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**Jason Allen,<sup>1</sup> Robert Clark<sup>2</sup> and Jean-François Houde<sup>3</sup>**

<sup>1</sup>Financial Stability Department  
Bank of Canada  
Ottawa, Ontario, Canada K1A 0G9  
jallen@bankofcanada.ca

<sup>2</sup>HEC Montréal  
CIRANO and CIRPÉE  
Montréal, Quebec  
robert.clark@hec.ca

<sup>3</sup>Wharton School  
University of Pennsylvania  
Philadelphia, PA 19104  
and NBER  
houde@wharton.upenn.edu

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## Abstract

This paper measures market power in a decentralized market where contracts are determined through a search and negotiation process. The mortgage industry has many institutional features which suggest competitiveness: homogeneous contracts, negotiable rates, and, for a given consumer, common lending costs across lenders. As a result, even with a small number of lenders, informed borrowers can gather multiple quotes. However, there is important heterogeneity in the ability of consumers to understand the subtleties of financial contracts, in their ability or willingness to search and negotiate for quotes, and also in their degree of loyalty to their main financial institution. We propose and estimate a model to disentangle the different channels through which market power can arise for a given transaction in this environment. There are two main sources of market power. The first is search frictions. We find that over the five year period of the contract the average search cost corresponds to an upfront sunk cost of between \$1,047 and \$1,590. The second main source of market power is switching costs. We estimate that consumers are willing to pay between \$759 and \$1,617 upfront to avoid having to switch banks.

*JEL classification: G21, L22, D4*

*Bank classification: Financial institutions; Financial services; Market structure and pricing*

## Résumé

Les auteurs mesurent le pouvoir de marché dans un marché décentralisé où les conditions contractuelles sont déterminées à l'issue d'un processus de recherche et de négociation. Le secteur hypothécaire possède de nombreuses caractéristiques qui dénotent la compétitivité : homogénéité des contrats, taux négociables et, pour un consommateur donné, coûts des prêts communs à tous les prêteurs. Par conséquent, même en présence d'un nombre limité de prêteurs, des emprunteurs informés sont en mesure d'obtenir différentes offres de prix. On observe cependant une importante hétérogénéité dans la capacité des consommateurs de comprendre les complexités des contrats financiers, dans leur faculté ou volonté de solliciter et de négocier des offres de prix, et aussi dans leur degré de loyauté envers leur banque principale. Les auteurs proposent et estiment un modèle permettant de distinguer les différents canaux par lesquels le pouvoir de marché peut être exercé sur les transactions, dans cet environnement. Le pouvoir de marché provient de deux sources principales. La première concerne les frictions associées à la prospection. Les auteurs constatent que, sur les cinq années de la durée d'un contrat, le coût moyen de prospection correspond à un coût initial irrécupérable allant de 1 047 à 1 590 dollars. Les coûts de transfert forment la seconde grande source du pouvoir de marché. À ce titre, les auteurs estiment que les consommateurs sont disposés à payer au départ entre 759 et 1 617 dollars pour ne pas avoir à changer de banque.

*Classification JEL : G21, L22, D4*

*Classification de la Banque : Institutions financières; Services financiers; Structure de marché et fixation des prix*

## 1. INTRODUCTION

Mortgage markets are decentralized. Contract terms for each borrower are determined through a search and negotiation process: borrowers search across different lender options and then bargain over a mortgage rate. The objective of this paper is to measure market power in this environment, and to quantify the importance of different market frictions that can lead to positive profit margins for lenders. Understanding the extent of market power is crucial for evaluating policies designed to regulate mortgage markets. These include policies regarding the approval of bank mergers, constraints on the scope of bank activities, price discrimination, and banks' costs of funding (e.g. capital or securitization).

The mortgage industry has many institutional features which suggest it should be competitive: homogeneous contracts, negotiable rates, and, for a given consumer lending costs across lenders are common largely due to securitization. As a result, even with a small number of competing lenders, informed borrowers can gather multiple quotes offering interest rates that reflect the expected cost of lending.

However, there is important heterogeneity in the ability of consumers to understand the subtleties of financial contracts, in their ability or willingness to negotiate and search for multiple quotes, and also in their degree of loyalty to their main financial institution. Survey evidence in Canada and in the United States reveals that, while some buyers get multiple quotes when shopping for their mortgage contract, nearly half only get one. Moreover, recent surveys suggest that 80% of consumers search for a quote at their main financial institution, and that the majority of these end up contracting with them. Even among homogeneous contracts consumers who remain loyal to their home bank, or those who gather few quotes may, as a result, be offered higher rates.

We propose and estimate a model to disentangle the different channels through which market power can arise for a given transaction in an environment where prices are determined through a search and negotiation process. The first source of market power is search frictions. In our context search frictions do not arise because borrowers lack information, but rather because of the effort they must put forth when gathering multiple quotes. These frictions may induce profits for lenders since they permit them to price discriminate between consumers. To quantify search frictions the model we develop is sequential; consumers are initially matched with a home bank to obtain a mortgage quote, and can then decide, based on their search costs, whether or not to gather additional quotes from the banks in their neighborhood.

The second source of market power is switching costs. In our context, switching costs might arise because consumers have a higher willingness-to-pay for their main financial institution than for competing lenders. This preference could stem from the fact that most lenders offer complementary services, and many consumers combine their deposit-taking, day-to-day banking, and loan transactions with the same financial institution. To the extent that there are costs of moving a checking account, investment account, etc., consumers may be willing to pay a higher price to stay with their home bank. Note that this home-bank premium could also come from other sources. For instance, a consumer's main financial institution may be better equipped to provide an overall more competitive banking service, perhaps by reducing the fees on other products.

Finally, our model permits an idiosyncratic match value between consumers and lenders which represents a form of cost differentiation. Lenders can value a particular borrower differently, and so, for observationally equivalent consumers some lenders will be more competitive than others.

To shed light on these issues, we analyze detailed transaction-level data on a large set of approved (and insured) mortgages in Canada between 1999 and 2001. Our analysis focuses on individually negotiated contracts, thereby excluding transactions generated through a financial intermediary (e.g. mortgage brokers). These data provide information on features of the mortgage, household characteristics (including place of residence), and market-level characteristics. One advantage of our setting is that all of the mortgage contracts in our sample are insured. Since lenders are protected in the case of default and insurance qualifications and premiums are the same across lenders, borrowers who qualify at one lender know they will also qualify at other lenders. The richness of the consumer data in combination with lender-level location data and survey data on the shopping habits of consumers allows us to empirically measure market power and distinguish between search costs, switching costs, and cost differentiation.

The key parameters of the model are the mean and variance of search costs and the home bank premium. Depending on the specification, we find that over the five year period of the contract the average search cost corresponds to an upfront sunk cost of between \$1,047 and \$1,590. We also estimate substantial amount of dispersion across consumers, which leads to significant amount of asymmetric information at the initial stage of the negotiation process. The home bank premium ranges from about \$759 to \$1,617. In other words, consumers are willing to pay between \$759 and \$1,617 upfront to stay with their home bank and avoid having to switch banks.

These two sets of factors are mostly responsible for generating positive markups for lenders. The average markup above marginal cost is estimated to be 2.9%. The remaining parameters suggest that conditional on searching, consumers are able to extract most of the transaction surplus.<sup>1</sup> Indeed, we estimate that lenders are nearly homogenous in terms of costs, which leads to intense price competition for consumers that exhibit low search costs. The average markup is estimated to be 4.1% for non-searchers and 1.9% for searchers, but the distribution is much more skewed for searchers with close to 25% of them facing zero markup.

Since we model search and negotiation in which rate dispersion is endogenously determined, we are related to two important literatures: search and bargaining. There is a small but growing empirical search literature, but it has mostly focused on posted-price markets and/or assumes exogenous price distributions. See for instance Sorensen (2000), Hortaçsu and Syverson (2004), Hong and Shum (2006), and De Los Santos, Hortacsu, and Wildenbeest (2011). There is also a growing empirical literature on the relationship between bargaining and price dispersion. This literature has mostly concentrated on markets for health care and medical devices (see Dafny (2010), Grennan (2011), Capps, Dranove, and Satterthwaite (2003), Dranove, Satterthwaite, and Sfekas (2008), and Town and Vistnes (2001)), although more recently has looked at the market for televisions (Crawford and Yurukoglu (2011)). One limitation of this literature is that it largely

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<sup>1</sup>In our context the transaction surplus is the difference between the borrower's willingness to pay for a contract, or home bank premium, and the marginal cost of the contract.

focuses on bilateral bargaining models. Specifically, the outside option of buyers is not determined as an equilibrium object dependent on offers they could expect to get from other sellers. It is therefore difficult to study questions related to market structure in this environment.

While the industrial organization theory literature provides a number of relevant models for combining these two elements, to our knowledge, the only other empirical paper that combines them is Hall and Woodward (2010), which also studies the mortgage market. Hall and Woodward study the compensation (ie. the origination fee) paid to mortgage brokers in the United States, and model the potential benefits to consumers of gathering quotes from two brokers rather than just one. They model the negotiation process as an English auction in which the lowest-cost broker wins and pays the cost of the losing broker. Theoretically, our setup is closest to Armstrong and Zhou (2011), Wolinsky (1986), and Bester (1993). In Bester (1993) competing firms negotiate with consumers that can search across stores for better prices. Armstrong and Zhou (2011) develop a similar model and focus on the incumbency advantage that firms can develop with regard to their loyal customers. In Wolinsky (1986) consumers are motivated by more than just price. They search for a firm that will provide them with a suitable product, not just one with a low price.

In the labor literature, empirical models combining search and negotiation have been developed and estimated. Postel-Vinay and Robin (2002) for instance estimate a model in which firms that are differentiated in terms of their productivity make take-it-or-leave-it wage offers to workers. Firms can adjust their offers depending on the characteristics of workers, and can make counter offers should their employees receive offers from competing firms.

The market for mortgages is not the only one in which prices are negotiated and consumers incur search costs to choose among a set of differentiated products. Other examples include markets for personal insurance, markets for both new and used cars, and markets for other consumer loans. Despite its prevalence, this form of pricing has been largely ignored by researchers studying market power in differentiated products markets. This is potentially problematic since these markets do not fit the standard discrete-choice model used to evaluate market power. Specifically, consumers do not necessarily consider all available products, and the researcher has no knowledge of the distribution of rejected prices. Ignoring the actual pricing mechanism, however, can lead to an incomplete and biased analysis. To the extent that transaction prices reveal something about the valuation of consumers for the product that they choose, this can lead to a biased estimate of preferences. There have been two main approaches to solving this problem. In their study of the demand for new automobiles, Berry, Levinsohn, and Pakes (2004) ignore transaction prices, abstracting away from the price setting mechanism actually used in the market. In contrast, in their analysis of sub-prime used car loans, Adams, Einav, and Levin (2009) assume monopoly pricing. We believe that the framework proposed here could be adapted to study any of the markets listed above. Moreover, although we focus on the home bank premium and switching costs, our framework can accommodate more general forms of differentiation. Our approach could, for instance, be applied in differentiated product markets with search and bargaining, such as the car market (see Berry, Levinsohn, and Pakes (2004) and Langer (2011)).

