0 \left| e\tilde{P}_{it-1}^{AMCA} < \tilde{P}_{it-1}^{AMUS}\right.\right) = \Phi\left[\log\left(\frac{e\tilde{P}_{it-1}^{AMCA}}{\tilde{P}_{it-1}^{AMUS}}\right), \log\left(\frac{P_{it-1}^{AMUS}}{P_{it-1}^{BN}}\right), X_{it}\right]. \quad (4)$$

All variables have been described earlier and X_{it} includes the same controls as before. Results presented in Table 6 show that none of the LOP coefficients are significant, except marginally so for *Chapters.ca*. In fact, for the two US retailers, the effects are of the wrong sign: as a book becomes cheaper in Canada, *Amazon.com* and *BN.com* become less likely to decrease that item's price. Conversely, firms generally appear to react significantly to domestic competition (note that the price difference between domestic competitors is not expressed in absolute value).

We then turn our attention to another question: conditional on a price being reset, is *Amazon.com* more likely to implement a price decrease for a book that initially sells for less in Canada? And vice-versa for Canadian retailers? Specifically, the following discrete choice model is estimated using:

$$P\left(\Delta P_{it}^{AMUS} < 0 \left| \Delta P_{it}^{AMUS} \neq 0\right.\right) = \Phi\left[e\tilde{P}_{it-1}^{CA} < \tilde{P}_{it-1}^{AMUS}, \log\left(\frac{P_{it-1}^{AMUS}}{P_{it-1}^{BN}}\right), X_{it}\right]. \quad (5)$$

Results in Table 6 show that there is little support for this hypothesis, with the exception of *Amazon.com*. The LOP indicator is not significant for the three other retailers, and of the wrong sign for *Amazon.ca*.

Table 6: Law of one price and sign of price change. *Probit regressions. Robust standard errors allowing for correlation within clusters (ISBN) are in brackets. *, ** and *** indicate significance at the 10, 5 and 1 percent level respectively.*

	$P\left(\Delta P_{it}^{CA}>0 \middle\| e\tilde{P}_{it-1}^{CA}<\tilde{P}_{it-1}^{US}\right)$		$P\left(\Delta P_{it}^{CA}>0 \middle\| \Delta P_{it}^{CA}\neq 0\right)$	
	Amazon.ca	*Chapters.ca*	*Amazon.ca*	*Chapters.ca*
	(4)	(4)	(5)	(5)
$e\tilde{P}_{it-1}^{CA}<\tilde{P}_{it-1}^{AMUS}$			-0.59	0.49
			(0.49)	(0.39)
$\log\left(\frac{e\tilde{P}_{it-1}^{CA}}{\tilde{P}_{it-1}^{AMUS}}\right)$	0.67	20.73^{*}		
	(0.97)	(10.97)		
$\log\left(\frac{P_{it-1}^{AMCA}}{P_{it-1}^{CH}}\right)$	-2.85^{***}	6.20^{**}	-5.67^{***}	3.01^{**}
	(0.73)	(3.08)	(2.00)	(1.24)
Pseudo-R^2	0.37	0.18	0.24	0.51
Obs.	3977	1658	279	195
	$P\left(\Delta P_{it}^{US}<0 \middle\| e\tilde{P}_{it-1}^{CA}<\tilde{P}_{it-1}^{US}\right)$		$P\left(\Delta P_{it}^{US}<0 \middle\| \Delta P_{it}^{US}\neq 0\right)$	
	Amazon.com	*BN.com*	*Amazon.com*	*BN.com*
	(4)	(4)	(5)	(5)
$e\tilde{P}_{it-1}^{AMCA}<\tilde{P}_{it-1}^{US}$			0.64^{***}	0.14
			(0.20)	(0.34)
$\log\left(\frac{e\tilde{P}_{it-1}^{AMCA}}{\tilde{P}_{it-1}^{US}}\right)$	-0.24	-0.28		
	(0.45)	(0.30)		
$\log\left(\frac{P_{it-1}^{AMUS}}{P_{it-1}^{BN}}\right)$	-0.84^{***}	-0.01	0.39	-6.97^{***}
	(0.19)	(0.29)	(0.54)	(1.87)
Pseudo-R^2	0.05	0.07	0.10	0.59
Obs.	4458	19887	602	305

