ONLINE SEARCH TOOLS AND FIRM PRICE-SETTING DECISIONS: A STUDY OF THE CANADIAN MORTGAGE MARKET

by

Elise Nelson

An essay submitted to the Department of Economics

in partial fulfillment of the requirements for

the degree of Master of Arts

Queen's University

Kingston, Ontario, Canada

August 2019

Acknowledgments

I am especially grateful to Robert Clark who provided vital insight, instruction and guidance. I am also thankful for the help of Shaoteng Li and Jason Allen who provided data. Lastly, I would like to thank Andrew Bootsma for assisting in scraping the data.

Table of Contents

1. Introduction

Over the last decade, there has been a significant increase in online retail which has major implications on market structure, firm decision making, and consumer welfare. Specifically, the development of online price searching tools has made it easier for consumers to find and compare prices, and for firms to change their prices online. In the residential mortgage market, online search tools have become an important step in the mortgage rate shopping process. According to CMHC's *Mortgage Consumer Survey 2018*, 75% of consumers research mortgage options and features online; of these, about half use rate-comparison websites. The increased online presence of mortgage lenders has especially benefited smaller players; such as credit unions, brokers, and mortgage finance companies. Online tools allow smaller lenders to post their rates online and monitor their rivals' rates at relatively little to no cost. As a result of improving information technology and changing government policy, the composition of Canada's mortgage market has changed over the last decade. There has been a shift away from large national banks towards smaller private lenders and mortgage finance companies (Coletti, Gosselin, & MacDonald, 2016). Banks still dominate the market; however, credit unions and mortgage finance companies are now prominent players holding 17% of the mortgage market.[1] The Bank of Canada and the Canadian Mortgage and Housing Corporation (CMHC) are closely monitoring these changes as they have important implications for financial stability and regulation in Canada.[2]

Additionally, online search tools have economic implications which motivate research in this area. Since it is less costly for firms to change their prices online than in brick-and-mortar

[1] Statistic from CMHC's *August 2018 Research Insight: Impact of Credit Unions and Mortgage Finance Companies on the Canadian Mortgage Market.*
[2] For more information see Coletti, Gosselin, and MacDonald's (2016) paper published by the Bank of Canada.

stores, economists expect firms to change their prices more frequently in response to cost changes and other economic factors in online markets. In my paper, I investigate the impact of online search tools on firm price-setting decisions. Specifically, I analyze price dispersion in the online mortgage market in Canada and investigate lenders' pricing patterns. Building on the price-rigidity literature, I follow the models used in Arbatskaya and Baye (2004) and Remer (2012) to measure asymmetric price adjustments. I also examine the duration of posted mortgage rates by applying survival models. My paper was motivated by the work of Arbatskaya and Baye (2004) whereby they analyze daily mortgage rates posted by online lenders on the American price comparison site, *Microsurf*. For my analysis, I collect firm-level panel data consisting of weekly observations on 5-year fixed term mortgage rates posted by online lenders on the Canadian mortgage rate comparison site *RateSpy.com*. I gather data for over 300 lenders in Canada consisting of a variety of lender types, such as banks, credit unions, and brokers. In section 2, I will review the relevant literature and discuss my paper's connection. Section 3 will provide an overview of the mortgage market in Canada and describe the changing landscape. In section 4, I will explain the data collection process and examine the timing of rate changes and price dispersion. In section 5, I will construct models to measure price adjustment and investigate the duration of mortgage rates. Section 6 will conclude.

2. Literature Review

This paper encompasses three areas; online retail, price comparison tools, and price rigidity. The literature on online retail began around the 2000s with Brynjolfsson & Smith (2000) who compare prices and price dispersion between online and physical bookstores. They find prices to be 9-16% lower and less disperse online. Bakos (2001) discusses the theoretical

economic implications of online retail which includes lower search costs, more competition, lower prices, and overall increased consumer welfare. In general, these theories have been accepted however empirical findings do not always support them. Clay, Krishnan, Wolff, and Fernandes (2002) find prices are similar in online and physical book stores but there is more price dispersion online. They suggest firms combat the increased competition online by differentiating their product by adding other features (e.g. loyalty programs, reviews, etc.). Cavallo (2017) compares prices on websites and physical store of 56 large multi-channel retailers in 10 countries and finds price levels the same about 72% of the time and little within-retailer price dispersion, both online and offline. These findings suggest the internet has incentivised companies to price identically across their own physical and online stores. In the online mortgage market, lenders face more competition since consumers have lower search costs when comparing rates. Theoretically, the increased competition and the relatively small cost for lenders to change their rates online would cause lenders to post lower rates, change rates more frequently, and for rates to be less dispersed. In the subsequent section, I will analyze mortgage rate data and look at the frequency of rate changes and rate dispersion present on the online mortgage rate comparison site *RateSpy.com*. I will not be comparing online and instore mortgage rates, however, it is important to understand why they may be different and the implications on economic outcomes.

The second area of literature pertinent to this paper is about online price comparison tools. Since my data are collected from the online mortgage rate comparison site *RateSpy.com*, the economic implications of the many firms posting their rates on the same online platform are relevant when discussing price-setting decisions. Baye, Morgan, and Scholten (2004) look at the relationship between the number of firms listing prices and price dispersion and find less price

dispersion when more firms list prices. Their results suggest it is useful to control for market structure in online markets when comparing levels of dispersion across products or over time. Tang, Smith, and Montgomery (2010) look at the impact of internet price search tools on prices and price dispersion and find a 1% increase in search tool usage leads to $0.41 decrease in price and 1.1% decrease in price dispersion. These papers suggest there should be less price dispersion present on online comparison sites, however, data from *RateSpy.com* display considerable mortgage rate dispersion across provider types and provinces.

The most significant area of literature drawn on for the empirical components of this paper is on price rigidity or price adjustment. Price rigidity is a large area of literature and has been widely studied in many industries. Pelzman (2000) analyzes price rigidity in 242 commodity markets (food, alcohol, fuel, etc.) and finds prices rise more than they fall in two-thirds of the markets. Particularly, price rigidity in retail gasoline markets has been widely studied. Borenstein, Cameron, and Gilbert (1997) study the price adjustment patterns in retail gasoline markets and find prices respond more quickly to increases than to decreases in crude oil prices. Their empirical model has served as the foundation for most price rigidity research and is the basis for the empirical work done in this paper. Godby, Lintner, Stengos, and Wandschneider (2000) test for asymmetric pricing in the Canadian retail gasoline market and find no evidence of asymmetric behaviour. Bachmeier and Griffin (2003) build on Borenstein, Cameron, and Gilbert's (1997) model by adding the standard Engle-Granger two-step estimation procedure. They find no evidence of asymmetry in the response of regional wholesale gasoline prices to crude oil price shocks. Remer (2012) follows the same model specified in Bachmeier and Griffin (2003) to estimate the degree of price asymmetry for over 11,000 retail gasoline stations. In the

empirical section of this paper, I will apply the model used by Remer (2012) to analyze mortgage rate adjustment asymmetry in the Canadian online mortgage market.

The literature on price rigidity in financial industries suggests financial products experience similar asymmetric pricing patterns as other products. Hannan and Berger (1997) analyze price rigidity in the United States banking industry and find more rigidity in concentrated markets and rates increase more than decrease. Hofmann and Mizen (2004) analyze the impact of interest rate changes on deposit accounts and mortgage products offered by UK financial institutions and find the speed of adjustment in retail rates depends on whether the perceived 'gap' between retail and base rates is widening or narrowing (adjusting faster to close growing gaps). Their method allows for asymmetry and non-linear price adjustments and they find complete pass-through in the long run for deposit rates but not for mortgage rates. The main inspiration for my paper comes from Arbatskaya and Baye (2004) who analyze price adjustment in the online mortgage market with data from the online mortgage rate comparison site *Microsurf*. Since my data are similar in format except from a Canadian source, I thought it would be useful to follow their methodology to investigate if the online Canadian mortgage market follows similar trends as those found in Arbatskaya and Baye (2004). They find mortgage rates are rigid, adjust more to cost increases than decreases, and change more in less concentrated markets which is consistent with the results found in this paper. In general, my paper will be adding to this area of literature by examining price rigidity in the Canadian mortgage market. Allen and McVanel (2009) empirically analyze the price-setting behaviour of the major Canadian banks in the residential mortgage market over the period 1991–2007. They find evidence of price leaders and a positive correlation between market concentration and price dispersion which suggests the mortgage market in Canada is imperfectly competitive. They also

find the existence of asymmetric pricing in the short run and complete cost pass-through in the long run. My paper examines the pricing decisions of not only the large banks in Canada but also of many smaller lenders including credit unions, brokers, and wholesale providers.

3. Institutional Details

At the end of 2018, the size of the Canadian residential mortgage market was $1.5 trillion, representing over 70% percent of total household credit.[3] The mortgage market in Canada is dominated by the six largest Canadian commercial banks; the Bank of Montreal (BMO), CIBC (CIBC), National Bank (NAT), RBC Financial Group (RBC), Scotiabank (BNS) and TD Bank Financial Group (TD). The 'Big Six' banks increased their market share from 39% to 65% from 1992 to 2000 due to the major banks acquiring trust companies over that period (Allen & McVanel, 2009). On the contrary, the mortgage market in the United States is less centralized and there are more localized lenders operating in specific states. Unlike in the United States, most Canadian banks operate nationally and post the same rates across the country which suggests local competition does not influence the posted rate. Canadian banks typically post mortgage rates on a weekly basis and there is little dispersion among the top six banks. However, in the United States, national lenders such as Bank of America will post different mortgage rates online depending on a consumer's zip code (Allen, Clark, & Houde, 2014). The structure of mortgage contracts also differs between Canada and the United States. In Canada, standard mortgage contracts are fixed-rate with five, three, or one-year terms and the contract is renegotiated at the end of the term. Additionally, the terms of the mortgage contract do not affect the amortization period, which is predominately 25 years. I analyze the 5-year fixed mortgage

[3] Statistics from the Bank of Canada's *Selected credit measures* table.

rate because it is the most popular type of rate in Canada and I use the 5-year swap-adjusted bond rate as a proxy for the cost of a lender's mortgage rate.[4] In the United States, mortgage contracts are longer and thus Arbatskaya and Baye (2004) look at 30-year fixed mortgage rates and use the 10-year T-bond rate as the proxy for cost.[5] It is important to acknowledge that the mortgage market in Canada is dominated by six large banks when analyzing the results found in the subsequent sections of this paper.