The paper is organized as follows. Section 2 presents details on the Canadian mortgage market, including market structure, contract types, and pricing strategies. Section 3 presents the model. Section 4 presents a description of the household-level data. Section 5 discusses the estimation strategy and Section 6 describes the empirical results. Section 7 concludes.

## 2. THE CANADIAN MORTGAGE MARKET

**2.1. Market structure.** The Canadian mortgage market is currently dominated by six national banks (Bank of Montreal, Bank of Nova Scotia, Banque Nationale, Canadian Imperial Bank of Commerce, Royal Bank Financial Group, and TD Bank Financial Group), a regional cooperative network (Desjardins in Quebec), and a provincially owned deposit-taking institution (Alberta's ATB Financial). Collectively, they control 90 per cent of assets in the banking industry. For convenience we label these institutions the "Big 8." Interest and fees generated from mortgages represent approximately 21% of total revenue for the largest banks.

The market was not always this concentrated. Until the early 1990s the Canadian residential-mortgage market also featured a large number of trust companies. Trusts in Canada are similar to Savings & Loan Companies in the U.S., in that they make mortgage loans, funding them by issuing guaranteed investment certificates and accepting deposits. Cross-ownership between the two types of institutions was not permitted until the 1992 revisions to the Bank Act. As a result of the Bank Act revisions and a series of bad residential and commercial loans that created solvency and liquidity issues for the trusts in the 1980s, Canadian chartered banks acquired the majority of trust companies over the course of the following decade. The merger wave led to the six largest banks controlling approximately 80 per cent of the mortgage market – almost double their 1980s market share. These mergers all resulted in significant expansion of the merged entity's branch network. Figure 1 presents the evolution of the mortgage-market share of the main lending groups – The Big 8, Trusts, Credit Unions and other banks. Today, there are still many trusts operating in Canada, but they are small and their influence on the mortgage market is much less than it was prior to 2000.

**2.2. Mortgage contracts and mortgage insurance.** There are two types of mortgage contracts in Canada – conventional mortgages which are uninsured since they have a low loan-to-value ratio, and high loan-to-value mortgages, which require insurance (for the lifetime of the mortgage). Today, 80% of new home-buyers require mortgage insurance. The primary insurer is the Canada Mortgage and Housing Corporation (CMHC), a crown corporation with an explicit guarantee from the federal government. There are a number of private insurers as well, the only one in operation during our sample was Genworth Financial, which also has an explicit government of Canada guarantee, albeit for only 90 per cent. CMHC's market share during our sample averages around 80 per cent. Our analysis focuses on mortgages insured by CMHC and Genworth.

All insurers use the same strict guidelines for insuring mortgages. First, borrowers with less than 25% equity must purchase insurance.<sup>2</sup> Second, borrowers with monthly gross debt payments

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<sup>2</sup>This is true during our sample and in fact not a guideline but a legal requirement for regulated lenders. Today borrowers with less than 20% equity must purchase insurance.

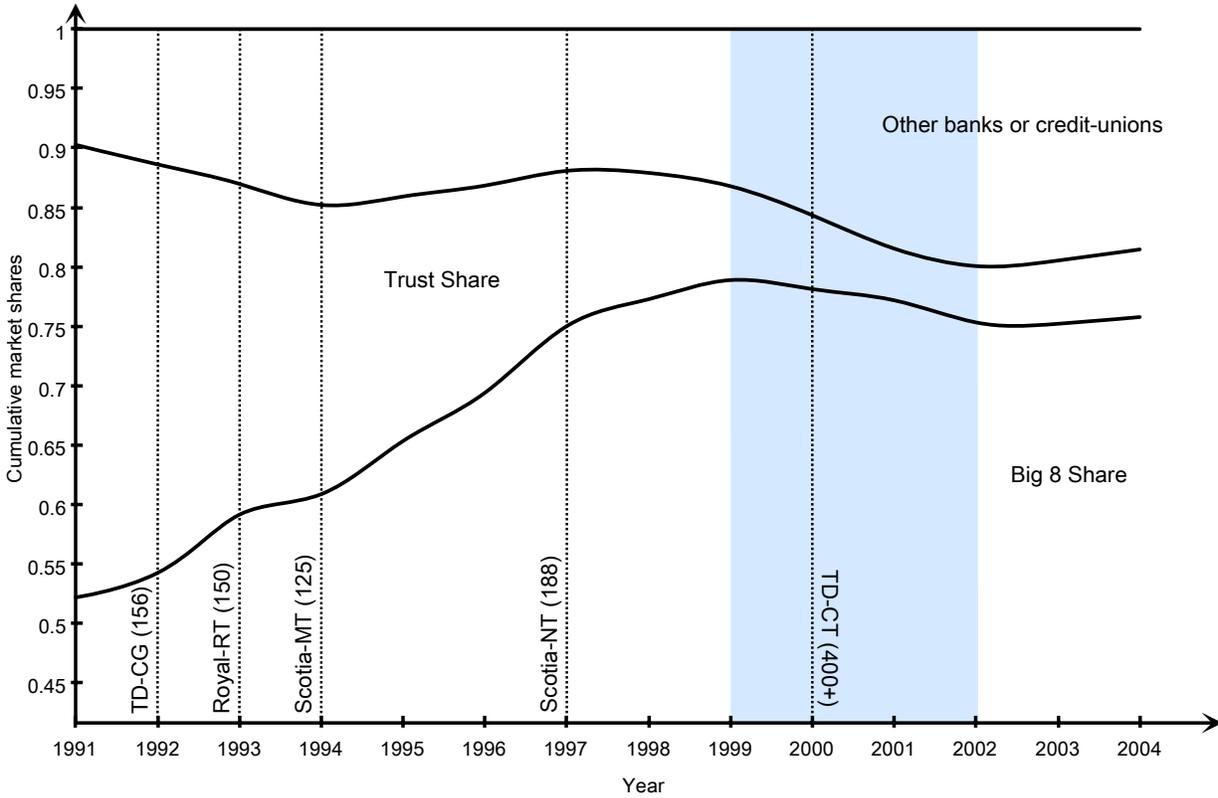


FIGURE 1. Evolution of the market share of financial institutions among new insured mortgage contracts (smoothed)

that are more than 32% of gross income or a total debt service ratio of 40% will almost certainly be rejected.<sup>3</sup> The mortgage insurers charge the lenders an insurance premium, ranging from 1.75 to 3.75 per cent of the value of the loan – lenders pass this premium onto borrowers. Insurance qualifications (and premiums) are common across lenders and based on the posted rate. Borrowers qualifying at one bank, therefore, know that they can qualify at other institutions, given that the lender is protected in case of default.

During our sample period, nearly all mortgage contracts were fixed rate, among which over 85 per cent had a 5 year term (the second most common term is 36 months). A 5 year fixed-rate mortgage contract must be renegotiated every five years, which in effect acts like an adjustable rate mortgage with a fixed time-frame to renegotiate. This has been the standard contract offered by Canadian banks since the late 1960's. Almost all contracts have 25 year amortization periods.

<sup>3</sup>Gross debt service is defined as principal and interest payments on the home, property taxes, heating costs, annual site lease in case of leasehold, and 50 per cent of condominium fees. Total debt service (TDS) is defined as all payments for housing and other debt. Both measures are as a percentage of gross income. These guidelines have been updated post our sample period to also be based on credit scores. Therefore borrowers with lower credit scores now face higher GDS requirements. Crucial to the guidelines is that the TDS and GDS calculations are based on the posted rate and not the discounted price. Otherwise, given mortgages are insured, lenders might provide larger discounts to borrowers above a TDS of 40 in order to lower their TDS below the cut-off. The guidelines are based on the posted rate to discourage this behavior.

TABLE 1. Summary statistics on shopping habits

	1999	2000	2001	2002	2003	2004
Contact main FI						80%
Contact other FI						32%
Number of Negotiations						1-2
Several rate offers	61%	56%	46%	57%	51%	
Arranged via Broker	18%	26%	38%	22%	30%	32%
Loyalty to main FI	57%	57%	48%	63%	63%	54%

Source: Canadian Association of Accredited Mortgage Professionals "Annual State of the Residential Mortgage Market in Canada" (1999-2004)

**2.3. Pricing and negotiation.** The large Canadian banks operate nationally and post prices that are common across the country on a weekly basis in both national and local newspapers, as well as online. There is little dispersion in posted prices, especially at the big banks where the coefficient of variation on posted rates for the six largest banks is close to zero. In contrast, as we can see from Figure 3a, there is a significant amount of dispersion in transaction rates. Approximately 25% of borrowers pay the posted rate. The remainder receive a discount below the posted price. This comes about because borrowers can search for and negotiate better rates. One option for borrowers is to visit local branches and negotiate directly with branch managers who have the authority to offer borrowers discounts below the posted price under general guidelines from headquarters. Local branch managers compete against rival banks, but not against other branches of the same bank. Alternatively borrowers can hire brokers to search for the best rates on their behalf. Unlike in the United States, brokers in Canada have fiduciary duties. Brokers are compensated by lenders, but "hired" by borrowers to gather the best quotes from multiple lenders. The model that we use in this paper focuses only on branch-level transactions, and therefore we exclude broker transactions from our main data-set. We discuss in the conclusion a possible extension of the model that would accommodate those transactions.

Our data do not provide direct information on the number of quotes gathered by borrowers. However, survey evidence from the Canadian Association of Accredited Mortgage Professionals (CAAMP) revealed that on average borrowers negotiate with between one and two financial institutions when searching for a rate, and between 46% and 61% of first-time home buyers gather multiple quotes. Table 1 reproduces these statistics from an annual survey conducted by CAAMP. Notice that we use these aggregate statistics on the fraction of consumers gathering more than one quote in the estimation of the search and negotiation model (see section 5.2).

In 2004, 80% of new borrowers revealed that they contacted their main financial institution when shopping for their mortgage. Depending on the year, nearly 60% of new home-buyers remained loyal to their main institution. This loyalty rate is higher in our data-set since the survey includes broker transactions (which we exclude from our analysis), and focuses only on first-time buyers (we also consider former home owners who buy a new house). Indeed, from our contract-level data-set, we observe that only 35% of consumers dealing with brokers remain loyal to their home institution, while 73% of individual transactions are loyal consumers.