For the last empirical exercise of this section, we estimate a linear model by using the size of price changes, $\Delta \log P_{it}$, as the dependent variable.

$$\Delta \log P_{it}^{AMUS} = \beta_0 + \beta_1 z_{it-1}^{US} + \beta_2 \log\left(\frac{P_{it-1}^{AMUS}}{P_{it-1}^{BN}}\right) + X_{it}'\Gamma + \varepsilon_{it} \tag{6}$$

Explanatory variables again include domestic price differentials as well as the usual controls. The regressor of interest is a variable z_{it} equal to the cross-border price differential when a book is in violation of LOP, and zero otherwise:

$$z_{it-1} = \begin{cases} \log\left(\frac{e\tilde{P}^{CA}_{it-1}}{\tilde{P}^{US}_{it-1}}\right) & \text{if } e\tilde{P}^{CA}_{it-1} < \tilde{P}^{US}_{it-1} \\ 0 & \text{otherwise.} \end{cases}$$

Here, as in the previous regression, we take as given the timing of firms' pricing decisions and rely only on observations characterized by a price change.

Once again, it appears difficult to reject the hypothesis of international market segmentation in the context of online bookselling. Based on the results in Table 7, online booksellers do not seem to implement more sizeable price changes for books in large deviation of LOP. In fact, only *Amazon.ca* exhibits a statistically significant relationship between these two variables, but it is of the wrong sign: a book which already sells for much less than in the US (from the perspective of an American consumer) on average experiences a larger price drop. On the other hand, coefficients on domestic price differentials are more in line with the model predictions and are indicative of market integration at the domestic level.

In general, the results from this section do not allow us to reject the hypothesis of full international market segmentation in the context of online bookselling over our sample period. Yet, the lack of conclusive evidence in favor of partial segmentation could be due to the pervasive price rigidity present in our database: when prices are seldom adjusted to start with, making conclusive conditional statements about variations in price-setting strategies represents a challenge.[28]

[28] The lack of price response to exchange rate fluctuations is particularly surprising for Canadian retailers: since most, if not all, of the books in our sample are printed in the US, one may think that exchange rate fluctuations would lead to significant marginal cost changes for *Amazon.ca* and *Chapters.ca*. However,

Table 7: Law of one price and size of price changes. *Linear regression (6) using observations characterized by a price change. Robust standard errors allowing for correlation within clusters (ISBN) are in brackets. *, ** and *** indicate significance at the 10, 5 and 1 percent level respectively.*

	Amazon.ca	*Chapters.ca*	*Amazon.com*	*BN.com*
z_{it}	0.64^{***} (0.13)	-3.25 (2.83)	0.14 (0.18)	0.23^{*} (0.14)
$\log\left(\frac{P^{AMCA}_{it-1}}{P^{CH}_{it-1}}\right)$	-0.54^{***} (0.09)	0.59^{*} (0.35)		
$\log\left(\frac{P^{AMUS}_{it-1}}{P^{BN}_{it-1}}\right)$			-0.25^{***} (0.07)	0.41^{***} (0.13)
R^2	0.28	0.44	0.28	0.62
Obs.	279	195	602	330

But then, if indeed nominal prices do not react to exchange rate shocks, it must imply that international relative prices are highly volatile. Under partial market segmentation, this in turn should have an impact on quantities. The next section analyzes this issue.

6.1. Ranking analysis

In the previous section, prices were used to test international market segmentation. However, as was already clear from Section 3., this task is complicated by the fact that prices in our online environment are very sticky. If nominal rigidities are indeed very large, it may simply not be worth it for retailers to adjust prices even when markets are in fact integrated. Yet, the model from Section 5. naturally predicts that even if prices do not to adjust to deviations from the law of one price, quantities should: if markets were not fully segmented, variations in the relative price of domestic and foreign retailers would lead to fluctuations in quantities sold as consumers switch retailer.[29] This is something we aim to test next.

rigorously testing this channel requires information on marginal cost, which we do not have.