Despite the enduring dominance of the Big Six banks, brokers and credit unions have become more popular in the last decade. Credit unions are locally owned financial cooperatives and their local market expertise allows them to extend mortgages to borrowers considered higher risk by other lenders (CMHC, 2018). Unlike banks, credit unions operate as not-for-profit organizations whose owners are also the customers. Credit unions are provincially regulated and only their insured mortgages are subject to federally mandated stress tests. Credit unions have experienced substantial growth since the financial crisis in 2008, which was primarily due to organic membership and market growth and partially due to industry consolidation (CMHC, 2018). Interestingly, the popularity of credit unions varies substantially across provinces with 30% market penetration in some provinces and only 5% in others.[6] The increased presence of credit unions can stimulate competition in the mortgage market and offer borrowers an alternative to the major banks.

Additionally, brokers have become more popular in Canadians with 40% of purchases, primarily by first-time homebuyers, coming from brokers.[7] Brokers are mortgage specialists who

[4] CMHC, *2018 Mortgage Consumer Survey*
[5] Arbatskaya and Baye (2004) collect mortgage rates from April 30 and July 22 in 1998.
[6] Statistics from CMHC's *June 2018 Housing Research Report: Impact of Credit Unions and Mortgage Finance Companies on the Canadian Mortgage Market.*
[7] ibid.

have access to mortgage rates from multiple lenders, including mortgage finance companies and large banks. Essentially, brokers are hired by consumers to search for the lowest rate and compensated by lenders. Brokers are generally compensated between 1–1.3 percent of the volume of mortgages they bring to a lender in a month (Allen, Clark, & Houde, 2014). Allen, Clark, and Houde (2014) show that a significant amount of the variation in mortgage rates in Canada is attributable to differences in a consumer's ability and willingness to search for the lowest rate. Allen, Clark, and Houde (2014) also show that price dispersion is significantly lower among borrowers who use brokers since they have greater bargaining power. Thus, hiring a broker can be advantageous for consumers looking for the best mortgage rates. Interestingly, on average, first-time buyers contact 2.1 brokers and 3.1 lenders and repeat buyers contact 1.5 brokers and 2.3 lenders when shopping for a mortgage.[8] The data used in this paper consist of mortgage rates posted by a variety of lender types with banks, brokers, and credit unions composing 8%, 32%, and 56% of the sample respectively. In the subsequent sections of this paper, I will analyze the differences in mortgage rate dispersion, adjustment to cost shocks, and duration between lender types.

4. Data and Summary Statistics

To examine price adjustment patterns in online markets, I assembled firm-level panel data consisting of weekly observations on the rates charged by different online lenders for 5-year fixed mortgage rates. Following the method of Arbatskaya and Baye (2004) who use data gathered from the American mortgage rate comparison site *Microsurf*, I collect data from the Canadian mortgage rate comparison site *RateSpy.com*. Lenders post their mortgage rate quotes

[8] Statistics from CMHC's *Mortgage Consumer Survey 2018*.

and corresponding terms and conditions for the loan to *RateSpy.com*. Consumers may input their home value, mortgage size, amortization period, province, the term (e.g. 1-year or 5-year) and rate type (e.g. variable or fixed) and *RateSpy.com* will provide all the rates and the characteristics of the loans that fit the given criteria, free of charge. *RateSpy.com* also has a 'historical rates' feature under the 'advanced options' which allows consumers to select a past day from a calendar and access the mortgage rates from that day. For each day, there are at least 25 pages with 15 rates listed per page.[9] I utilize the historical rates feature to scrape the first 25 pages of rates from each Monday in 2018. Beside each mortgage rate there is a 'details' section which reports the mortgage characteristics. I utilize the details feature to scrape data on the mortgage characteristics which includes the rate hold period, lump sum prepayment allowance, payment increase, double-up payments, permitted loan-to-value, pre-approvals, provider type, and provinces served, for each posted mortgage rate. The description of each mortgage characteristic is outlined in Table 1.

Table 1: Mortgage characteristic descriptions

Mortgage Characteristic	**Description**[10]	**Unit**
Rate hold period	The length of time that the lender will guarantee the rate.	Days
lump prepayments	The amount you can prepay in a lump sum each year without incurring a penalty.	Percentage
Payment Increase	The amount that you can optionally increase your payments by each year.	Percentage
Double-up Payments	If the lender allows you to pay up to twice as much as your regular payments, on any normal payment date.	1 = 'Yes' 0 = 'No'
Permitted Loan-to-Value	The maximum percentage of your home's value that your mortgage can comprise.	Percentage
Pre-approvals	If the lender will hold your rate while you shop for a new home.	1 = 'Yes' 0 = 'No'
Provider Type	The type of mortgage provider offering this rate.	Numerically coded
Provinces Served	The provinces where this rate offer is valid.	For each province, 1 = 'Yes', 0 = 'No'

[9] There were a few days with 26 or 27 pages, however, for simplicity, I choose to only take the first 25 pages.
[10] From *RateSpy.com*

In total, the panel has 19,364 lender-rate observations, with 339 different lenders appearing at least once and an average of 372 observations per Monday for 52 weeks.[11] For my analysis, I limit my panel to 5-year fixed mortgage rates and I use the 5-year swap-adjusted bond rate as a proxy for the cost of a lender's mortgage rate.[12]

Interestingly, some lenders posted multiple rates on a given day and some lenders did not post a rate each week.[13] Many lenders post multiple rates since they correspond to different mortgage characteristics. On average, each bank, broker, and credit union listed 1.8, 2.5, and 1.2 rates per day respectively. An identification problem arose when a lender would post multiple rates on the same day, with the same or similar loan characteristics. To identify the lender-rate observation, I ranked all the rates posted by a lender on a given day by value and assumed the rank remains the same over time.[14] The Big Six banks would have up to three rates posted on a given day; a discretionary rate, a special offers rate, and a posted rate. The posted rate and special offers rate are published by the bank with certain mortgage characteristics. The posted rates are the highest and are the 'official' rates published on all banks' websites whereas the special offers rates are lower and not all banks choose to publish them. *RateSpy.com* also posts 'discretionary' rates for the Big Six banks which are discounted rates available for certain 'well-qualified' borrowers but not advertised publicly.[15] The discretionary rate is estimated by *RateSpy.com* based on typical industry discounts from posted rates and intelligence from mortgage advisors in the field and is the same for the Big Six banks. Essentially, the discretionary rate is the rate a consumer should be able to negotiate under normal circumstances

[11] There were 53 Monday's in 2018 however, May 20th was missing all observations for an unknown reason.
[12] The 5-year swap bond rate is retrieved from Bloomberg
[13] For the empirical analysis section, the missing rates are imputed with the previous week's rate.
[14] i.e. highest rates are given a 1, second highest a 2, etc.
[15] *RateSpy.com* notes "a client's ability to obtain discretionary discounts is based on a variety of factors, including their history with that institution, their negotiating ability, their credit worthiness, etc."

and is published by *RateSpy.com* to help combat the information asymmetry between banks and consumers.[16] For my analysis, the discretionary rates are omitted and only the posted rates and special offers rates are kept.[17] I added the posted rates for the Big Six manually to my data set because not all of them they had posted rates listed on *RateSpy.com* in 2018.[18] Table 2 shows statistics for the posted and special offers rates of the Big Six banks. CIBC has the lowest average posted rate at 5.129 and TD has the highest at 5.446. Overall, there is not a lot of variation between the posted rates for the top six banks. There are also 18 smaller banks present in the data which have a similar average mortgage rate as the Big Six. Note, for the rest of the paper 'banks' will refer to all the banks.

Table 2: 5-year fixed mortgage rate statistics for the Big Six banks

Bank	**Rate**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
BMO	Posted rate	5.213	0.094	4.99	5.34
	Special offers rate	3.506	0.162	3.29	3.99
CIBC	Posted rate	5.129	0.133	4.89	5.34
	Special offers rate	3.273	0.104	3.19	3.49
National	Posted rate	5.269	0.107	4.99	5.34
	Special offers rate	3.644	0.197	3.39	3.99
RBC	Posted rate	5.269	0.107	4.99	5.34
	Special offers rate	3.699	0.143	3.39	3.89
Scotia	Posted rate	5.286	0.129	4.99	5.44
TD	Posted rate	5.446	0.220	4.99	5.59
Big Six banks	Average mortgage rate	4.609	0.857	3.19	5.59
Non-Big Six banks	Average mortgage rate	4.575	1.038	2.99	6.74

[16] *RateSpy.com* notes "discretionary rate estimates do not apply to all mortgages. For example, you won't typically get these rates on non-prime mortgages, non-marketable properties, investment property mortgages, construction mortgages, new immigrant financing, cottage mortgages and other unique situations."
[17] Scotiabank and TD did not list any special offers rates on *RateSpy.com*.
[18] Posted rate data are from the CANNEX Financial Exchange.