TABLE 2. Distribution of financial services between main and secondary institutions

Account	Main FI	Second FI	All other FI
Mortgage (all)	67.4%	10.9%	21.7% <sup>a</sup>
Mortgage (no broker)	70.3%	10.8%	18.9%
Mortgage (broker)	37.3%	30.6%	32.1%
Loan	55.8%	9.6%	34.6%
Credit card	77.9%	20.7%	1.4%
GIC or term deposit	72.8%	15.8%	11.4%
Bonds, t-bills, GI's	45.3%	7.8%	46.9%
Mutual funds	38.8%	7.2%	54.0%

Source: Canadian Finance Monitor survey conducted by Ipsos-Reid, between 1999 and 2007.

This loyalty stems largely from the evolution of the banking system following regulatory changes in 1992 which led many Canadian households to treat their primary bank as a “one-stop shop”, where they purchase the majority of their financial services. Another survey, the Canadian Financial Monitor (Ipsos-Reid), also characterizes the leading role played by the main institution of consumers; defined as the one with which borrowers conduct day-to-day banking activities. From Table 2 we see that 67 per cent of Canadian households have their mortgage at the same financial institution as their main checking account. In addition, 55 per cent of household loans, 78 per cent of credit cards, 73 per cent of term deposits, 45 per cent of bonds/guaranteed investments and 39 per cent of mutual funds are held at the same financial institution as the households main checking account.

### 3. MODEL

We propose a sequential model in which consumers with heterogeneous search costs initially obtain a quote from their home bank and then decide whether to keep searching by gathering multiple quotes from the remaining lenders in their local market. The initial stage is analogous to a bargaining model with incomplete information. The home bank makes a take-it-or-leave-it initial offer without knowing the cost (pecuniary and non-pecuniary) for the consumer of gathering multiple quotes, and tries to screen consumers who are unlikely to search. This is the first source of market power for large network institutions: banks with a large consumer base have an incumbency or first-mover advantage, and are more likely to transact with consumers with high search costs.

We consider a second source of market power, arising from the presence of consumer switching costs for financial services. As documented in section 2.3, a wide majority of consumers combine most of their banking services with the same financial institution, suggesting that there exists a complementarity in the valuation of banking services. Moreover, to the extent that consumers face a cost of switching service provider, this complementarity creates a home-bank premium, such that, everything else being equal, consumers have a higher willingness-to-pay for their home

bank relative to competing financial institutions. This is analogous to quality differentiation across lenders for a given individual.

Complementarities in banking can be generated from the convenience of reducing the number service providers, or the fact that loyal consumers can have access to better lending terms on other loans. It is also possible that the home bank is better able to retain consumers by offering discounts on other services, such as checking-account fees. We do not attempt to distinguish between these various sources of the home-bank premium, and label them “switching-cost” in the model description. Empirically, they all induce the same form of loyalty or inertia in consumers’ mortgage lender choice.

Finally, the third source of market power in the model comes from the presence of an idiosyncratic match value between borrowers and lenders which introduces an additional source of differentiation. In particular, lenders in the model have heterogenous evaluations of the benefits and costs of dealing with an observationally equivalent consumer. We model this heterogeneity as idiosyncratic differences in lending costs across banks.

We describe the model in detail in the next three subsections. First, we present the notation, and formally define the timing of the model. Then, we solve the model backward, starting with the second stage of the model in which banks are allowed to compete for consumers. Finally, we describe the search decision of consumers, and the process generating the initial quote.

**3.1. Timing and payoffs.** The timing of the model is as follows. First, consumers obtain an initial quote  $P^0$  from their home bank  $h$ . At this point information about lenders’ costs is publicly revealed, and consumers privately observe their cost of gathering additional quotes (denoted by  $\kappa_i$ ). If the offer is rejected, consumers organize a multilateral negotiation game between a set of banks in their neighborhood, denoted  $\mathcal{N}_i$ . We model the multilateral negotiation process as a simultaneous Bertrand-Nash game among lenders in  $\mathcal{N}_i$ , in which consumers choose the highest utility option rather than the lowest offer.

The simultaneous assumption in the second stage allows us to abstract from considerations related to the order of arrival of competing offers. We believe it is a more accurate description of the market than a model with sequential offers. In practice, banks are able to lower their initial offer if consumers receive a lower price quote from a competing bank.

We assume the following payoff structure for consumers and firms, respectively:

$$\text{Consumers:} \quad S_{ij} = \lambda E_{ij} - P_{ij}, \quad (1)$$

$$\text{Firms:} \quad \pi_{ij} = P_{ij} - C_{ij}, \quad (2)$$

where  $P_{ij} = r_{ij} \times L_i$  is the monthly payment on a loan of size  $L_i$  offered by bank  $j$ . Throughout the paper, we assume that the loan size and the downpayment are pre-determined at the beginning of the initial negotiation stage. Consumers and banks are therefore assumed to negotiate solely on the interest rate.

The willingness to pay of consumer  $i$  for bank  $j$  is determined by the home-bank premium. Consumers are assumed to be associated with at most one lender, and therefore  $E_{ij}$  is a dummy variable equal to one if consumer  $i$  has prior experience dealing with bank  $j$ , and zero otherwise.

Throughout the paper we use  $\lambda$  to denote the home-bank premium or switching cost interchangeably.

The cost term measures the direct lending costs for the bank, net of the future benefits associated with selling complementary services to consumer  $i$ . Both components are related to variables affecting the risk of default, and the risk of loan pre-payment over the length of the contract. While lenders are fully insured against default risk, the event of default implies additional transaction costs to lenders that lowers the value of lending to risky borrowers. Pre-payment risk is perhaps more relevant in our context, since consumers are allowed to reimburse between 10-20% of their mortgage every year without penalty.<sup>4</sup> Since we do not observe the performance of the contract along these two dimensions, we use a reduced-form expression to approximate the net present value of the contract. In particular, we model  $C_{ij}$  as a function of observed consumer and firms fixed-effects, denoted by  $Z_{ij}$ , an unobserved attribute  $\epsilon_i$  that symmetrically affects all lenders, and an idiosyncratic match value  $u_{ij}$ :

$$C_{ij} = L_i \times (Z_{ij}\gamma + \epsilon_i - u_{ij}) = L_i \times (c_{ij} - u_{ij}). \quad (3)$$

Note that we use small-case letters to identify variables measured in terms of a hundred dollar loan. The idiosyncratic component of firms' profits comes from several sources: branch manager compensation, idiosyncratic evaluation of future revenues, and idiosyncratic evaluation of pre-payment or default risks. Importantly, we assume that  $C_{ij}$  is observed by all parties at the beginning of the negotiation process.

Finally, the transaction surplus from a  $(ij)$  match is equal to:

$$V_{ij} = \lambda E_{ij} - C_{ij} = \xi_{ij} + U_{ij}, \quad (4)$$

where  $U_{ij} = L_i \times u_{ij}$ , and we label  $\xi_{ij}$  as the deterministic component of the transaction surplus.<sup>5</sup>

It should be noted that most of the model's predictions are the same whether or not we assume that the match value enters firms' profits, or consumers' willingness to pay. While we believe that it is more reasonable to think that most of the randomness across consumers arises from differences in lending opportunity costs across banks, as we will see below the choice of lender and the transaction price depend only on the distribution of total surplus.

**3.2. Competition stage.** Conditional on rejecting  $P^0$ , all lenders in the choice-set  $\mathcal{N}_i$  compete for the contract (including bank  $h$ ). We model this competition as a simultaneous Bertrand-Nash pricing game in which consumers choose the highest utility option.

Banks are willing to "bid" for consumer  $i$  as long as they can earn positive profits:  $P_{ih} \geq C_{ij}$ . An offer equal to  $C_{ij}$  yields the highest utility that each bank can provide, and is equal to the transaction surplus  $V_{ij}$ . If bank  $j$  is the highest surplus lender, it can match the offer of the second-highest surplus bank and still make positive profits. The unique Nash equilibrium transaction price is therefore a quote  $P_i^*$  such that the consumer is indifferent between the highest-surplus

<sup>4</sup>On average borrowers pre-pay an additional 1% of their mortgage every year.

<sup>5</sup>This distinction is not quite exact since  $\epsilon_i$  is a random variable from the econometricians points of view. We use this notation to facilitate the derivation of the likelihood function.

bank, and the zero-profit offer from the second-highest surplus bank:

$$P_i^* = \lambda E_{ij} - \max_{k \neq j} V_{ik}, \text{ if } V_{ij} = \max_{k \in \mathcal{N}_i} V_{ik} = V_{(1)}. \quad (5)$$

This expression implies that the transaction price will include a positive markup that depends on the importance of consumers switching cost, and heterogeneity in lending costs. We can distinguish between three cases depending on the ranking of the home bank in the value distribution:

$$P_i^* = \begin{cases} \lambda + C_{(2)} & \text{If } V_{ih} = V_{(1)}, \\ -\lambda + C_{i,h} & \text{If } V_{ih} = V_{(2)}, \\ C_{(2)} & \text{If } V_{ih} < V_{(2)}. \end{cases} \quad (6)$$

Therefore, loyal consumers at the competitive stage will on average pay a premium, while lenders directly competing with the home-bank will on average have to discount the contract by a margin equal to the switching cost in order to attract new customers.

Finally, the value of shopping corresponds the surplus generated by the second-highest lender in consumer  $i$ 's choice-set:

$$W_i = V_{(2)} = \max_{k: V_{ik} < V_{(1)}} V_{ik}. \quad (7)$$

This expression determines the value of the outside option in the first-stage negotiation process.

**3.3. Search decision and initial quote.** Consumers choose to search for additional quotes by weighting the value of accepting  $P^0$ , or paying a sunk cost  $\kappa_i$  in order to lower their monthly payment. The benefit of gathering quotes,  $W_i$ , originates from generating competition between lenders. It is observed by consumers and their home bank at the beginning of the negotiation process. We therefore use the terminology “search” to describe the action of shopping for extra quotes, rather than acquiring information.

The search decision of consumers is defined by a threshold function, which yields a search probability that is increasing in the value of the initial offer and the outside option of consumers, and decreasing in the home-bank premium:

$$\begin{aligned} \Pr(\text{Reject}|P^0, W_i) &= \Pr(\kappa_i < W_i - (\lambda - P^0)) \\ &= H(P^0|W_i). \end{aligned} \quad (8)$$

Lenders do not commit on a fixed interest rate, and are open to haggling with consumers based on their outside options. This practice allows the home bank to price discriminate by offering up to two quotes to the same consumer: (i) an initial quote  $P^0$ , and (ii) a competitive quote  $P_i^*$  if the first one is rejected.

The price discrimination problem is based on the value of the outside option relative to the switching cost, and the expected search cost of consumers. More specifically, anticipating the second-stage outcome, the home bank chooses  $P^0$  to maximize its expected profit:

$$\max_{P^0} (P^0 - C_{ih}) (1 - H(P^0|W_i)) + 1(V_{ih} > W_i) H(P^0|W_i) \underbrace{(P_i^* - C_{ih})}_{=V_{ih} - W_i},$$

which yields the following implicit representation of the initial-quote markup:

$$P_i^0 - C_{ih} = \underbrace{1(V_{ih} > W_i)(V_{ih} - W_i)}_{\text{Differentiation}} + \underbrace{\frac{1 - H(P_i^0|W_i)}{h(P_i^0|W_i)}}_{\text{Search cost}} \quad (9)$$

where  $h(P_i^0|W_i) = \partial H / \partial P^0$ . In words, the previous expression decomposes the home-bank markup into a component coming from quality and cost differentiation across lenders, and the unobserved search cost of consumers.