[29] This is true under the condition that prices are sticky. For example, consider the case where there is partial segmentation with the indifferent agent in country 1. We are interested in the impact of a change in e on $\widetilde{x}^1_{1a2a}$, holding constant p_{1a} and p_{2a}. Recall from above that $\widetilde{x}^1_{1a2a} = \frac{p_{2a}e+b_1-p_{1a}}{2t} + \frac{1}{8}$ and therefore we

Book sales disaggregated at the retailer level are not public information. However, sales rankings are available for all of our retailers except Chapters. Using a few experiments, Chevalier and Golsbee (2003) show that a Pareto relationship approximates quite well the relationship between sales and rankings for *Amazon.com* and *BN.com*:[30]

$$\log\left(Q_{it}^{k,CA}\right) = \delta_0 + \delta_1 \log\left(R_{it}^{k,CA}\right),$$

where $Q_{it}^{k,CA}$ and $R_{it}^{k,CA}$ are the quantity and the sales rank respectively. This relationship allows us to consider a basic log-log demand function for book i sold at time t by Canadian retailer k:

$$\begin{aligned} \log\left(R_{it}^{k,CA}\right) &= \alpha_0^k + \alpha_1^k \log P_{it}^{k,CA} + \alpha_2^k \log P_{it}^{-k,CA} \\ &\quad + \alpha_3^k \log\left(\frac{P_{it}^{j,US}}{e}\right) + \alpha_4^k \log\left(\frac{P_{it}^{-j,US}}{e}\right) + \Phi^{k\prime} X_{it}^{k,CA} + \eta_{it}^k, \end{aligned} \tag{7}$$

where $P_{it}^{-k,CA}$, $P_{it}^{j,US}$ and $P_{it}^{-j,US}$ are the prices charged by Canadian and US competitors, and $X_{it}^{k,CA}$ is a set of controls. All prices are in local currency and include shipping costs, and e corresponds to the exchange rate (US dollars per Canadian dollar).[31] The demand function (7) is similar to the one also used by Ghose and Gu (2006) and Brynjolfsson, Smith and Hu (2003) in the context of online book retailing.

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have that $\frac{\partial \tilde{x}_{1a2a}^1}{\partial e} = \frac{p_{2a}}{2t} > 0$.

If prices do react to exchange rate fluctuations, the model predictions are not as clear. As an illustration, recall what happens following an appreciation of the US dollar (assuming no price rigidity): the Canadian firm raises its price in domestic currency, which depresses domestic demand, but foreign sales rise since the price in USD drops following the exchange rate movement. The net effect on total sales is ambiguous.

[30] Amazon in fact changed its ranking methodology in 2004. It is believed that the new system puts a larger weight on recent sales to compute rankings. While this may have led to changes in the coefficients δ_0 and δ_1, since we are not primarily interested in quantifying the price elasticities of demand, this change in methodology is not really relevant in our context.

[31] Shipping costs are based on four-book bundles.

A difficulty when estimating (7) stems from the fact that demand for books is hit by shocks which are unobservable or difficult to quantify by the econometrician: appearance of the author on a popular TV show, publication of a sequel, etc. Assuming that such shocks affect demand at each retailer in a somewhat similar fashion, one could run a regression where the dependent variable is the difference in rankings for a pair of retailers.[32] The resulting expression is given by

$$\begin{aligned}\log\left(\frac{R_{it}^{k,CA}}{R_{it}^{j,US}}\right) &= \gamma + \left(\alpha_1^k - \alpha_3^j\right)\log P_{it}^{k,CA} + \left(\alpha_2^k - \alpha_4^j\right)\log P_{it}^{-k,CA} \\ &+ \left(\alpha_3^k - \alpha_1^j\right)\log\left(P_{it}^{j,US}\right) + \left(\alpha_4^k - \alpha_2^j\right)\log\left(P_{it}^{-j,US}\right) \\ &+ \left(\Phi^{k\prime} - \Phi^{j\prime}\right)\left(X_{it}^{CA} - X_{it}^{US}\right) - \left(\alpha_3^k + \alpha_3^j + \alpha_4^k + \alpha_4^j\right)\log e + \nu_{it},\end{aligned} \tag{8}$$

As argued by Chevalier and Goolsbee, this type of transformation does not allow us to distinguish own and cross-price elasticities. However, in our setup there still is some useful information about the object of interest to be gleaned from such regression. The coefficient on the log of the USD/CAD exchange rate is expected to be positive under partially segmented markets since it involves only cross-price elasticity coefficients. The advantage of this approach is that it eliminates book-time specific factors (e.g. taste shocks).