Table 3: Summary statistics

Variable	Mean	Std. Dev.	Minimum	Maximum
5-year fixed mortgage rate - All	3.884	0.738	2.680	7.990
5-year fixed mortgage rate - Banks	4.569	0.980	2.990	6.740
5-year fixed mortgage rate - Brokers	3.308	0.229	2.680	6.740
5-year fixed mortgage rate - Credit Union	4.030	0.707	2.750	7.990
5-year swap-adjusted bond rate	2.527	0.143	2.251	2.842
Indicator for change in mortgage rate - All	0.128	0.334	0	1
Indicator for change in mortgage rate - Banks	0.146	0.355	0	1
Indicator for change in mortgage rate - Brokers	0.210	0.408	0	1
Indicator for change in mortgage rate - Credit Unions	0.078	0.269	0	1
Indicator for change in swap-adjusted rate	0.970	0.171	0	1
Lender markup (as a percentage of the bond rate)	0.523	0.302	0.084	2.275
Number of days rate held	55.869	51.576	0	366
Permitted loan-to-value	93.133	6.112	40.0	95.0
Total number of mortgage rate observations: 19,364				

Table 3 provides summary statistics for the relevant variables. The average mortgage rate in 2018 was 3.9% compared to the average 5-year swap-adjusted bond rate of 2.5%. There is considerable deviation from the mean mortgage rate within the sample with a minimum of 2.7% and a maximum of 8.0%. The average daily standard deviation is 0.706 which is remarkably close to the standard deviation for the entire sample.[19] This suggests there is considerable dispersion in mortgage rates on any given day. There is significantly less dispersion in the 5-year swap-adjusted bond rate for 2018 with a standard deviation of 0.143. In my sample, banks, brokers, and credit unions are the most popular provider types with 1,505, 6,188, and 10,803 observations respectively. Interestingly, banks and credit unions have higher average mortgage

[19] Obtained by taking the standard deviation of mortgage rates for each day and then taking the yearly average

rates of 4.6% and 4.0% respectively, whereas brokers have a lower average mortgage rate of 3.3%. These findings are consistent to those of Allen, Clark, and Houde (2014) since consumers who use brokers could be more likely to switch lenders and thus, they have more bargaining power and can negotiate a lower rate.

The indicators for change show the mortgage rate changes 12.8% of the time whereas the 5-year swap-adjusted bond rate changes 97% of the time.[20] This suggests the mortgage rates posted on *RateSpy.com* do not change nearly as frequently as the 5-year swap-adjusted bond rate changes. Interestingly, Arbatskaya and Baye (2004) find the mortgage rate changed 16.1% of the time and the 10-year T-Bond rate changed 87.3% of the time. My results are not drastically different from the results found by Arbatskaya and Baye (2004) however it appears that the mortgage rates are 'stickier' in Canada than in the United States. This is consistent with the theory claiming mortgage markets in Canada are less competitive as discussed in Allen and McVanel (2009) and thus lenders face less incentive to change prices in response to cost changes. Interestingly, mortgage rates posted by brokers change the most often, 21% of the time, compared to banks which change 14.6% of the time and credit unions which only change 7.8% of the time. These results may be indicative of the different business structures of banks, brokers, and credit unions. It is reasonable to think that since credit unions tend to be smaller and more localized firms; they may face higher costs associated with changing their rates. Whereas, since brokers have access to a variety of lender rates and implicitly are attracting consumers by offering the lowest rate then they have an incentive to change their rate more often. The differences between banks, brokers, and credit unions will become more distinctive in the following empirical analysis section.

[20] Obtained by coding a 0 if the rate does not change from the previous week and 1 if it does change.

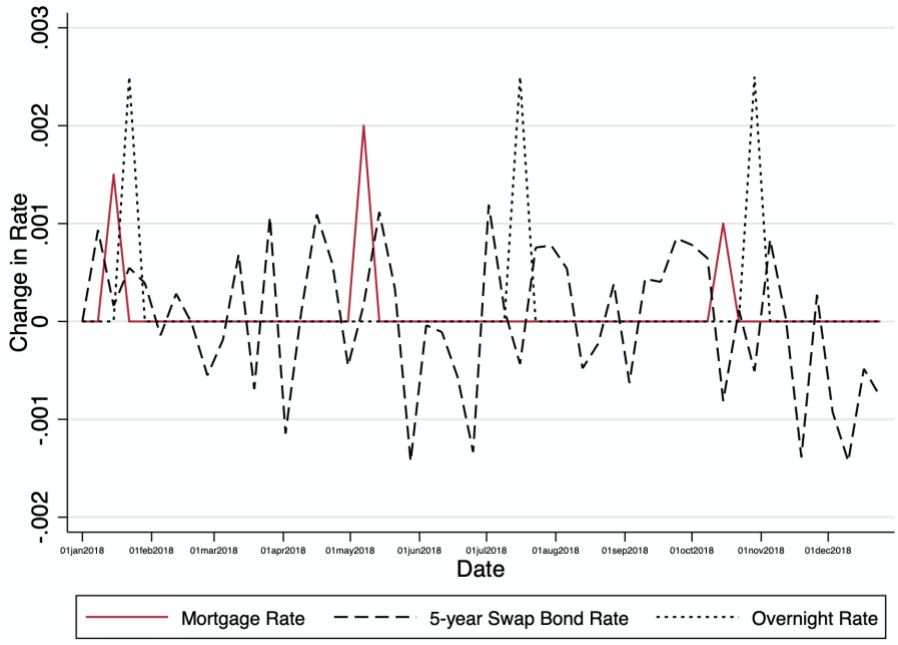
The markup can act as an indicator of market power and has been shown to be related to the Herfindahl index.[21] The markup is defined as the difference between the mortgage rate and the 5-year swap-adjusted bond rate, as a percentage of the 5-year swap-adjusted bond rate and has an average of 51.4%.[22] The markup ranges from around 8% to 275% which suggests there is considerable heterogeneity between firms. Arbatskaya and Baye (2004) find the markup ranges from 22% to 44% which indicates there is considerably more heterogeneity in the Canadian mortgage market. Arbatskaya and Baye (2004) attribute the range in markup to differences in market concentration, non-price aspects of mortgages and other product heterogeneities, as well as unobserved heterogeneity in lender costs. Interestingly, I find banks and credit unions have average markups around 81% and 60% respectively, whereas brokers have an average markup of 31%. Note, the broker does not actually charge the mark up since they simply arrange the mortgage contract with a lender. In this case, the mark up is what the lender gets from using a broker less the commission paid to the broker. These results suggest there may be some fundamental differences in cost correlated with provider type. In some of the econometric specifications presented below, I include markup as a crude control for otherwise unobservable mortgage characteristics that contribute to lenders' market power.[23]

Another interesting aspect to analyze is the timing of rate changes and the heterogeneity between firms. Figure 1 shows Scotiabank's posted rate changes relative to the changes in the 5-year swap-adjusted bond rate and the overnight rate. Surprisingly, the top six banks in Canada do not all follow the same pattern. National and RBC have the same posted rates and timing of changes, but the other four banks are different. Figure 2 illustrates the posted rates from the top

[21] See Dansby and Willig (1979)
[22] Following Arbatskaya and Baye (2004)
[23] Following Arbatskaya and Baye (2004)

six banks in Canada over time.[24] Additionally, there is considerable heterogeneity between different provider types. Figure 3 shows Scotiabank's and First National's rate changes. First National is a large wholesale provider and it appears to often change its rate at different times than Scotiabank. More generally, 13% of lenders never change their rates over the entire sample and 3% of lenders change their rates over 50% of the time. The heterogeneity in the timing of rate changes provides motivation for analyzing the response of mortgage rates to cost changes done in the following section.

Figure 1: Scotiabank's mortgage rate changes



[24] Only the posted (highest) rates are used.

Figure 2: Posted rates for the Big Six banks

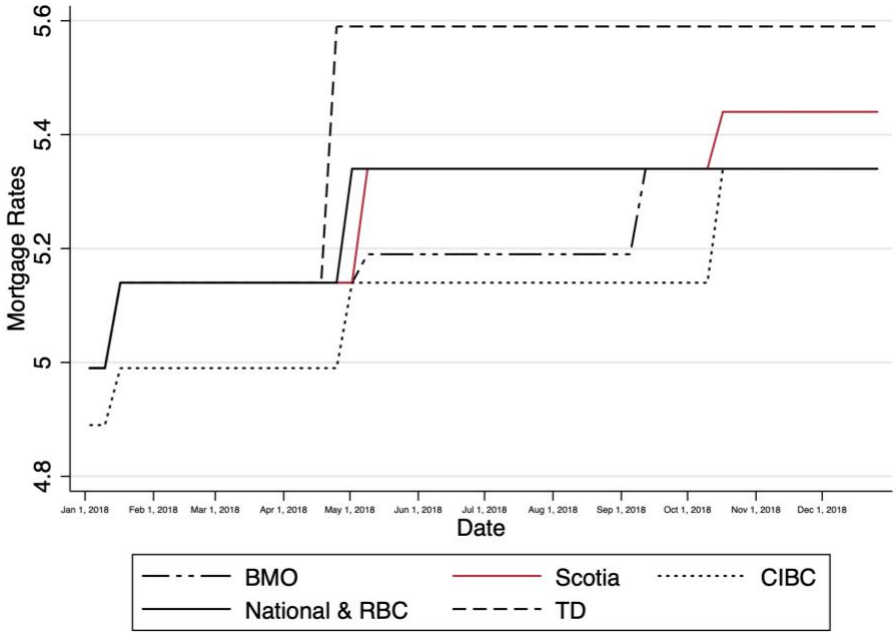
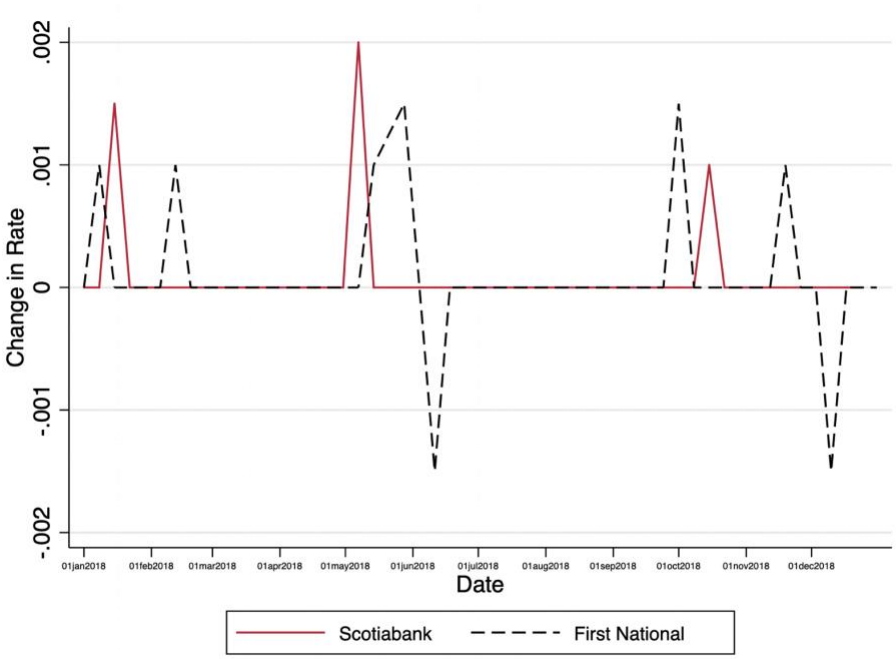