In order to estimate the model, we assume that  $\kappa_i$  is distributed according to an exponential distribution with translation parameter  $\bar{\kappa}$  and variance  $\sigma_\kappa$ .<sup>6</sup> The translation parameter corresponds to the common sunk search cost, and the variance term measures the importance of asymmetric information. The exponential distribution has a constant hazard-ratio, which yields the following piece-wise linear expression for the optimal initial quote:

$$P_{ih}^0 = \begin{cases} \lambda - W_i + \sigma_\kappa & \text{If } V_{ih} > W_i, \\ C_{ih} + \sigma_\kappa & \text{Otherwise.} \end{cases} \quad (10)$$

Finally, by substituting this expression for the initial quote into equation (8), we can characterize the equilibrium search probability conditional on the value of the outside option  $W_i$ :

$$H(W_i) = 1 - \exp\left(-\frac{1}{\sigma_\kappa}(\max\{W_i - V_{ih}, 0\} + \sigma_\kappa - \bar{\kappa})\right). \quad (11)$$

The previous expression implies a lower bound on the rejection probability, given by  $\bar{H} = 1 - \exp\left(-\frac{\sigma_\kappa - \bar{\kappa}}{\sigma_\kappa}\right)$ . This probability is associated with the case in which the home bank is guaranteed to retain the consumer (i.e.  $V_{ih} > W_i$ ). As the value of the outside option increases, the monthly reduction in payment that consumers can hope to obtain gets larger, and the search probability increases towards one.

### 3.4. Discussion of model assumptions.

*Inelastic housing demand.* We model the choice of lenders as a discrete choice, abstracting away from the possibility that consumers can decrease their down-payment or buy a larger house when receiving larger discounts. In principle this assumption could be relaxed by modeling the decision as a discrete-continuous choice problem, adapting the framework developed Dubin and McFadden (1984) and Hanemann (1984).

We decided against this approach based on the observed loan-to-value ratios. The insurance premium charged by the two insurance companies have a piece-wise linear form, with kinks at every increase of 10%. As a result, consumers tend to bunch around the kinks of the premium schedule (see Figure 2 (a)), which effectively discretizes the down-payment decision. This prevents us from using Roy's identity to derive a smooth loan-size demand function, complicating the analysis. Moreover, the discrete nature of the LTV distribution suggests that loan size demand

<sup>6</sup>The translated exponential cumulative distribution function takes the following form:  $\Pr(\kappa_i < x) = 1 - \exp\left(-\frac{1}{\sigma_\kappa}(x - \bar{\kappa})\right)$ , where  $\sigma_\kappa > \bar{\kappa} \geq 0$ .

is locally inelastic: for small changes in interest rate offers consumers choose a fixed loan-size in order to avoid paying an extra amount in insurance premiums.

*Posted interest rates.* Posted rates do not enter the model. In practice, banks post a common interest rate that is adjusted weekly to reflect changes in the cost of funding. This rate can be thought of as an upper bound on the monthly payment that branch managers across the country can offer, since overage is illegal in Canada. This could in principle constrain the equilibrium interest rates, and affect the lending decisions of banks. For instance, consumers should not qualify for a loan if the cost of lending exceeds the revenue evaluated at the current posted rate. Similarly, high cost borrowers could be constrained to borrow at the posted rate if their outside option was less attractive than the posted-rate at their home bank.

We abstract from these considerations because they would add unnecessary complexities to the likelihood function, without providing extra benefits in terms of our analysis. First, few consumers are actually paying the posted interest rate. We estimate that less than 25% of borrowers pay a rate that is within 10 basis points of the lowest posted rate within 90 days of the contract date.<sup>7</sup> Second, for nearly every week in our sample, there is no dispersion in posted interest rates across the major lenders. Therefore, it is unlikely that the posted rate is used to attract new customers; at least not during our sample period. Third, banks have an incentive to post an artificially high interest rate that is not binding. Indeed, the pre-payment penalty is calculated as a fraction of the interest payments remaining on the contract, evaluated at the posted rate valid at the signature date, rather than the transaction interest rate. Banks therefore have an incentive to raise the posted rate, in order to reduce their pre-payment risk.

*Complete versus incomplete information.* The model also assumes that the value of consumers' outside options is known by consumers and banks (i.e.  $u_{ij}$  is observed to all parties). This assumption greatly simplifies our analysis, by providing analytical expressions for both stages of the game. An incomplete information version of the model, in which the outcome of the competition stage is privately observed is perhaps more intuitive, but is significantly more complicated to estimate. Moreover, it exhibits very similar empirical predictions.

To see this, notice that the Bertrand pricing game is strategically equivalent to a descending auction in which the consumer sequentially lowers the asking price, and openly announces a bid preference formula given by his/her willingness to pay function. The transaction price, therefore, is invariant to our information assumption.

However, our information assumption does affect the outcome of the first-stage negotiation. Under incomplete information, both lenders and borrowers are uncertain about the value of the competitive outcome, but observe the value of the home-bank transaction  $V_h$ . The value of search then becomes a function of two random variables: the surplus from the first and second best options among  $\mathcal{N}_i \setminus h$  banks. This affects the expression for the search probability, and modifies the profit maximization problem of the home bank.

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<sup>7</sup>Lenders typically guarantee a rate that is the lowest rate within 90 days of the mortgage being approved.

TABLE 3. Summary statistics on contractual characteristics in the full sample

	Distribution observations	
	Number	Fraction
New home purchase	74,155	0.939
Fixed-rate term	75,576	0.957
5 Years term	68,469	0.867
25 Years amortization	72,891	0.923
Non-broker transaction	47,429	0.755
Missing values (broker, fico, residential status)	20,000	0.253
Total sample size	29,279	0.419

Although the optimal initial offer does not have a simple analytical expression, it shares similar properties with the full-information optimal quote. In particular, for low values of the winning probability  $F_1(V_{ih})$ , the initial quote is equal to its complete information counterpart (i.e.  $P_i^0 = C_{ih} + \sigma_\kappa$ ). As  $V_{ih}$  gets larger, the premium over  $C_{ih}$  increases non-linearly, and converges to a finite constant function of the expected consumer surplus from the highest surplus option (excluding the home bank). In this region of  $V_{ih}$  the two models differ. Empirically, the incomplete-information model is less flexible than the full-information model, since it imposes a strict lower bound on the size of monthly payments. A detailed analysis of the incomplete information model, including its corresponding likelihood function is available upon request.

#### 4. DATA

**4.1. Mortgage contracts and sample selection.** Our main data-set is a sample of insured contracts from the Canada Mortgage and Housing Corporation (CMHC) and Genworth Financial between January 1999 and December 2001. We focus on this window for three reasons. First, between 1992 and 1999, the market transitioned from markets with a larger fraction of posted-price transactions and loans originated by trust companies, to a decentralized market dominated by large multi-product lenders. Our model is a better description of the latter period. Second, between August 2002 and September 2003, TD/Canada Trust experienced a new pricing scheme based on a “no-haggle” principle. Understanding the consequences of this experimentation is beyond the scope of this paper. Finally, the 1999-2001 period also includes the TD-Canada Trust merger, which produces useful variation in the choice-set of consumers.

We obtained a 10% random sample of all contracts from CMHC, and the full set of contracts originated by the 12 largest lenders from Genworth Financial. We further sample from the Genworth contracts to match their annual market share, which is about 20%. Both data-sets contain information on 20 household/mortgage characteristics, including all of the financial characteristics of the contract (i.e. rate, loan size, house price, debt-ratio, risk-type), and some demographic characteristics (e.g. income, prior relationship with the bank, residential status, dwelling type).

TABLE 4. Summary statistics on mortgage contracts in the selected sample

	<b>N</b>	<b>Mean</b>	<b>SD</b>	<b>Min</b>	<b>Median</b>	<b>Max</b>
Loan	29,279	134,063	53,275	40,531	126,449	299,899
Income	29,279	68,201	25,900	16,126	64,699	198,277
Other debt	29,279	859	520	0	756	4,758
LTV	29,279	.91	.044	.75	.91	.95
FICO (mid-point)	29,279	.666	.074	.5	.7	.75
Switchers	18,692	.27	.44			
Renters	29,279	.55	.50			
Living with parents	29,279	.07	.25			

*Sample:* 5-year fixed-rate contracts issued by one of the Big-12 lenders between 1999 and 2004. Contracts negotiated through brokers are excluded. The sample also excludes top and bottom 1% of the loan size distribution.

Table 9 in the Appendix lists all of the variables included in data-set. In addition, we observe the location of the purchased house up to the forward sortation area (or FSA).<sup>8</sup>

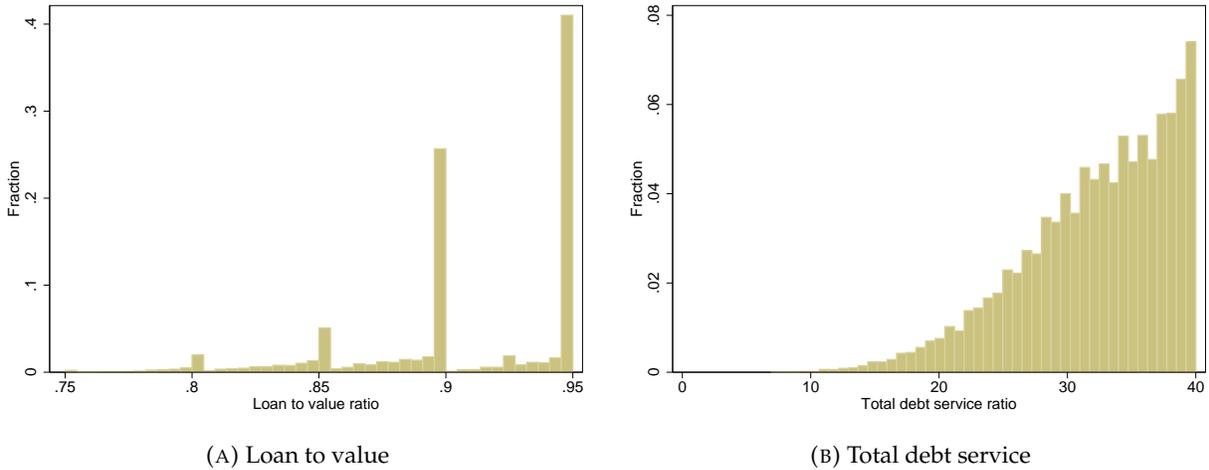
We restrict our sample to contracts with homogenous terms. In particular, from the original sample we select contracts that have the following characteristics: (i) 25 years amortization period, (ii) 5 year fixed-rate term, (iii) newly issued mortgages (i.e. excluding refinancing and renewal), (iii) contracts that were negotiated individually (i.e. without a broker), (iv) contracts without missing values for key attributes (e.g. credit score, broker and residential status). Table 3 illustrates the breakdown of the full sample according to those characteristics. The final sample includes slightly more than twenty-nine thousand observations, or 37% of the initial sample. Most of the dropped observations originate from omitting broker transactions, which represent 25% of newly issued mortgages. We also drop a large number of contracts with missing characteristics. Most of these missing values are concentrated in first six months of 1999, when CMHC and Genworth started collecting additional information on broker transactions and the residential status on households (i.e. new home owner).