Under fully segmented markets, the coefficients α_3 and α_4 should equal zero: foreign prices are irrelevant to domestic sales. However, in the case of partially segmented markets coupled with stable prices, sales are expected to react to foreign prices. That is, the coefficients α_3 and α_4 should be negative for books in violation of the law of one price.

[32] The correlation between the log of rankings of *Amazon.com* and *Amazon.ca* is equal to 0.76, and to 0.85 between *BN.com* and *Amazon.com*.

An issue that arises when estimating demand regressions for online book retailers is that rankings are measures of *relative* sales. The ranking of a given book may be changing because of fluctuations in the quantities sold of other products. In our context, however, this problem is less acute: the model from Section 5. predicts that exchange rate movements should only have an impact on quantities sold under partially segmented markets. Hence, if border costs are small, relative quantities and rankings will be affected: currency fluctuations will change the demand for books which are in deviation of the law of one price, but not of other products.

Table 8 presents a summary of the empirical results using the rankings for *Amazon.ca*.[33] Only the observations for which books are cheaper in Canada than in the US from the perspective of a US resident are used for the regressions: these are the most likely to yield evidence of partially segmented markets.[34] Control variables include weekly time dummies and number of months since first publication. Book fixed effects are also included in the panel regressions.

First, as expected, a rise in the price of a book at *Amazon.ca* has a large impact on rankings. This coefficient is strongly significant under all specifications. In contrast, the price at *Chapters.ca* has little or no impact on *Amazon.ca* sales: the $\log P_{it}^{CH}$ parameter is small in size and never significant. It may not be that surprising after all: *Chapters.ca* has very sticky prices, and the lack of price variation makes it difficult to identify any significant cross-price elasticity. In fact, when considering only observations for which *Chapters.ca* implemented a sale, we find a negative correlation between $\log P_{it}^{CH}$ and $\log\left(R_{it}^{AMCA}\right)$.

[33] Rankings for Amazon.ca are only available starting on December 28, 2008.

[34] For books which are cheaper domestically, the model predicts that quantities will not be responding to exchange rate fluctuations (conditional on local prices being constant). Regarding the products that a Canadian resident could find for less in the US, there are just too few observations in our dataset to obtain reliable inference.

Looking at the question of international market segmentation, both the prices of *Amazon.com* and *BN.com* seem to have an impact on *Amazon.ca* sales in regression (1). However, the effects go in the wrong direction: the positive coefficients indicate that a rise in the price of a US retailer (in Canadian dollars) leads to an increase in the ranking, or a fall in quantities sold at *Amazon.ca*. Introducing the *Amazon.com* rankings as an explanatory variable to control for demand shocks does not alter our findings (see column (2)). Also, in column (3), the regression is run on weekly-average data instead to smooth out the wide variations in sales rankings. The results are qualitatively similar.

Next, we estimate equation (8), once again exploiting the panel nature of our dataset. The own-price elasticity parameter remains high and significant, while the coefficients on US prices are negative but never statistically significant. They are, however, a mixture of own and cross-price elasticities, so their sign cannot be interpreted as an indicator of partial market segmentation. To do that, one has to look at the coefficient on the log exchange rate: at 1.39, it is of the right sign, but the standard error is very large at 1.65. Recall from (8) that this parameter consists of the sum of four cross-price elasticities; it is therefore not surprising that it is so large.

Given that it is not possible to determine what time window the retailers use to compute their sales rankings, we also tried to introduce a lagged dependent variable as well as price lags. The conclusions are not affected by these alternative specifications.[35] In sum, we cannot find any evidence of partially segmented markets: variations in relative international prices do not appear to lead to variations in sales at online book retailers.

[35] In addition, we expanded the dataset to include all books, instead of focusing on those for which data are available for all thirteen months. The results are very similar to those reported in Table 8.