Figure 3: Timing of rate changes of two large lenders in Canada



The data also provide insight into the price dispersion present in the online mortgage market. As discussed earlier, mortgage rate dispersion could be caused by unobserved lender cost heterogeneity, product differences, and competition. Allen, Clark and Houde (2014) investigate the underlying causes of price dispersion in the Canadian mortgage market and find lenders set prices based on consumers' bargaining ability and not just costs. Theoretically, online mortgage rates would exhibit less price dispersion because rates posted online face more competition since consumers can search with little to no cost. However, there is still considerable price dispersion observed in the data. Figure 4 illustrates the rate dispersion for all rates, banks, credit unions, and brokers on October 1st, 2018.[25] Banks, brokers, and credit unions have coefficients of variation of 0.2076, 0.0486, and 0.1631 respectively. Not surprisingly, brokers exhibit the least price dispersion since they have a large number of lenders which could indicate they face more competition. Banks and credit unions exhibit similar price dispersion despite credit unions having more lenders. These results may also be indicative of the institutional differences between banks, brokers, and credit unions as discussed in the previous section.

Figure 5 shows the mortgage rate dispersion by province on October 1st, 2018. The larger provinces, Ontario, Quebec, British Columbia, Alberta, and Manitoba exhibit slightly less price dispersion which could be due to the larger number of lenders (more competition) but overall there are no drastic differences between the rates in all provinces. The smallest provinces, Northwest Territories and Nunavut, have slightly higher rates but not as high as would be expected. The similarity between provinces may be due to the number of national lenders, including the Big Six banks, who post the same rate in all provinces. Note, these results may not be reflective of the prices actually paid by consumers. There may be additional unobserved

[25] Note, 'banks' includes the Big Six banks and all the other banks listed on *RateSpy.com*.

search costs in smaller provinces which allow lenders to charge rates higher than their rates posted online. Furthermore, since there are more lenders in larger provinces consumers have greater bargaining power and may be able to negotiate lower rates.

Figure 4: Mortgage rate dispersion by provider type on October 1st, 2018

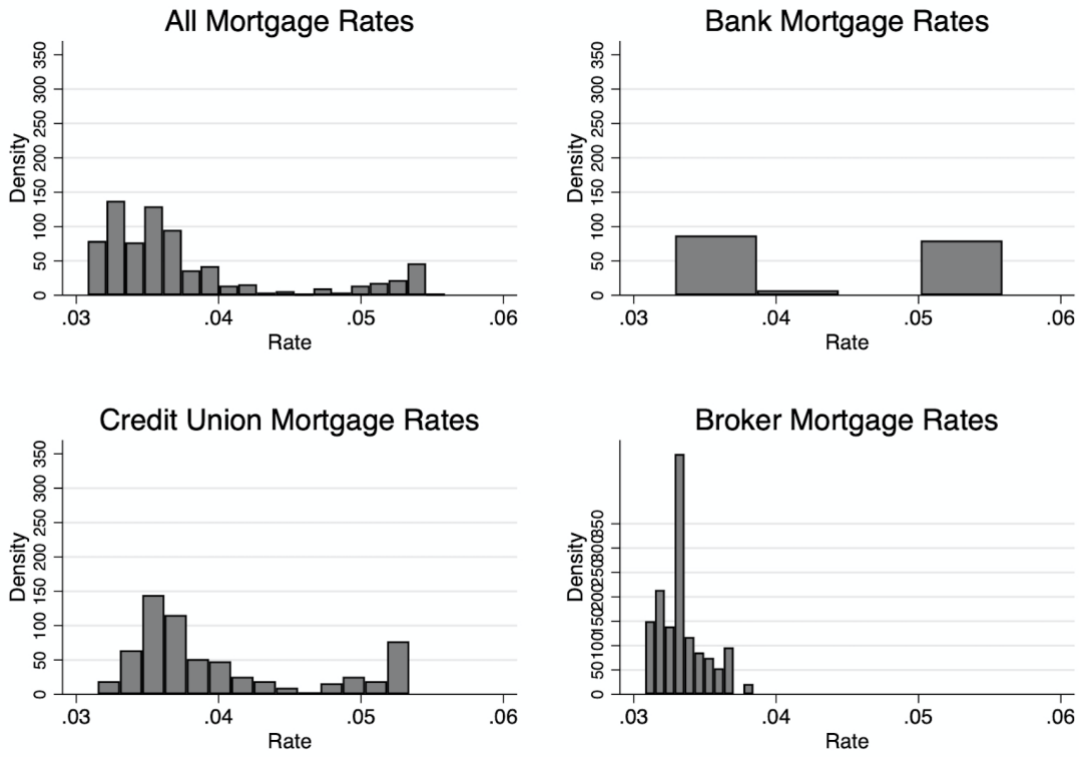
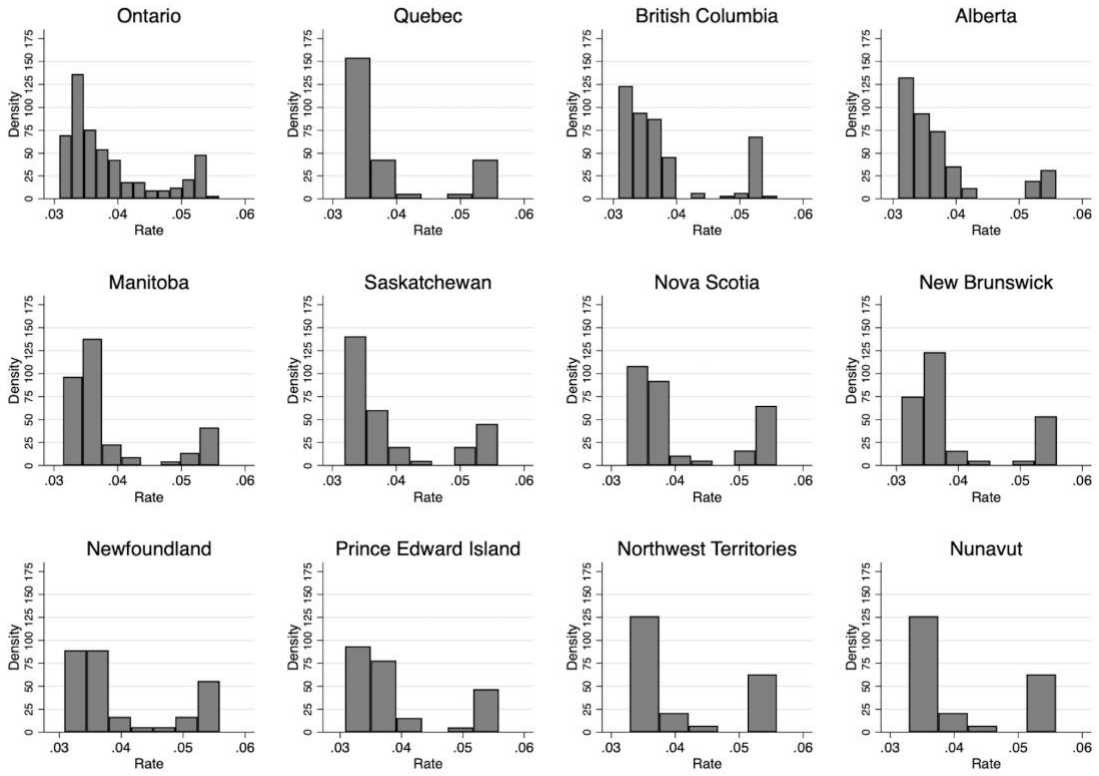


Figure 5: Mortgage rate dispersion by province on October 1st, 2018



5. Empirical Analysis

5.1. Mortgage rate adjustment to cost shocks

In this section, I use data to examine the magnitude and speed of rate adjustments in response to cost shocks. I first estimate a distributed lag model following Arbatskaya and Baye (2004) and then take a more robust approach using a distributed lag model with the addition of the Engle-Granger (1985) two-step estimation procedure following Remer (2012). Table 4 illustrates the asymmetry of price adjustments which is consistent to that found in many other industries.[26] Conditional on a price change, lenders increased their rates 75% of the time and

[26] See, for example, Pelzman (2000).

only decreased their rates 25% of the time and the magnitude of a rate decrease is larger than that of an increase.[27] Whereas, the cost increases 53% of the time and decreases 47% of the time and the magnitude of a cost decrease is similar to an increase. These results indicate lenders are changing rates more in response to cost increases. On the contrary, Arbatskaya and Baye (2004) find lenders are almost equally as likely to increase rates as decrease rates and the average magnitude of rate increases are larger than rate decreases. These differences between my data and those of Arbatskaya and Baye (2004) may be due to the geography or time period these rates are collected from. The significant asymmetry in price changes present in my data set may lead to the unexpected results present in the first estimated model compared to the results obtained by Arbatskaya and Baye (2004). Note that the price adjustments observed are quite small which is consistent with the notion that lenders' costs to change rates are very small in online mortgage markets.