Table 4 describes the main financial and demographic characteristics of the borrowers in our sample, where we trim the top and bottom 1% of observations in terms of income, loan-size, and interest-rate premium. The resulting sample corresponds to a fairly symmetric distribution of income and loan size. The average loan size is nearly \$140,000 which is twice the average annual household income. The total debt service (TDS) ratio is capped at 40%, but most consumers are not constrained by this maximum. Figure 2 (b) illustrates the distribution of TDS in our sample. From this variable we construct a measure of the total other monthly debt payments subtracting the mortgage payments from the total debt services (e.g. credit card debts, car loans). On average households monthly debt payments other than the mortgage are \$862.

The loan-to-value (LTV) variable shows that many consumers are constrained by the minimum down-payment of 5% imposed by the government guidelines. Nearly 40% of households invest

<sup>8</sup>The FSA is the first half of a postal code. We observe nearly 1,300 FSA in the sample. While the average forward sortation area (FSA) has a radius of 7.6 kilometers, the median is much lower at 2.6 kilometers.

FIGURE 2. Loan to Value and Total Debt Service Ratios: 1999-2001



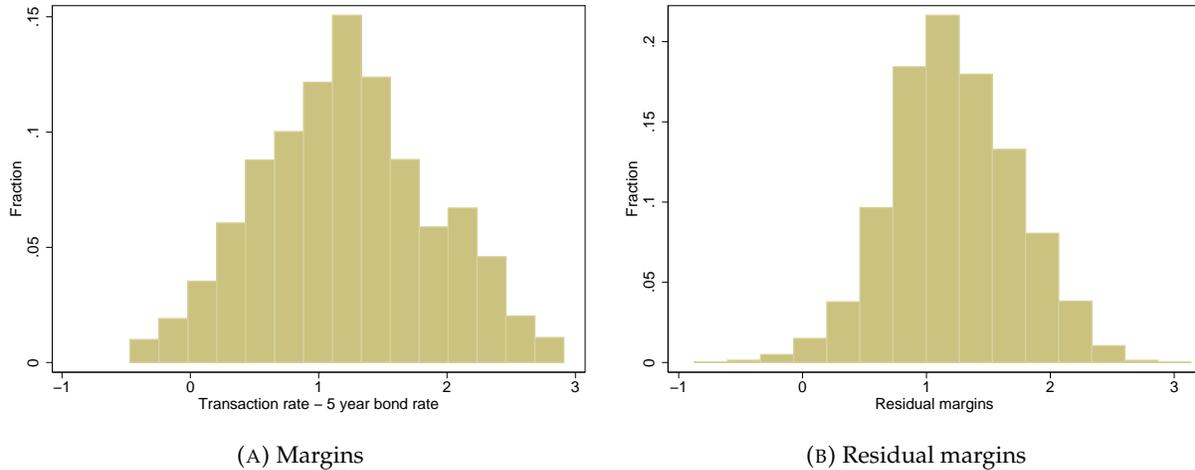
the minimum, and the average loan-to-value is 91%. Figure 2 (a) plots the distribution of the LTV ratio. LTV ratios are highly localized around 90 and 95, and to a lesser extent 75, 80, and 85. The clustering comes about because the insurance premium schedule is discrete, and there are only a small number of price-quantity pairs. Moreover, the vast majority of households in our data (i.e. 96%) roll-over the insurance premium into the initial mortgage loan. The loan size measure that we use includes the insurance premium for those households.

The variable labeled “switchers” is a dummy variable equal to one if the duration of the prior relationship with the mortgage lender is zero. 73% of households choose a lender with which they already have a prior financial relationship.<sup>9</sup> The fraction of switchers is significantly larger for new home-buyers (i.e. formerly renters or living with their parents), and for contracts negotiated through a broker.

The fact that transaction interest rates are negotiated rather than posted induces a substantial amount of dispersion. Figures 4a and 4b illustrate this dispersion by plotting the distribution of retail margins in the sample. We measure margins using the 5-year bond-rate as a proxy for marginal cost. The transaction rate is on average 1.2 percentage points above the 5-year bond rate, and exhibits substantial dispersion. Importantly, a large share of the dispersion is left unexplained when we control for a rich set of covariates: financial characteristics, week fixed effects, lender/province fixed-effects, lender/year fixed-effects, and location fixed-effects. These covariates explain 43% of the total variance of observed margins. Figure 4b shows the histogram of the residual dispersion in margins, scaled up using the unconditional average margin. The standard-deviation of retail margins is equal to 66 basis points, while the residual margins has a standard-deviation of 50 basis points.

<sup>9</sup>Note that due to data limitations we do not measure the switcher variable for contracts issued by Genworth, and for one financial institution. The fraction of switchers is measured using only the remaining contracts.

FIGURE 3. Dispersion of retail margins between 1999-2001



**4.2. Local markets and lender information.** Our main data-set contains the lender information for 10 lenders during our sample period. For mortgage contracts where we do not have a lender name but only a lender type, these are coded as “Other Bank”, “Other credit union”, and “Other trusts”. While the “Other trusts” category corresponds to less than 2% of contracts in our sample, the other two categories represent a sizable share of contracts in some regions. We assign the contracts issued by Trusts to generic “Other lender” category. The credit-union market is fragmented, and we do not attempt to impute the missing lender information (i.e. this would amount to estimating a large number of credit-union fixed effects). Instead, consumers transacting with an “Other credit-union” are assumed to deal with the same “Other lender” category, which share common characteristics across the country. The “Other Bank” category includes mostly two institutions: Laurentian Bank is mostly present in Québec and Eastern Ontario, while HSBC is present mostly in British Columbia and Ontario. We exploit this geographic segmentation and assign the “Other banks” customers to HSBC or Laurentian based on their relative presence in the local market around each home location. After performing this imputation, consumers face at most 13 lending options: Alberta Treasury Branch, Bank of Montreal, Bank of Nova Scotia, Canada Trust, Canadian Imperial Bank of Commerce, Caisse Desjardins, Laurentian Bank, National Bank of Canada, Royal Bank of Canada, Toronto-Dominion Bank, Vancity, HSBC, and Other Lender.

Not all consumers have access to every option, because of the uneven distribution of branches across local markets. We exploit this variation by assuming that consumers shop for their mortgage locally, in a neighborhood around the location of their new house (e.g. municipality). To implement this, we match the new house location with the postal code associated with each financial institution’s branches. The branch location data is available annually, and comes from Micromedia-ProQuest; a provider of commercial address information in Canada. The information relative to the location of each house is coarser than the location of branches. Therefore, we assume that each house is located in the center of its FSA, and calculate a somewhat large euclidian distance radius of 10 KM around it to define the borrower’s maximum choice-set. Formally, a

FIGURE 4. Distribution of minimum distances between banks and consumers

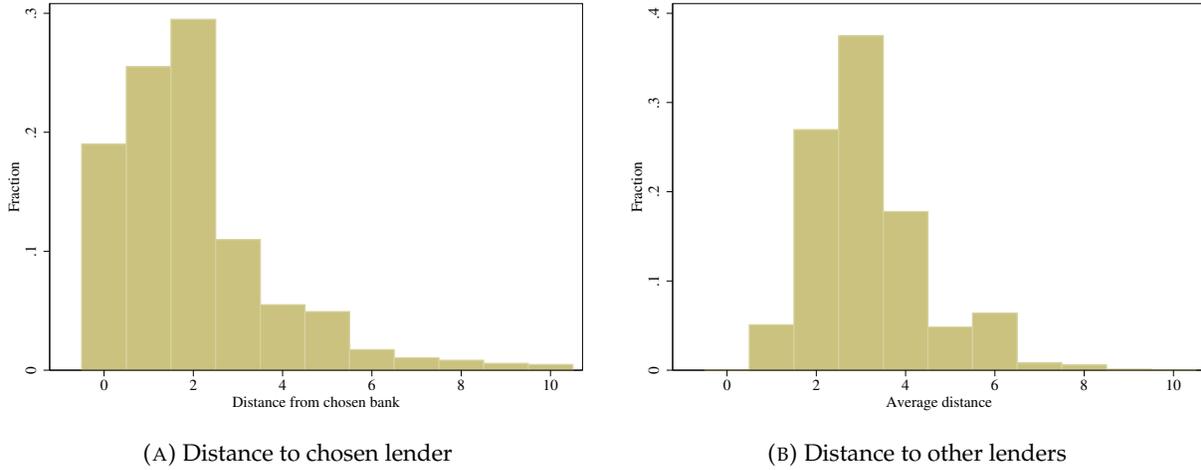


TABLE 5. Descriptive statistics on local market structure

	Mean	Min	P25	P50	P75	Max
Nb. contracts	455	11	29	169	410	4288
Nb. FIs (in 10 KM)	6.09	2	5.18	6.12	7.03	8.12
HHI-Branch (in 10 KM)	2240	1527	1874	2089	2325	5370
C1-Contract	41.4	21.6	29.2	36.8	48.5	90
HHI-Contract	1304	338	517	762	1424	7300
Relative network size	1.58	.831	1.11	1.28	1.52	10.6

Markets are defined as census-divisions (130 obs.). Sample excludes market with less than 10 contracts between 1999 and 2004, and only includes contracts with Big-12 lenders.

lender is part of consumer  $i$  maximum choice-set if it has a branch located within less than 10KM of the house location. We use this definition to measure the relative presence of each lender (i.e. number of branches in a choice-set), and the number of lenders within each choice-set (i.e. number of lender with at least one branch).

Figures 4 illustrate the distribution of minimum distances between each house’s FSA centroid and the closest branch of each lender. On average consumers transact with banks that tend to be located close to their house. The average minimum Euclidian distance is nearly 2 KM for the chosen institution, and above three for the other lenders. In fact the distributions indicate that 80% of consumers transact with a bank that has a branch within 2 KM of their new house, while only 30% of consumers have an average distance to competing lenders lower or equal to 2 KM. This feature reflects the fact that consumers tend to choose lenders with large networks of branches.