Table 8: Sales rankings as function of various price measures. *Panel regressions with book fixed effects. Robust standard errors allowing for correlation within clusters (ISBN) are in brackets. *, ** and *** indicate significance at the 10, 5 and 1 percent level respectively.*

	(1)	(2)	(3)	(4)
	$\log\left(R_{it}^{AMCA}\right)$	$\log\left(R_{it}^{AMCA}\right)$	$\log\left(R_{it}^{AMCA}\right)$	$\log\left(\frac{R_{it}^{AMCA}}{R_{it}^{AMUS}}\right)$
$\log P_{it}^{AMCA}$	3.24	3.24	2.53***	3.14
	(0.29)	(0.29)	(0.37)	(0.37)
$\log P_{it}^{CH}$	−0.04	−0.06	−0.07	−0.19
	(0.14)	(0.14)	(0.07)	(0.18)
$\log\left(P_{it}^{AMUS}/e\right)$	0.73	0.60	0.89	
	(0.27)	(0.27)	(0.58)	
$\log\left(P_{it}^{BN}/e\right)$	0.48	0.39	0.30	
	(0.20)	(0.20)	(0.30)	
$\log P_{it}^{AMUS}$				−0.55
				(0.35)
$\log P_{it}^{BN}$				−0.48
				(0.26)
$\log e$				1.39
				(2.03)
$\log\left(R_{it}^{AMUS}\right)$		0.10		
		(0.02)		
R^2	0.09	0.10	0.15	0.10
Obs.	3610	3610	1260	3610

7. Conclusion

There is considerable empirical evidence showing that prices react very little to exchange rate fluctuations. In many contexts, however, deviations from the law of one price may not be too surprising: transaction costs, imperfect product substitution, trade laws, taste differences or even informational frictions could lead to *de facto* market segmentation. In this paper, we gather data from online booksellers in the US and Canada. Arguably, trade frictions are minimal in this context: each product is identical across all retailers, price comparisons can be performed at minimal costs, the physical concept of distance is irrelevant beyond shipping costs which are observable, books are not subject to trade restrictions or tariffs according to NAFTA rules, there are no constraints to buying books from foreign retailers, and Canada and the US share similar tastes and economic environments.

In our sample, we find widespread evidence of deviations from the law of one price across countries. Does this represent conclusive evidence of market segmentation? Not necessarily. One possibility is that retailers face constraints to price adjustment which lead to nominal price rigidity. Indeed, our dataset shows that even in an online environment, prices remain quite rigid.

In addition, while deviations of the law of one price are prevalent between Canada and the US over our sample period, there is also significant price dispersion at the national level. We therefore use a simple theoretical model to derive predictions about the response of prices to exchange rate fluctuations. Under partially segmented markets, one would expect retailers to react to changes in the exchange rate in order to minimize movements in relative prices. Empirically, we find very little evidence of such behavior: the probability of a price change is not higher for books in violation of the law of one price. There is also no conclusive evidence that when prices do change, they move in a direction to close the deviation from the law of

one price. Finally, if prices are sticky, variations in international relative prices should lead to fluctuations in quantities: using sales rankings as proxies, we do not find any support for this hypothesis in our dataset. Overall, these results are consistent with the presence of international market segmentation.[36]

What could prevent consumers from taking advantage of arbitrage opportunities in a market as transparent and frictionless as the online book industry? One possibility is that consumers value highly the shorter shipping times or easier return policies of domestic sellers. It could also be that informational frictions remain: US consumers may simply be unaware that cross-border deals exist or even that they can easily order books from Canadian websites.[37] In fact, recent experience suggests that in some well publicized instances, retailers have indeed adjusted prices in response to deviations from the law of one price: in 2007, as the Canadian dollar appreciated strongly against the US dollar, public uproar over cross-border price disparities led to widespread price adjustments by Canadian retailers, notably for cars, electronics and books.

In the end, our view of how the economy works and what should be the role of economic policies is largely function of how prices react to market forces. For this reason, it is crucial to go beyond documenting the unconditional behavior of prices at the micro level and study how prices respond to particular shocks. This, in turn, will hopefully help us shed light on the mechanisms behind price rigidity at the macroeconomic level.

[36] There may also be significant market segmentation at the domestic level. While our analysis indicates that retailers react to prices set by their domestic competitors, cross-price elasticities appear to be very small on the Canadian market.

[37] Consumers may also be unsure as to the fees charged by credit card companies for currency conversion.

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