Table 4: Levels of mortgage rate and cost changes

Variable	***Observations***	***Mean***	***Std. Dev.***	***5th Percentile***	***95th Percentile***
Level of change in mortgage rate	2481	0.074	0.505	-0.350	0.450
Level of change in cost	18,777	0.001	0.072	-0.134	0.109
Absolute value of change in mortgage rate	2481	0.251	0.444	0.040	1.350
Absolute value of change in cost	18,777	0.060	0.040	0.004	0.134
Level of increase in mortgage rate	1869	0.215	0.363	0.050	0.610
Level of increase in cost	9,989	0.058	0.037	0.009	0.119
Level of decrease in mortgage rate	612	-0.361	0.617	-1.750	-0.020
Level of decrease in cost	8,788	-0.063	0.042	-0.139	-0.004

As discussed previously, there is extensive research done on price adjustment asymmetry in various markets. Following the approach of Arbatskaya and Baye (2004) and Remer (2012), I

[27] Percentages are calculated by taking the number of observations in a mortgage increase or decrease (i.e. 1852 or 559) as a percentage of the total number of rate changes (i.e. 2481).

estimate a variety of distributed lag models. First, I estimate a distributed lag model to capture the symmetric and asymmetric responses to cost shocks for all observations. Second, I use a more robust distributed lag model with an Engle-Granger two-step estimation procedure to estimate the magnitude of price asymmetry. For both models, I examine the differences between lender types.

For the second model, I need a balanced panel to test for cointegration. I create a balanced panel by imputing the missing weeks with the previous week's observation and taking out lenders with less than 40 weeks of data and excluding data from December 31st which decreases my number of observations to 16,862.[28] However, similar summary statistics for the dropped observations and the remaining observations suggest the absence of a selection problem when composing the balance panel. The balanced panel is used for all the price adjustment analysis.

The first model relies on the econometric model specified in Borenstein et al. (1997) and then adapted by Arbatskaya and Baye (2004). Specified in equation (1) is the symmetric response model and equation (2) is the asymmetric response model.

$$\Delta R_t = \sum_{i=0}^{n} (\beta_i \, \Delta C_{t-i}) + \alpha M_t + \varepsilon_t \tag{1}$$

Here, R_t is the mortgage rate and C_t is the 5-year swap-adjusted bond rate at time *t*, $\Delta X_t = X_t - X_{t-1}$ is defined for any variable of interest X, M_t denotes the controls for market structure, mortgage characteristics, and various fixed effects, and ε_t is the error term.

$$\Delta R_t = \sum_{i=0}^{n} (\beta_i^+ \, \Delta C_{t-i}^+ + \beta_i^- \Delta C_{t-i}^-) + \alpha M_t + \varepsilon_t \tag{2}$$

[28] December 31st is excluded so there are only 52 weeks of data in the year.

Where ΔC_{t-i}^{+} is positive values of ΔC_{t-i}, and zero otherwise, and ΔC_{t-i}^{-} is negative values of ΔC_{t-i}, and zero otherwise. Table 5 presents the results for these distributed lag models estimated using OLS as done in Arbatskaya and Baye (2004).[29] Unlike Arbatskaya and Baye (2004) who include two lags of each variable, I choose to include four lags to capture a longer period of price adjustment. Market structure includes controls for overnight rate changes and markup. Mortgage characteristics includes controls for the rate hold length, preapprovals, double-up payments, and the permitted loan-to-value percentage. Other controls include province, lender and provider type fixed effects. The controls included are the same as those included by Arbatskaya and Baye (2004) with the added control for provider type and without the day-of-week fixed effects. The symmetric response specification assumes firms respond identically to cost (5-year swap-adjusted bond rate) increases as they do for decreases. Whereas, the asymmetric specification allows for firms to respond differently to cost increases than to decreases. The small coefficients in table 5 suggest firms do not change their rates very much in response to a cost shock. It also appears the response to a cost shock is slightly larger after three or four weeks. Table 6 presents the asymmetric response model for banks, brokers, and credit unions. Interesting, it shows banks adjust the least to cost increases and have little statistical significance. Brokers seem to adjust the most to cost increases and banks adjust the most to cost decreases. Table 7 presents the cumulative response of mortgage rates to cost changes obtained by adding the coefficients in table 5 and 6. Coefficients that are not statistically significant are given a value of zero. Table 7 indicates lenders have an asymmetric response to cost shocks, especially banks. Surprisingly, the response is significantly larger to cost decreases which is contrary to the results found in other

[29] Except Arbatskaya and Baye (2004) estimate their model conditional on a rate change being present whereas I choose to include all observations as done in Borenstein et al. (1997).

literature. These results motivate me to investigate an alternative model to measure the asymmetric response to cost shocks.

Table 5: Simple distributed lag model

Variables	SYMMETTIC RESPONSE (1)	ASYMMETRIC RESPONSE (2)
ΔC_t	0.07294***	
	(0.01927)	
ΔC_{t-1}	0.07266***	
	(0.01953)	
ΔC_{t-2}	0.12593***	
	(0.01823)	
ΔC_{t-3}	0.13840***	
	(0.02180)	
ΔC_{t-4}	0.16523***	
	(0.02315)	
ΔC_t^-		-0.0084
		(0.0352)
ΔC_{t-1}^-		0.0983***
		(0.0381)
ΔC_{t-2}^-		0.1702***
		(0.0311)
ΔC_{t-3}^-		0.2258***
		(0.0417)
ΔC_{t-4}^-		0.2173***
		(0.0446)
ΔC_t^+		0.1693***
		(0.0441)
ΔC_{t-1}^+		0.0284
		(0.0362)
ΔC_{t-2}^+		0.0822**
		(0.0366)
ΔC_{t-3}^+		0.0734
		(0.0448)
ΔC_{t-4}^+		0.1305***
		(0.0384)
Other controls		
Market structure	Yes	Yes
Mortgage characteristics	Yes	Yes
Province fixed effects	Yes	Yes
Lender fixed effects	Yes	Yes
Provider type fixed effects	Yes	Yes
Constant	-0.02383	-0.0180
	(0.08808)	(0.0894)
Observations	15,517	15,517
R-squared	0.05319	0.0542

Robust standard errors in parentheses
*** p-value<0.01, ** p-value<0.05, * p-value<0.1

The dependent variable is the value of change in lender *i*'s mortgage rate on date *t*.

Table 6: Asymmetric response by provider type

VARIABLES	ASYMMETRIC RESPONSE (1) Banks	(2) Brokers	(3) Credit Unions
ΔC_t^-	0.0385	0.1393	-0.0330
	(0.2932)	(0.1125)	(0.0434)
ΔC_{t-1}^-	0.4667**	0.3805***	0.0065
	(0.2340)	(0.1108)	(0.0523)
ΔC_{t-2}^-	0.1370	0.3772**	0.1546***
	(0.1563)	(0.1552)	(0.0417)
ΔC_{t-3}^-	0.5818*	0.2550***	0.2367***
	(0.3054)	(0.0979)	(0.0554)
ΔC_{t-4}^-	0.7350***	0.2403***	0.1934***
	(0.2605)	(0.0808)	(0.0612)
ΔC_t^+	0.1380	0.2524**	0.1807***
	(0.2729)	(0.1241)	(0.0578)
ΔC_{t-1}^+	-0.2866	0.0014	0.0831*
	(0.2477)	(0.0746)	(0.0501)
ΔC_{t-2}^+	0.2124	0.0776	0.0961**
	(0.2979)	(0.0480)	(0.0485)
ΔC_{t-3}^+	-0.1238	0.1734***	0.0306
	(0.2524)	(0.0556)	(0.0652)
ΔC_{t-4}^+	0.0134	0.1225*	0.1787***
	(0.2331)	(0.0713)	(0.0524)
OTHER CONTROLS			
Market structure	YES	YES	YES
Mortgage characteristics	YES	YES	YES
Province fixed effects	YES	YES	YES
Lender fixed effects	YES	YES	YES
Constant	-1.2877	-0.1918*	-0.1069
	(1.1400)	(0.1161)	(0.1639)
Observations	1,085	4,302	9,365
R-squared	0.0783	0.0984	0.0563

Robust standard errors in parentheses
*** p-value<0.01, ** p-value<0.05, * p-value<0.1
The dependent variable is the value of change in lender *i*'s mortgage rate on date *t*.

Table 7: Cumulative response of mortgage rates to cost changes (from coefficients in table 5 and 6)

	All		Banks		Brokers		Credit Unions	
	Cost increase	Cost decrease	Cost increase	Cost decrease	Cost increase	Cost decrease	Cost increase	Cost decrease
Immediate	0.169	0.000	0.000	0.000	0.252	0.000	0.181	0.000
One week	0.169	0.098	0.000	0.467	0.252	0.381	0.264	0.000
Two weeks	0.252	0.269	0.000	0.467	0.252	0.758	0.360	0.155
Three weeks	0.252	0.494	0.000	1.049	0.426	1.013	0.360	0.391
Four weeks	0.382	0.712	0.000	1.784	0.548	1.253	0.539	0.585

The second model takes a more robust approach by using an extension of the error-correction model developed by Engle and Granger (1987) for cointegrated time-series data. Augmented Dickey-Fuller tests confirm the mortgage rates and the 5-year swap-adjusted bond rates are cointegrated and stationary in first difference. The model is specified as follows;

$$\Delta R_t = \sum_{i=0}^{n}(\beta_i \Delta C_{t-i}) + \sum_{i=1}^{n}(\gamma_i \Delta R_{t-i}) + v_1(R_t - \emptyset_1 C_{t-1} - \emptyset_0) + \epsilon_t. \quad (3)$$