In Table 5 we measure the average network size of the chosen institution relative to the average size of others present in the same neighborhood (i.e. relative network size). On average consumers transact with lenders that are nearly 60% larger than their competitors in terms of branches; the median is smaller at 28%.

The remaining variables in Table 5 measure the level of concentration aggregated at the census-division level. On average each consumer faces six lenders within 10 KM. Most of these banks have a relatively small presence, as indicated by the large Herfindahl-Hirschman index, calculated using the distribution of branches within 10 KM of each contract (i.e. both the mean and median are above two thousand). The C1 and HHI-contract measures also suggest a lack of competition. On average, the top lender in each region controls 41.4% of contracts. The HHI-contract variable suggests a somewhat lower level of concentration, although this variable is subject to measurement error due to the small sample size in some regions. This difference nonetheless suggests that, although the top lender in each region has a disproportionately large market share, the remaining contracts are distributed more uniformly across other banks.

## 5. ESTIMATION METHOD

In this section we describe the steps taken to estimate the model parameters. We begin by describing the functional form assumptions imposed on consumers and lenders unobserved attributes. Then we derive the likelihood function induced by the model, and discuss the sources of identification in the final subsection.

**5.1. Distributional assumptions.** Our baseline model has four sources of randomness beyond observed financial and demographic characteristics: (i) identity of banks with prior experience and origin of the first quote, (ii) consumer choice-set, (iii) common unobserved profit shock  $\epsilon_i$ , and (iv) idiosyncratic match values  $u_{ij}$ . The first unobservable is the most critical, and arises mostly because we do not observe the identity of the home bank for non-loyal consumers. We circumvent this problem by estimating the distribution of main financial institution in the population. We describe each point in turn.

*Distribution of main financial institutions.* The identity of home banks is partially observed when consumers transact with a bank which they have at least one month of experience, and consumers are assumed to have experience with at most one bank. For the consumers that switch institutions, the identity of the bank with prior experience is unknown (i.e. we only know it is not the chosen lender). Moreover, this variable is absent for the contracts insured by Genworth Financial.

We assume that  $E_{ij}$  is a multinomial random variable with a probability distribution  $\psi_{ij}$ . This distribution is a function of the location of consumers, and income group. We estimate this probability distribution separately using a survey of consumer finances performed bi-yearly (Ipsos-Reid) which identifies the main financial institution of consumers. This data-set surveys nearly 12,000 households per year in all the regions of the country. We group the data into six years, ten regions, and four income categories. Within these sub-samples we estimate the probability of a consumer choosing one of the twelve largest lenders as their main financial institution. We denote this estimated probability by  $\psi_j(X_i)$ , where  $X_i$  identifies consumer  $i$ 's group. This probability corresponds to the density of positive experience level given the year, income, and location of borrower  $i$ .

In addition, it is possible that consumers have no prior experience with lenders in their choice-set. For instance, a bank might not be present in the new residential neighborhood of consumers. As a result, the identity of the first offer (i.e.  $h_i$ ) is not always equal to the “home” bank, which means that we must integrate out two possibilities when evaluating the likelihood: (i) receiving an initial quote from the home bank (i.e.  $E_{ij} = 1$ ), and (ii) receiving an initial quote from a bank with no prior experience (i.e.  $E_{ij} = 0$ ). In the latter case, we assume that the matching probability is proportional to the branch network share of bank  $j$ , denoted by  $s_{ij}$ . Formally the probability of the pair  $(h, E)$  is:

$$\Pr(h, E | X_i, \mathcal{N}_i) = \begin{cases} 1(h \in \mathcal{N}_i) \hat{\psi}_h(X_i) & \text{If } E_{ih} = 1, \\ \sum_{k \notin \mathcal{N}_i} \hat{\psi}_k(X_i) s_{ik} & \text{If } \sum_{k \in \mathcal{N}_i} E_{ik} = 0, \\ 0 & \text{Otherwise.} \end{cases} \quad (12)$$

In words, when possible, the initial offer comes from a bank with prior experience of consumer  $i$ , otherwise, it is randomly sampled from the set of available options.

In the estimation of the model, we also allow a fraction,  $\eta$ , of consumers to have zero valuation for their home bank (i.e.  $E_{ij} = 0$  for all  $j$ ). For those consumers, the initial matching is random, and is solely determined by the distribution of branch shares in  $\mathcal{N}_i$ .

*Consumer choice-sets.* As discussed in section 4.2, we assume that consumers shop locally for their new mortgage. In our baseline specification, we assume that all consumers consider lenders located within a 10 KM euclidian distance around the center of their postal code area (i.e. FSA).

Similar to Goeree (2008), we allow heterogeneity in consumer choice sets. In addition to the baseline specification, we consider a richer econometric specification in which a fraction  $\mu$  of consumers only consider dominant banks in their local area, while the remaining “sophisticated” consumers consider the full set of banks in  $\mathcal{N}_i$ . We identify dominant lenders by computing the cumulative distribution of branches in each local market: dominant lenders are defined as the largest banks in  $\mathcal{N}_i$  controlling at least 75% of branches. Recall that the distribution of branches is highly skewed for most consumers, and the largest bank in each local market controls on average 40% of branches. The average number of lenders in the restricted choice-set is equal to 3, compare to 6 in the full set.

*Unobserved profit shocks.* The common unobserved lending cost  $\epsilon_i$  is normally distributed with mean zero and variance  $\sigma_\epsilon^2$ , and the bank-specific idiosyncratic match values  $u_{ij}$  are independently distributed according to a type-1 extreme-value (EV) distribution with location and scale parameters  $(0, \sigma_u)$ . As a result, the surplus  $V_{ij}$  is also distributed according to a type-1 extreme-value distribution with location  $\xi_{ij} = (\lambda E_{ij} - C_{ij})$  and scale  $\sigma_{i,u} = L_i \sigma_u$ . Let  $F(v; \xi_{ij}, \sigma_u)$  and  $f(v; \xi_{ij}, \sigma_u)$  denote the CDF and PDF of  $V_{ij}$ , respectively.

The EV distribution assumption leads to analytical expressions for the distribution functions of the first and second-order statistics, and has often been used to model asymmetric value distributions in auction settings (see for instance Brannan and Froeb (2000)). To simplify the notation, we use the term  $\mathcal{N}_i$  to denote the number and identity of lenders present in the choice-set of consumer

$i$  (i.e. vector of  $\xi_{ij}$ ). Also, the notation  $\mathcal{N}_i \setminus j$  identifies the choice-set of consumer  $i$  excluding option  $j$ . The distribution of the highest surplus in consumer  $i$ 's choice-set is directly obtained from the extreme-value functional form:

$$F_1(v; \mathcal{N}_i) \equiv F(v; \xi_{i,\max}, \sigma_u), \quad \text{where } \xi_{i,\max} = \sigma_{i,u} \log \left( \sum_{j \in \mathcal{N}_i} \exp(\xi_{ij}/\sigma_{i,u}) \right). \quad (13)$$

This leads to the familiar multinomial logit form for the probability that bank  $j$  offers the highest surplus:

$$\rho_{ij} = \Pr \left( V_{ij} = \max_{k \in \mathcal{N}_i} \{V_{i,k}\} \right) = \frac{\exp(\sigma_{i,u} \xi_{ij})}{\sum_{k \in \mathcal{N}_i} \exp(\sigma_{i,u} \xi_{ik})} = \frac{\partial \xi_{i,\max}}{\partial \xi_{ij}}. \quad (14)$$

The second-order statistics of the  $V$ 's distribution can also be derived analytically from  $F_1(\cdot)$ :

$$\begin{aligned} F_2(v|V_{ij} = V_{(1)}; \mathcal{N}_i) &= \frac{1}{\rho_{ij}} \left( F_1(v; \mathcal{N}_i \setminus j) + (\rho_{ij} - 1) F_1(v; \mathcal{N}_i) \right) \\ F_2(v; \mathcal{N}_i) &= \sum_{j \in \mathcal{N}_i} F_1(v; \mathcal{N}_i \setminus j) + F_1(v; \mathcal{N}_i) \sum_{j \in \mathcal{N}_i} (\rho_{ij} - 1) \\ &= \sum_{j \in \mathcal{N}_i} F_1(v; \mathcal{N}_i \setminus j) + (1 - |\mathcal{N}_i|) F_1(v; \mathcal{N}_i), \end{aligned}$$

The densities  $f_2(v|V_{ij} = V_{(1)}; \mathcal{N}_i)$  and  $f_2(v; \mathcal{N}_i)$  are defined analogously.

**5.2. Likelihood function.** We estimate the model by maximum likelihood. In order to derive the likelihood function, we first consider the likelihood contribution of an individual  $i$ , first conditioning on  $Z_i, \epsilon_i$ , and  $E_i$  which groups all the relevant information to calculate  $\lambda E_{ij}$  and  $c_{ij}$ , the choice-set of consumers, as well as the model parameter vector  $\beta$  and the identity of the bank issuing the first quote  $h_i$ . After describing the likelihood contribution conditional on  $\mathcal{I}_i = (\mathcal{N}_i, Z_i, \epsilon_i, E_i, h_i)$ , we discuss the integration of the model unobservables. We do so for the baseline specification in which consumers have homogenous choice sets (i.e.  $\mu = 0$ ), and all consumers have positive home bank premium (i.e.  $\eta = 0$ ).

We use the following notation. With a slight abuse of notation, we use cap-letters to refer to random variables, and small-case letters to refer to the realizations of consumer  $i$ . We also remove the conditioning  $(\mathcal{I}_i, \beta)$  whenever possible, since it is common to all probabilities. The endogenous outcomes of the model are: the chosen lender and transaction price  $(b_i, p_i)$ , as well as the selling mechanism  $M_i = \{\mathbf{c}, \mathbf{n}\}$  (i.e. competition versus negotiation). The observed prices are either generated from consumers accepting the initial quote (i.e.  $M_i = \mathbf{n}$ ), or accepting the competitive offer (i.e.  $M_i = \mathbf{c}$ ). Importantly, only the latter case is feasible if  $B_i \neq h_i$ , while both cases have positive likelihood if  $B_i = h_i$ . We derive the likelihood contribution for the loyal case first, and then discuss the case of switchers.

*Case 1: Loyal consumers ( $B_i = h_i$ ).* The main obstacle in evaluating the likelihood function is that we do not observe the selling mechanism,  $M_i$ . The likelihood contribution of loyal consumers is therefore:

$$L^l(p_i, B_i = h_i) = l(p_i, B_i = h_i, M_i = \mathbf{c}) + l(p_i, B_i = h_i, M_i = \mathbf{n}). \quad (15)$$

Three random variables determine the observed outcomes: (i) the surplus generated by the home bank  $V_{h_i}$ , (ii) the surplus generated by the second highest-option, and (iii) the search cost  $\kappa_j$ .