The model assumes the long run linear relationship between the mortgage rates and costs;

$$R_t = \emptyset_0 + \emptyset_1 C_t + \epsilon_t. \quad (4)$$

Thus, $R_t - \emptyset_1 C_{t-1} - \emptyset_0$ in equation (3) captures the extent to which mortgage rates and costs were away from their long-run equilibrium. Hence, the short-run effects of changes in own-rates and costs are captured by β_i and γ_i, and the long-run effects of pressure to return to equilibrium are captured by v_1. Bachmeire and Griffen (2003) modify the model developed by Borenstein et al. (1997) by including the long-run relationship component to create an equation as follows;

$$\begin{aligned}\Delta R_t = {} & \sum_{i=0}^{n}(\beta_i^{+} \Delta C_{t-i}^{+} + \beta_i^{-} \Delta C_{t-i}^{-}) + \sum_{i=1}^{n}(\gamma_i^{+} \Delta R_{t-i}^{+} + \gamma_i^{-} \Delta R_{t-i}^{-}) \\ & + v_1{}^{+}(R_t - \emptyset_1 C_{t-1} - \emptyset_0)^{+} + v_1{}^{-}(R_t - \emptyset_1 C_{t-1} - \emptyset_0)^{-} + \alpha M_t + \varepsilon_t.\end{aligned} \quad (5)$$

In general, if $\beta_i^{+} > \beta_i^{-}$ then mortgage rates increase quicker than they decrease. I first estimate equation (4) using OLS and then substitute the resulting coefficients ($\emptyset_0$ & $\emptyset_1$) into equation (5) and estimate with OLS. Since mortgage rates and the 5-year swap-adjusted bond rates are cointegrated, estimates of $\emptyset_0$ and $\emptyset_1$ are super consistent, and thus can be treated at truly known, it is appropriate to use the estimated residual in place of $R_t - \emptyset_1 C_{t-1} - \emptyset_0$ in equation (5) (Remer, 2012). The stationarity of the regressors permits standard significant tests of both the parameters and functions from multiple parameters. Since, measuring the degree of price adjustment asymmetry involves constructed response functions from multiple parameters,

estimating the error-correction model with the two-step procedure ensures I am constructing appropriate confidence intervals to test for asymmetry (Remer, 2012). Table 8 reports the regression results. Note, the coefficients on the positive and negative long-run relationship components, υ_1^+ and υ_1^- respectively, are negative which implies there is pressure on mortgage rates to go back to their long-run relationship with cost. Additionally, hypothesis testing verifies the coefficients on the positive and negative long-run relationship components are not equal. This suggests there is long-run adjustment asymmetry whereby, lenders adjust their rates downwards when they are above equilibrium more quickly then they adjust them upwards when they are below equilibrium. The long-run adjustment asymmetry also exists for banks, brokers, and credit unions. Interestingly, the estimated value of the long-run relationship, $\emptyset_1$ in equation (4), is 0.49 indicating only about 50% cost pass-through. Allen and McVanel (2009) find evidence of full cost pass-through in the long run, however, their sample spans 16 years whereas my sample only spans one year. This suggests full pass-through is not reached within one year.

The regression results also support the presence of short-run mortgage rate adjustment asymmetry. The coefficient on the immediate positive cost shock is 0.82 which is significantly greater than the coefficient on the immediate negative cost shock of 0.32. Thus, a 100-basis point increase in the bond rate would lead to an 82-basis point increase in the mortgage rate but a 100-basis point decrease in the bond rate would only lead to a 32-basis point decrease in the mortgage rate. These results are larger and more statistically significant than the results from the previous model and indicate a larger response to cost increases than decreases. Thus, taking a more robust approach in measuring price adjustment, I attain results consistent with the majority of price rigidity literature.

Table 8: Asymmetric response with two step estimation ($\emptyset_0$=2.6444, $\emptyset_1$=0.4897)

Variable	Estimate	Variable	Estimate		
ΔC_t^-	0.3160***	ΔR_{t-1}^-	-0.0847***	***OTHER CONTROLS***	
	(0.0312)		(0.0239)	**Market structure**	YES
ΔC_{t-1}^-	0.0607***	ΔR_{t-2}^-	-0.0347*	**Mortgage characteristics**	YES
	(0.0227)		(0.0200)	**Province fixed effects**	YES
ΔC_{t-2}^-	0.3517***	ΔR_{t-3}^-	-0.0029	**Lender fixed effects**	YES
	(0.0247)		(0.0084)	**Provider type fixed effects**	YES
ΔC_{t-3}^-	0.3904***	ΔR_{t-4}^-	-0.0125		
	(0.0295)		(0.0160)		
ΔC_{t-4}^-	0.2411***	ΔR_{t-1}^+	-0.0606**		
	(0.0251)		(0.0287)		
ΔC_t^+	0.8189***	ΔR_{t-2}^+	-0.0031		
	(0.0501)		(0.0120)		
ΔC_{t-1}^+	0.4991***	ΔR_{t-3}^+	0.0040	**Constant**	-0.7042***
	(0.0391)		(0.0102)		(0.0577)
ΔC_{t-2}^+	0.2803***	ΔR_{t-4}^+	0.0105		
	(0.0302)		(0.0111)	**Observations**	15,517
ΔC_{t-3}^+	0.2654***	v_1^-	-0.5104***	**R-squared**	0.6078
	(0.0286)		(0.0257)		
ΔC_{t-4}^+	0.5118***	v_1^+	-0.6282***		
	(0.0345)		(0.0329)		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The dependent variable is the value of change in lender *i*'s mortgage rate on date *t*.

Table 9, 10, and 11 present the estimated model for banks, brokers, and credit unions respectively. Interestingly, banks have the smallest long-run pass-through of only about 16% whereas brokers have 61% and credit unions have 45%. This result may be due to the smaller number of banks present and since more banks operate on a national scale if would be reasonable for banks to take longer to fully adjust to cost changes. Table 12 presents the cumulative response of mortgage rates to cost changes obtained by adding the coefficients in table 8, 9, 10, and 11. Again, coefficients without statistical significance are given a value of zero.

Table 9: Asymmetric response with two-step estimation for Banks ($\emptyset_0$=4.1615, $\emptyset_1$=0.1596)

Variable	Estimate	Variable	Estimate		
ΔC_t^-	0.2906*	ΔR_{t-1}^-	-0.1217**	***OTHER CONTROLS***	
	(0.1609)		(0.0588)	**Market structure**	YES
ΔC_{t-1}^-	0.1577	ΔR_{t-2}^-	-0.0337	**Mortgage characteristics**	YES
	(0.1335)		(0.0379)	**Province fixed effects**	YES
ΔC_{t-2}^-	0.4875***	ΔR_{t-3}^-	-0.0070	**Lender fixed effects**	YES
	(0.1004)		(0.0230)		
ΔC_{t-3}^-	0.5462***	ΔR_{t-4}^-	-0.0637		
	(0.1526)		(0.0509)		
ΔC_{t-4}^-	0.4600***	ΔR_{t-1}^+	0.0127		
	(0.1273)		(0.0452)		
ΔC_t^+	1.0748***	ΔR_{t-2}^+	0.0193		
	(0.1702)		(0.0328)		
ΔC_{t-1}^+	0.8543***	ΔR_{t-3}^+	0.0106	**Constant**	-1.7848***
	(0.1766)		(0.0303)		(0.3907)
ΔC_{t-2}^+	0.5806***	ΔR_{t-4}^+	0.0673		
	(0.1639)		(0.0481)	**Observations**	1,085
ΔC_{t-3}^+	0.4580***	v_1^-	-0.6534***	**R-squared**	0.7126
	(0.1439)		(0.0528)		
ΔC_{t-4}^+	0.8240***	v_1^+	-0.7245***		
	(0.1672)		(0.0660)		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The dependent variable is the value of change in lender *i*'s mortgage rate on date *t*.

Interestingly, banks have the largest cumulative response to both increases and decreases in cost whereas brokers have the smallest. Banks also have the greatest initial response to cost increases and brokers have the smallest. In contrast, brokers have the greatest initial response to cost decreases and banks have the smallest. Credit unions' cumulative response is always between that of banks and brokers. Furthermore, banks may only change their rates 14.6% of the time, but they adjust their rates quickly in response to cost changes. Whereas, brokers change their rates 21% of the time, but do not adjust their rates as quickly in response to cost changes. In other

words, since banks do not change their prices as often, when they do change their rate it is in response to a cost change. Whereas, brokers are changing their rates more often and not in response to a cost change. These differences may come from a brokers' inherent incentive to post the lowest rate to attract consumers and ability to change rates being dependent on the lenders they use. Also, since banks own the majority of the mortgage market, they may respond quickly to cost increases to maintain their high markups. Overall, banks, brokers, and credit unions exhibit significant levels of asymmetric price adjustment by responding more to cost increases.

Table 10: Asymmetric response with two-step estimation for Brokers ($\emptyset_0$=1.7566, $\emptyset_1$=0.6125)

Variable	**Estimate**	**Variable**	**Estimate**		
ΔC_t^-	0.3488***	ΔR_{t-1}^-	-0.0745**	***OTHER CONTROLS***	
	(0.0897)		(0.0346)	**Market structure**	YES
ΔC_{t-1}^-	0.0610**	ΔR_{t-2}^-	-0.0202	**Mortgage characteristics**	YES
	(0.0266)		(0.0204)	**Province fixed effects**	YES
ΔC_{t-2}^-	0.2297***	ΔR_{t-3}^-	0.0160	**Lender fixed effects**	YES
	(0.0544)		(0.0210)		
ΔC_{t-3}^-	0.2244***	ΔR_{t-4}^-	-0.0217		
	(0.0419)		(0.0165)		
ΔC_{t-4}^-	0.1591***	ΔR_{t-1}^+	-0.1986**		
	(0.0339)		(0.0845)		
ΔC_t^+	0.6419***	ΔR_{t-2}^+	-0.0259		
	(0.1435)		(0.0259)		
ΔC_{t-1}^+	0.2670***	ΔR_{t-3}^+	0.0029	**Constant**	-0.3325***
	(0.0862)		(0.0174)		(0.0945)
ΔC_{t-2}^+	0.1313***	ΔR_{t-4}^+	0.0175		
	(0.0477)		(0.0178)	**Observations**	4,302
ΔC_{t-3}^+	0.1895***	v_1^-	-0.4425***	**R-squared**	0.6315
	(0.0393)		(0.0763)		
ΔC_{t-4}^+	0.3166***	v_1^+	-0.6448***		
	(0.0695)		(0.1055)		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The dependent variable is the value of change in lender *i*'s mortgage rate on date *t*.

Table 11: Asymmetric response with two-step estimation for Credit Unions ($\emptyset_0$=2.9202, $\emptyset_1$=0.4502)

Variable	Estimate	Variable	Estimate		
ΔC_t^-	0.3152***	ΔR_{t-1}^-	-0.0774***	***OTHER CONTROLS***	
	(0.0426)		(0.0296)	**Market structure**	YES
ΔC_{t-1}^-	0.0679**	ΔR_{t-2}^-	-0.0415	**Mortgage characteristics**	YES
	(0.0320)		(0.0277)	**Province fixed effects**	YES
ΔC_{t-2}^-	0.4070***	ΔR_{t-3}^-	-0.0115	**Lender fixed effects**	YES
	(0.0361)		(0.0099)		
ΔC_{t-3}^-	0.4694***	ΔR_{t-4}^-	0.0068		
	(0.0433)		(0.0082)		
ΔC_{t-4}^-	0.2779***	ΔR_{t-1}^+	-0.0584		
	(0.0363)		(0.0357)		
ΔC_t^+	0.7471***	ΔR_{t-2}^+	-0.0049		
	(0.0631)		(0.0150)		
ΔC_{t-1}^+	0.4656***	ΔR_{t-3}^+	0.0117	**Constant**	-0.7885***
	(0.0506)		(0.0117)		(0.0980)
ΔC_{t-2}^+	0.2338***	ΔR_{t-4}^+	0.0015		
	(0.0415)		(0.0110)	**Observations**	9,365
ΔC_{t-3}^+	0.1944***	v_1^-	-0.4838***	**R-squared**	0.5829
	(0.0403)		(0.0347)		
ΔC_{t-4}^+	0.5190***	v_1^+	-0.6135***		
	(0.0450)		(0.0430)		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The dependent variable is the value of change in lender *i*'s mortgage rate on date *t*.

Table 12: Cumulative response of mortgage rate to cost change (from coefficients in table 8-11)

	All		**Banks**		**Brokers**		**Credit Unions**	
	Cost increase	Cost decrease	Cost increase	Cost decrease	Cost increase	Cost decrease	Cost increase	Cost decrease
Immediate	0.819	0.316	1.075	0.291	0.642	0.349	0.747	0.315
One week	1.318	0.377	1.929	0.291	0.909	0.410	1.213	0.383
Two weeks	1.598	0.728	2.510	0.778	1.040	0.640	1.447	0.790
Three weeks	1.864	1.119	2.968	1.324	1.230	0.864	1.641	1.260
Four weeks	2.376	1.360	3.792	1.784	1.546	1.023	2.160	1.537

5.2. Mortgage rate duration

This section analyzes the duration of posted mortgage rates and the impact of market structure and mortgage characteristics on the length of time between rate changes. In this case, the variable of interest is the number of weeks between consecutive changes in a lender's mortgage rate. Since the data are from a one-year period, they are missing the initial change for the earlier rates and missing the end change for the later rates. I estimate the survival function with two samples; first, with data restricted to only observations with a known start and end date and second, with all the data treating them as censored. The first sample contains 2,025 observations with a start date (when the rate changed initially) and end date (when the rate changes subsequently) and the difference between the end and start date is the duration of the rate in weeks. Figure 6 displays the Kaplan-Meier survival function estimated with the uncensored data. The horizontal axis measures the duration of mortgage rates in weeks and the vertical axis measures the proportion of rates that have survived (not changed) for a given number of weeks. From figure 6, it is evident most mortgage rates have changed by 40 weeks. Figure 7 depicts the Kaplan-Meier survival function estimated with the uncensored data for banks, brokers, and credit unions. It indicates brokers adjust their mortgage rates quickest, then banks, and then credit unions are the slowest to adjust. Banks and brokers have adjusted all their rates by around 26 weeks whereas credit unions have not adjusted all their rates until after 40 weeks. Note, brokers are getting quotes from other lenders so a broker can change their posted rate when any of their lenders gives them a new rate. Thus, it is reasonable for brokers to change their rates faster than banks and credit unions. A log-rank test and Wilcoxon (Breslow) test for equality of survivor functions confirm these results are statistically significant.

Figure 6: Kaplan-Meier survival curve (Uncensored)

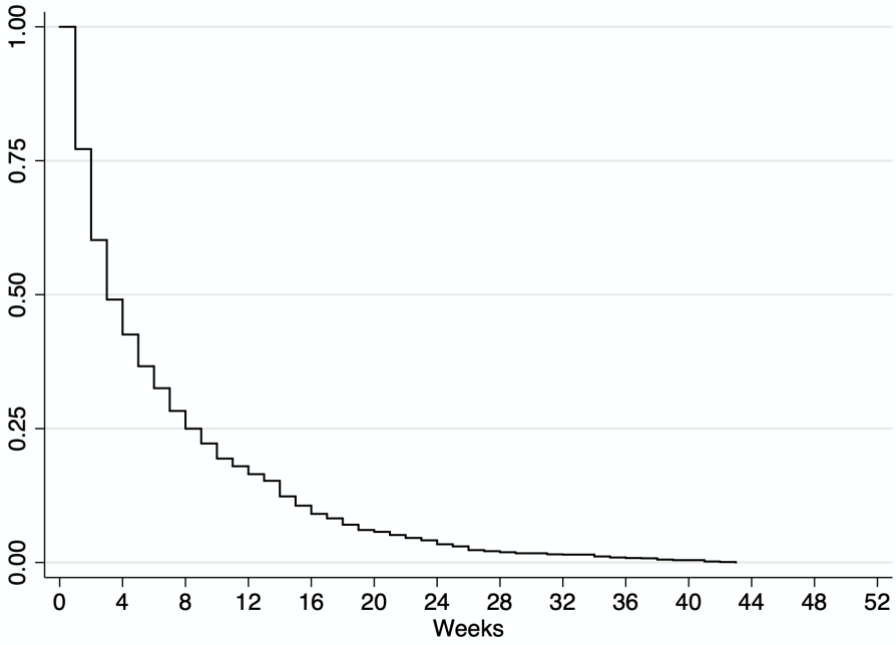
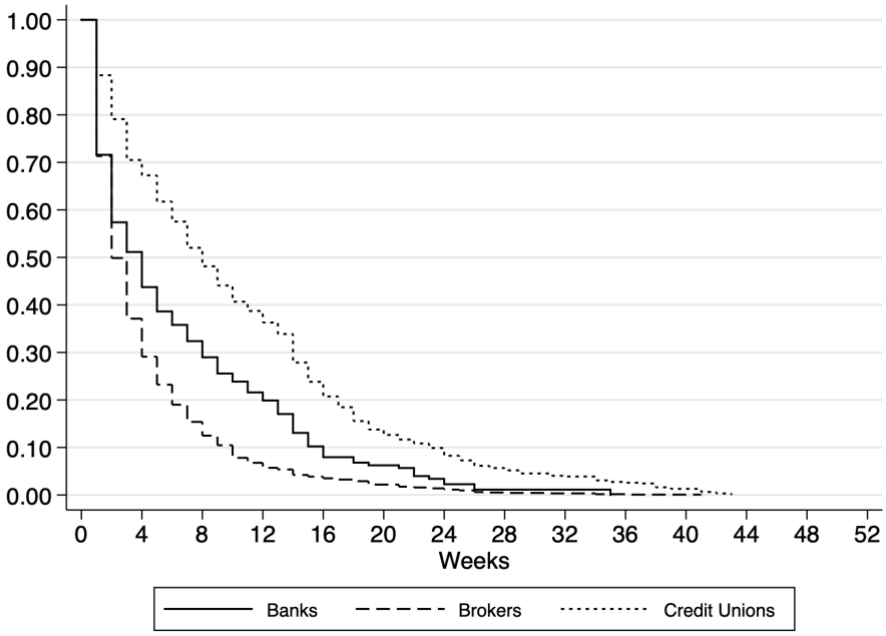


Figure 7: Kaplan-Meier survival curve by provider type (Uncensored)



The second sample contains 2,844 observations and is treated as censored data with a likelihood-based approach.[30] Note, an observation is a duration in weeks between an initial rate change and the subsequent change. In this sample, all rates are given an initial start date of January 1st and the last possible end date is December 31st.[31] Figure 8 shows the Kaplan-Meier survival function estimated with the censored data. In general, mortgage rates have all changed by 48 weeks. Figure 8 depicts the Kaplan-Meier survival function estimated with the censored data for banks, brokers, and credit unions. Consistent with the previous graph, brokers adjust their mortgage rates quickest, then banks, and then credit unions are the slowest. Banks and brokers have adjusted their rates by around 36 weeks whereas credit unions have not adjusted all their rates until after 44 weeks. A log-rank test and Wilcoxon (Breslow) test for equality of survivor functions confirm these results are statistically significant. Thus, the rates posted by credit unions are the most durable and rates posted by brokers are the least durable. As discussed previously, these results may come from differences in business structure. Brokers have an inherent ability and incentive to change their rates more often to remain current and competitive. Whereas, credit unions may have less of an incentive be the most competitive since they operate on a more localized level and have a more unique approach.

[30] The Kaplan-Meier estimator is a likelihood-based approach.
[31] Note, every time the rate changes a new duration count begins.