Recall that for loyal consumers who choose to gather extra quotes, the price reveals perfectly the value of  $V_{(2)} = \lambda E_{i,b_i} - P_i$ . To construct the likelihood we consider first the joint probability of three discrete outcomes:  $P_i < p, B_i = h_i, M_i = \mathbf{c}$ .

$$\begin{aligned} \Pr(P_i < p, B_i = h_i, M_i = \mathbf{c}) &= \int \Pr(P_i < p, B_i = h_i | M_i = \mathbf{c}, v_h) \Pr(M_i = \mathbf{c} | v_h) f(v_h; \xi_{h_i}, \sigma_u) dv_h \\ &= \int \Pr(\lambda E_{i,h_i} - p < \max_{j \neq h_i} V_j < v_h) \Pr(M_i = \mathbf{c} | v_h) f(v_h; \xi_{h_i}, \sigma_u) dv_h \\ &= \int_{\lambda E_{i,h_i} - p}^{\infty} [F_1(v_h; \mathcal{N}_i \setminus h_i) - F_1(\lambda E_{i,h_i} - p; \mathcal{N}_i \setminus h_i)] \bar{H} f(v_h; \xi_{h_i}, \sigma_u) dv_h, \end{aligned}$$

where  $F_1(v_h; \mathcal{N}_i \setminus h_i)$  is the CDF of the first-order statistics of surpluses excluding the winning banks  $h_i$ .

The likelihood contribution is obtained by differentiating the previous joint probability with respect to  $p$ , and evaluating it at the observed transaction price  $p_i$ :

$$l(p_i, B_i = h_i, M_i = \mathbf{c}) = \int_{\lambda E_{i,h_i} - p_i}^{\infty} f_1(\lambda E_{i,h_i} - p_i; \mathcal{N}_i \setminus h_i) \bar{H} f(v_h; \xi_{h_i}, \sigma_u) dv_h. \quad (16)$$

From equation 10, we know that the initial quote is linearly increasing in  $C_{i,h_i}$  if  $V_{i,h_i} < V_{(1)}$ , and linearly decreasing in  $V_{(2)}$  otherwise. Depending on the case, the transaction price of loyal consumers choosing the negotiation mechanism reveals  $V_{ih}$  or  $V_{(2)}$ . Moreover, in the first case the acceptance probability is a function of  $V_{(2)} - V_{ih}$ , while it is constant when the home bank offers the highest surplus. Using these two results from the model, we can write the conditional likelihood as the sum of two independent events:

$$\begin{aligned} l(p_i, B_i = h_i, M_i = \mathbf{n}) &= f_1(\lambda E_{i,h_i} + \sigma_\kappa - p_i; \mathcal{N}_i \setminus h_i) (1 - \bar{H}) [1 - F(\lambda E_{i,h_i} + \sigma_\kappa - p_i; \xi_{h_i}, \sigma_u)] + \\ &f(\lambda E_{i,h_i} + \sigma_\kappa - p_i; \xi_{h_i}, \sigma_u) \Pr(M_i = \mathbf{n} | V_{(1)} > \lambda E_{i,h_i} + \sigma_\kappa - p_i) [1 - F_1(\lambda E_{i,h_i} + \sigma_\kappa - p_i; \mathcal{N}_i \setminus h_i)]. \end{aligned} \quad (17)$$

The conditional acceptance probability included in the the second term of (17) is given by:

$$\begin{aligned} \Pr(M_i = \mathbf{n} | V_{(1|h_i)} > v_h) &= \left[ \int_{v_h}^{\infty} \exp\left(-\frac{1}{\sigma_\kappa}(v_{(2)} - v_h + \sigma_\kappa - \bar{\kappa})\right) f_2(v_{(2)} | \mathcal{N}_i \setminus h_i) dv_{(2)} \right. \\ &\left. + \bar{H} [F_2(v_h | \mathcal{N}_i \setminus h_i) - F_1(v_h | \mathcal{N}_i \setminus h_i)] \right] / (1 - F_1(v_h | \mathcal{N}_i \setminus h_i)). \end{aligned}$$

*Case 2: Switching consumers ( $B_i \neq h_i$ ).* The density of prices for switchers reflects the distribution of the second-highest surplus option since the bank  $b_i$  cannot be the outcome of the negotiation mechanism:  $p_i = -\max\{V_{h_i}, V_{(1)}\}$ , where  $V_{(1)} = \max_{j \neq b_i, h_i} V_j$  and  $E_{i,b_i} = 0$  (abusing notation slightly). Let  $\mathcal{N}_i \setminus (b_i, h_i)$  denote the choice-set excluding the home bank and the choice. Importantly  $V_{i,b_i}$ ,  $V_{i,h_i}$ , and  $V_{(1)}$  are three independent extreme-value random variables. We proceed as before by integrating out the value of  $V_{h_i}$ , and then integrating out the value of  $V_{(1)}$  (note: the

order of integration is different from the first to the second term):

$$\begin{aligned}
& \Pr(P_i < p, B_i = b_i, M_i = \mathbf{c}) \\
&= \int_{-p}^{\infty} \int_{-\infty}^{v_h} \Pr(V_{i,b_i} > v_h) \bar{H} f_1(v_{(1)}; \mathcal{N}_i \setminus (b_i, h_i)) f(v_h; \xi_{h_i}, \sigma_u) dv_{(1)} dv_h \\
&+ \int_{-p}^{\infty} \int_{-\infty}^{v_{(1)}} \Pr(V_{i,b_i} > v_{(1)}) H(v_h, v_{(1)}) f(v_h; \xi_{h_i}, \sigma_u) f_1(v_{(1)}; \mathcal{N} \setminus (b_i, h_i)) dv_h dv_{(1)} \\
&= \int_{-p}^{\infty} \Pr(V_{i,b_i} > v_h) \Pr(V_{(1)} < v_h) \bar{H}^c f(v_h; \xi_{h_i}, \sigma_u) dv_h \\
&+ \int_{-p}^{\infty} \Pr(V_{i,b_i} > v_{(1)}) \left[ \int_{-\infty}^{v_{(1)}} H(v_h, v_{(1)}) f_1(v_{(1)}; \mathcal{N}_i \setminus (b_i, h_i)) dv_h \right] f_1(v_{(1)}; \mathcal{N}_i \setminus (b_i, h_i)) dv_{(1)}.
\end{aligned}$$

Differentiating the previous expression with respect to  $p = p_i$  gives us the likelihood of switchers:

$$\begin{aligned}
L^s(p_i, B_i = b_i | \mathcal{I}_i, \beta) &= (1 - F(-p_i; \xi_{b_i}, \sigma_u)) \left[ f(-p_i; \xi_{h_i}, \sigma_u) F_1(-p_i; \mathcal{N}_i \setminus (h_i, b_i)) \bar{H} \right. \\
&\quad \left. + f_1(-p_i; \mathcal{N}_i \setminus (h_i, b_i)) \int_{-\infty}^{-p_i} \left( 1 - \exp\left(-\frac{1}{\sigma_i}(-p_i - v_h + \sigma_i - \bar{\kappa})\right) \right) f(v_h; \xi_{h_i}, \sigma_u) dv_h \right]. \tag{18}
\end{aligned}$$

*Integration of other unobservables.* The likelihood function is evaluated by integrating out three other unobservables:  $h_i$ ,  $E_i$  and  $\epsilon_i$ . The common lending profit shock  $\epsilon_i$  is distributed according to a normal distribution with common variance  $\sigma_\epsilon$ . We integrate it out using a quadrature approximation. The identity of the home bank, and the choice-set heterogeneity is then integrated out by summing the possible combinations.

The likelihood contribution of a contract  $i$  can therefore be written as:

$$L(b_i, p_i | Z_i, \beta) = \int \sum_{h, E} \Pr(h, E | X_i) \left( \begin{array}{l} 1(b_i = h) L^l(b_i, p_i | \mathcal{I}_i) \\ + 1(b_i \neq h_i) L^s(b_i, p_i | \mathcal{I}_i) \end{array} \right) \phi(\epsilon_i; \sigma_\epsilon) d\epsilon_i. \tag{19}$$

*Aggregate likelihood function.* The aggregate likelihood function sums over the  $n$  observed contracts, and incorporates additional external survey information on search effort. We use the results of the annual survey conducted by CAAMP and presented in Table 1 to match the aggregate probability of gathering more than one quote. More specifically, we augment the data with the extra aggregate moment that 54% of consumers gather more than one quote. On average around 1,000 consumers are surveyed each year.<sup>10</sup>

Using the model and the observed new-home buyers characteristics we calculate for each year the unconditional probability of rejecting the initial quote; integrating over  $V_{ih}$ ,  $\epsilon_i$  and the identity of the home bank. Let  $\bar{H}_t(\beta)$  denotes this function, and  $\hat{H}_t$  the survey estimate for year  $t$ . Since the number of observations used to calculate  $\hat{H}_t$  is large (i.e  $N_2 \approx 1,000$ ), we use the normal approximation to the binomial distribution to construct the likelihood from this second source of data.

<sup>10</sup>Recall that this statistic from the CAAMP refers only to first-time home buyers, while our data-set includes fraction of previous home owners. Therefore, when we match the model prediction with this aggregate statistic, we use only the new-home owners from our data-set.

That is:

$$L^2(\hat{H}_t|\beta) = \phi\left(N_2\hat{H}_t; N_2\bar{H}_t(\beta), N_2\bar{H}_t(\beta)(1 - \bar{H}_t(\beta))\right), \quad (20)$$

where  $\phi(y; \mu, \sigma)$  is the normal density with mean and variance  $\mu$  and  $\sigma$ .

The log-likelihood function combines both contract-level and aggregate information:

$$\mathcal{L}(\mathbf{Y}|\mathbf{Z}, \beta) = \sum_i \log L(b_i, p_i|Z_i, \beta) + \sum_t \log L^2(\hat{H}_t|\beta), \quad (21)$$

where  $(\mathbf{Y}, \mathbf{Z})$  denotes the vectors of observed outcomes and covariates.

**5.3. Identification.** The model includes four groups of parameters: (i) consumer observed heterogeneity (i.e.  $\gamma$ ), (ii) unobserved cost heterogeneity (i.e.  $\sigma_u$  and  $\sigma_\epsilon$ ), (iii) search cost ( $\bar{\kappa}$  and  $\sigma_\kappa$ ), and (iv) switching cost ( $\lambda$ ).

Although we estimate the model by maximum likelihood, it is useful to consider the empirical moments contained in the data. The contract data include information on market share, and conditional price distributions. For instance, we can measure the reduced-form relationship between average prices and number of lenders in consumers' choice-sets, or other borrower-specific attributes. Similarly, we measure the fraction of switchers, along with the premium that loyal consumers pay above switchers. Finally, we augment the contract data with the aggregate fraction of consumers who gather more than one quote.

Intuitively, the cost parameters can be identified from the sample of switching consumers. Under the timing assumption of the model, most switchers are consumers who reject the initial quote, and set-up the Bertrand game. The transaction price therefore reflects the second-order statistic of the value distribution. This conditional price distribution can therefore be used to identify the contribution of observed consumer characteristics.