Figure 8: Kaplan-Meier survival curve (Censored)

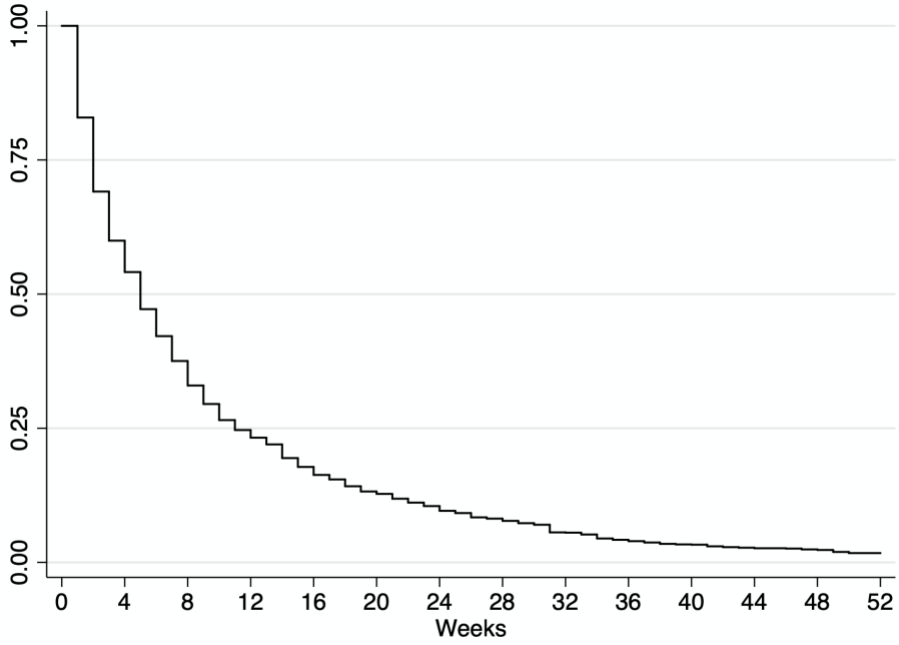
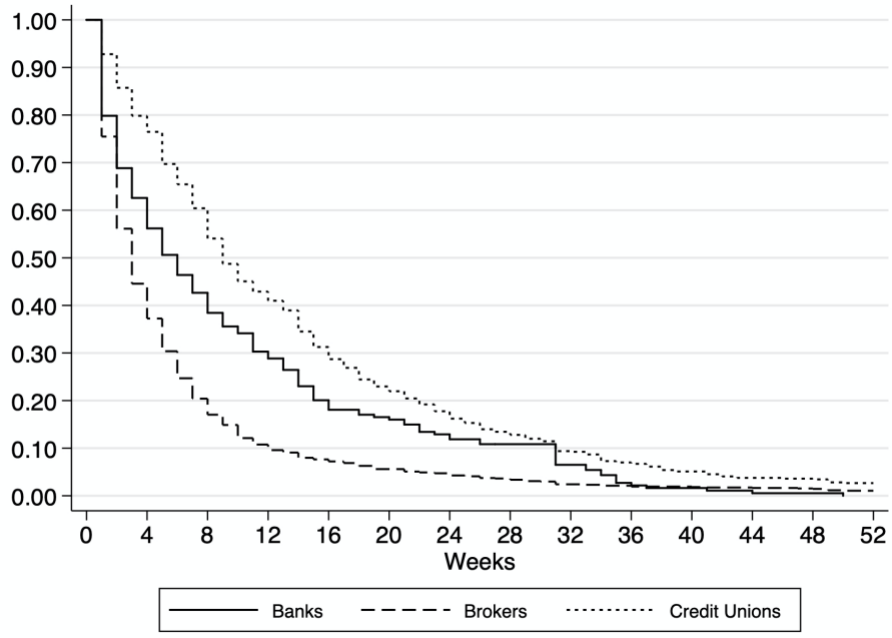


Figure 9: Kaplan-Meier survival curve by provider type (Censored)



6. Conclusion

This paper attempts to analyze and understand firm price-setting decisions in the Canadian online mortgage market. Specifically, by comparing and contrasting the differences between three major competitors; banks, brokers, and credit unions. My analysis, based on over 19,000 observations from the online mortgage rate comparison site *RateSpy.com*, finds evidence of price dispersion and price rigidity in the Canadian online mortgage market. Although price dispersion is present for all types of lenders, mortgage rates posted by banks and credit unions are more disperse than those posted by brokers. Price rigidity is also present for all lenders and on average mortgage rates change 12.8% of the time compared to the 97% of the time the 5-year swap-adjusted bond rate changes. Interestingly, banks and brokers change their rates more than average and credit unions change their rates less than average. Additionally, all lenders exhibit asymmetric mortgage rate adjustment by responding more to cost increases than decreases which is consistent with findings in conventional markets. However, banks have the greatest cumulative response to both cost increases and decreases. Furthermore, the mortgage rate duration analysis reiterates the fact that brokers change their rates quickest, followed by banks and then credit unions are the slowest. These findings suggest there are fundamental differences in how banks, brokers, and credit unions operate. Banks still dominate the residential mortgage market in Canada, and they tend to be larger and operate on a national level which implies they are less affected by local competition. Whereas, credit unions tend to be smaller and operate on a local level which allows them to take on more risky loans and could be reflective of their more rigid pricing. Brokers are especially different because they have access to multiple rates from different lenders and they operate by searching for the lowest rate for their customers. Thus, brokers may have the most to gain from posting the lowest rates and keeping their rates up-to-date to attract

consumers. The recent movement away from the Big Six banks and towards smaller private lenders has drawn attention by policymakers in Canada. Thus, it is valuable to analyze the rate-setting decisions of various types of lenders to better understand how they function. While I provide some speculative arguments for the differences in price dispersion and price rigidity between types of lenders, further theoretical work in the area is needed.

7. References

Allen, J., Clark, R., & Houde, J. (2014). Price dispersion in mortgage markets. *The Journal of Industrial Economics*, 62(3), 377-416.

Allen, J., McVanel, D., Depository Services Program (Canada), & Bank of Canada. (2009). Price movements in the Canadian residential mortgage market. Ottawa: *Bank of Canada*.

Arbatskaya, M., & Baye, M. R. (2004). Are prices 'sticky'online? Market structure effects and asymmetric responses to cost shocks in online mortgage markets. *International Journal of Industrial Organization*, *22*(10), 1443-1462.

Atil, A., Lahiani, A., & Nguyen, D. K. (2014). Asymmetric and nonlinear pass-through of crude oil prices to gasoline and natural gas prices. *Energy Policy*, *65*, 567-573.

Bachmeier, L. J., & Griffin, J. M. (2003). New evidence on asymmetric gasoline price responses. *The Review of Economics and Statistics*, 85(3), 772-776.

Bakos, Y. (2001). The emerging landscape for retail e-commerce. *Journal of economic perspectives*, *15*(1), 69-80.

Bank of Canada (2019). *Selected credit measures* [Data file].

Baye, M. R., & Morgan, J. (2001). Information gatekeepers on the internet and the competitiveness of homogeneous product markets. *American Economic Review*, *91*(3), 454-474.

Baye, M. R., Morgan, J., & Scholten, P. (2004). Price dispersion in the small and in the large: Evidence from an internet price comparison site. *The Journal of Industrial Economics*, *52*(4), 463-496.

Borenstein, S., Cameron, A. C., & Gilbert, R. (1997). Do gasoline prices respond asymmetrically to crude oil price changes? *The Quarterly Journal of Economics*, 112(1), 305-339.

Brynjolfsson, E., & Smith, M. D. (2000). Frictionless commerce? A comparison of Internet and conventional retailers. *Management science*, *46*(4), 563-585.

Cavallo, A. (2017). Are online and offline prices similar? Evidence from large multi-channel retailers. *American Economic Review*, *107*(1), 283-303.

Clay, K., Krishnan, R., Wolff, E., & Fernandes, D. (2002). Retail strategies on the web: Price and non–price competition in the online book industry. *The Journal of Industrial Economics*, 50(3), 351-367.

CMHC (2018). *Mortgage Consumer Survey*, Online.

CMHC (2018). *Research Insight: Impact of Credit Unions and Mortgage Finance Companies on the Canadian Mortgage Market*, Online.

Coletti, D., Gosselin, M. A., & MacDonald, C. (2016). the Rise of mortgage Finance Companies in Canada: benefits and Vulnerabilities. *Financial System Review*, 39-52.

Dansby, R. E., & Willig, R. D. (1979). Industry performance gradient indexes. *The American Economic Review*, 69(3), 249-260.

De Graeve, F., De Jonghe, O., & Vennet, R. V. (2007). Competition, transmission and bank pricing policies: Evidence from Belgian loan and deposit markets. *Journal of Banking and Finance*, 31(1), 259-278.

Engle, R. F., & C. W. J. Granger. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica*, 55(2), 251-276.

Godby, R., Lintner, A. M., Stengos, T., & Wandschneider, B. (2000). Testing for asymmetric pricing in the Canadian retail gasoline market. *Energy Economics*, 22(3), 349-368.

Gorodnichenko, Y., & Weber, M. (2016). Are sticky prices costly? Evidence from the stock market. *American Economic Review*, *106*(1), 165-99.

Hannan, T. H., & Berger, A. N. (1997). The rigidity of prices: Evidence from the banking industry. *J. Reprints Antitrust L. & Econ.*, *27*, 245.

Hofmann, B., & Mizen, P. (2004). Interest Rate Pass-Through and Monetary Transmission: Evidence from Individual Financial Institutions' Retail Rates. *Economica*, *71*(281), 99-123.

Peltzman, S. (2000). Prices rise faster than they fall. *Journal of political economy*, *108*(3), 466-502.

RateSpy.com (2019). Best Mortgage Rates Canada. Retrieved from https://www.ratespy.com/.

Tang, Z., Smith, M. D., & Montgomery, A. (2010). The impact of shopbot use on prices and price dispersion: Evidence from online book retailing. *International Journal of Industrial Organization*, *28*(6), 579-590.