The residual dispersion can be explained by  $u$  or  $\epsilon$  (i.e. common versus idiosyncratic). To differentiate between the two, we exploit variation in the size of consumers' choice-sets. Indeed, the number of lenders directly affects the distribution of the second-order statistic through the value of  $\sigma_u$ . The "steepness" of the reduced-form relationship between transaction rates and number of lenders therefore identifies the relative importance of  $\sigma_u$  and  $\sigma_\epsilon$ .

The data exhibits three sources of variation in the choice-set of consumers. First, consumers living in urban areas tend to face a richer choice-set than consumers living in small cities. Second, nearly 50% of consumers were directly affected by the merger between Canada Trust and Toronto Dominion Bank in 2000, and effectively lost one lender. The third source of variation comes from differences in the shape of the branch distribution across markets. Indeed, we estimate a specification in which a fraction  $\mu$  of consumers only consider "dominant" lenders, with a cumulate branch share greater than 75%. In this specification, the model has two parameters to explain the relationship between the structure of local markets and the distribution of prices.

The three remaining parameters are identified from differences in the price distribution across switching and loyal consumers, as well as from the relative fraction of switchers and searchers. Intuitively the task is to tell the difference between two competing interpretations for the observed consumer loyalty: high switching cost (or home-bank premium), and/or high search cost.

Using the model specification, we know that the equilibrium search probability is a function of the ratio  $\frac{\sigma_{\kappa} - \bar{\kappa}}{\sigma_{\kappa}}$  (see equation 11). The observed aggregate fraction of consumers gathering more than one quote therefore pins down the ratio of the two search cost parameters. The level of the private information component and the home-bank premium are separately identified from the observed price difference between loyal and switching consumers, and the fraction of switchers. Indeed, we observe that 54% of consumers search in the population, and more than 70% of consumers remain loyal. The difference between those two fractions suggests a sizeable home-bank premium. Finally, the model specification imposes strong restrictions on the relationship between loan size, and the probability of searching and switching. The value of shopping is increasing in the loan size, but the home bank premium and the search cost are invariant to  $L_i$ . Therefore, the model implies that consumers financing larger loans are more likely to incur the sunk shopping cost.

## 6. ESTIMATION RESULTS

**6.1. Reduced form relationships.** Before introducing the estimates of the structural model we first provide empirical evidence describing the reduced-form relationships discussed in section 5.3. Specifically, we want to quantify the relationship between interest rates and market structure, switching behavior, and financial factors, and measure the importance of unobserved heterogeneity. Allen, Clark, and Houde (2011) provide a detailed description of mortgage discounting in Canada. Here we focus on a substantially smaller set of contracts, and the results are similar.

Columns (1) and (2) in Table 6 present the results of linear regressions of transaction margins, measured by subtracting the 5 year bond rate from the transaction interest rate, on financial and demographic characteristics of borrowers, as well as market structure controls. The relationships between the financial characteristics of consumers and retail margins are mostly consistent. We interpret these as showing that low risk and wealthy consumers represent lower lending costs, and therefore tend to pay lower rates on average. The loan sizes and credit scores of consumers are particularly strong predictors of the observed transaction interest rates. Similarly, financially constrained consumers pay on average a premium equal to 14 basis points. Notice also that the marginal effect of income is positive and statistically different from zero for most observed contracts, except for richer households with relatively small loans. Therefore, conditional on loan size, richer households tend to pay more.

Although we do not take a stand on the specific channel that explains these relationships in the cost function of banks, it is reasonable that standard risk factors are correlated with transaction rates, even in a setting in which lenders are fully insured. On the one hand, lenders can incur transaction costs in the event of default, therefore lowering the expected revenue from risky borrowers. On the other hand, most of these characteristics are also associated with the expected revenues generated from complementary services offered by banks, including other loans and saving accounts. For instance, the income effect result is consistent with the fact that richer households are more likely to pre-pay their mortgage, which reduces the expected revenue for lenders.

TABLE 6. Margin and switching probability regression results

VARIABLES	(1) Margin	(2) Margin	(3) Switcher	(4) Switcher
Annual income (X 100K)	-0.277 <sup>a</sup> (0.043)	-0.282 <sup>a</sup> (0.043)	0.087 <sup>a</sup> (0.033)	0.088 <sup>a</sup> (0.033)
Loan size (X 100K)	0.084 <sup>a</sup> (0.022)	0.088 <sup>a</sup> (0.022)	-0.054 <sup>a</sup> (0.016)	-0.054 <sup>a</sup> (0.016)
Loan/Income	-0.220 <sup>a</sup> (0.015)	-0.222 <sup>a</sup> (0.015)	0.051 <sup>a</sup> (0.012)	0.051 <sup>a</sup> (0.012)
<i>LTV</i> = 0.95	0.141 <sup>a</sup> (0.011)	0.140 <sup>a</sup> (0.011)	0.027 <sup>a</sup> (0.008)	0.027 <sup>a</sup> (0.008)
CREDIT (mid-point)	-0.763 <sup>a</sup> (0.042)	-0.764 <sup>a</sup> (0.042)	-0.124 <sup>a</sup> (0.031)	-0.125 <sup>a</sup> (0.031)
Switcher	-0.090 <sup>a</sup> (0.010)	-0.089 <sup>a</sup> (0.010)		
Renter	-0.013 (0.008)	-0.013 (0.008)	0.080 <sup>a</sup> (0.006)	0.080 <sup>a</sup> (0.006)
Living w/ parents	-0.052 <sup>a</sup> (0.013)	-0.052 <sup>a</sup> (0.013)	0.040 <sup>a</sup> (0.008)	0.039 <sup>a</sup> (0.008)
Relative network	0.025 <sup>a</sup> (0.005)	0.033 <sup>a</sup> (0.005)	-0.009 <sup>a</sup> (0.003)	-0.012 <sup>a</sup> (0.003)
Concentration level (C1)	0.277 <sup>a</sup> (0.051)		0.023 (0.041)	
Nb. FIs > 7		-0.045 <sup>a</sup> (0.009)		0.033 <sup>a</sup> (0.007)
Observations	29,279	29,279	24,015	24,015
R-squared	0.405	0.405	0.286	0.287
Period	99-01	99-01	99-01	99-01

Some of these reduced-form relationships are also captured in the model through the search decision. Consumers financing larger loans, for example, are more likely to search (and pay lower rates), since the sunk cost is invariant to the level of monthly payment. Although it in the model, it is also conceivable that richer households have a higher value of time, and therefore higher search costs on average. These two interpretations are also consistent with the fact that the marginal effect of loan size on the switching probability is positive, while the marginal effect of income is negative for most observed contracts (see columns 3 and 4). While we do not observe searches in the data, switching decisions are correlated with searching decisions in the model.

The coefficient associated with the “switcher” dummy variable implies that loyal consumers pay on average nearly 9 basis points above the rate paid by switchers. Similarly, consumers dealing with large-network institutions pay more on average for their mortgage. These relationships are captured in the model by the search cost and home-bank premium.

Finally, we control for two measures of the structure of local markets surrounding each consumer: a dummy equal to one when the number of lenders is greater than seven, and the branch

share of the largest lender (C1). Both measures suggest that more competitive local markets are associated with lower rates. We included these measures, instead of the number of lenders for instance, because the relationship is non-linear. The presence of dominant banks matters more than just the number of firms. This suggest that our specification with heterogeneous choice-sets will fit the data better than the specification with homogeneous choice-sets.

Finally, we point out that the R-square of the margin regressions is around 0.4 indicating that even after controlling for a wide range of financial, demographic, and market characteristics, there is still a significant amount of unexplained variation in margins.

**6.2. Preference parameter estimates.** Table 7 presents the maximum likelihood estimates for the key parameters of the model. To reduce the computational burden, the model is estimated on a random sample of 3,000 observations. We do not report the parameter estimates for the cost function (i.e.  $\gamma$ ), which includes financial characteristics, bank fixed-effects, and year/region fixed-effects. The baseline specification includes 39 parameters. The price coefficient is normalized to one and monthly payments are measured in hundreds of dollars. The scale of the parameters translates into \$100 of monthly expenses for the life of the contract (i.e. 5 years).

We report the results of four specifications. The first column corresponds to our baseline specification: the choice-sets are a deterministic function of the location of individuals, and consumers have a homogenous valuation for their home bank (i.e.  $\lambda$ ). Columns (2) and (3) relax these assumptions, first introducing a fraction  $\mu$  of consumers facing a smaller choice-set (i.e. only dominant lenders), and then allowing a fraction of consumers,  $(1 - \eta)$ , to have zero home-bank premium. The last column combines both sources of unobserved heterogeneity.

TABLE 7. Maximum likelihood estimation results

	(1)	(2)	(3)	(4)
Common shock: $\sigma_\epsilon$	0.311 (0.0015)	0.312 (0.0016)	0.311 (0.0018)	0.309 (0.0018)
Idiosyncratic shock: $\sigma_u$	0.0795 (0.0012)	0.0819 (0.0017)	0.0671 (0.0011)	0.0624 (0.0011)
Idiosyncratic search cost: $\sigma_\kappa - \bar{\kappa}$	0.0708 (0.0026)	0.0669 (0.0043)	0.145 (0.0037)	0.127 (0.0037)
Baseline search cost: $\bar{\kappa}$	0.0602 (0.0023)	0.0574 (0.0048)	0.0733 (0.0018)	0.0633 (0.0018)
Home premium: $\lambda$	0.138 (0.0034)	0.123 (0.0099)	0.294 (0.01)	0.278 (0.01)
Fraction with small CS: $\mu$	0	0.373 (0.0032)	0	0.284 (0.0032)
Fraction with $\lambda > 0$ : $\eta$	1	1	0.728 (0.11)	0.72 (0.11)
N	3000	3000	3000	3000
LLF/N	-1.9238	-1.9095	-1.8848	-1.8832

The two parameters entering the search cost distribution suggest that search frictions are economically important, and fairly stable across specifications. The baseline cost is equal to \$6.02, and the average is \$19.1 per month (i.e.  $E(\kappa_i) = \bar{\kappa} + \sigma_{\kappa} = 0.191$ ). The search cost estimate, especially the private value component, tends to be larger when we introduce additional sources of unobserved heterogeneity. The largest estimate, in specification (3), corresponds to an average search cost of \$29 per month. The estimates also imply an important amount of dispersion. In the baseline specification, the median search cost is equal to \$15, and the inter-quantile range is \$14.38.

According to the model, the marginal consumer accepting the initial quote is indifferent between searching and reducing his monthly payment by  $\$ \kappa_i$ , or accepting  $p^0$ . Over a five year period, with a discount factor equal to 0.96, these estimates correspond to an average upfront sunk cost of between \$1,047 and \$1,590.<sup>11</sup>

Are these number realistic? Allen, Clark, and Houde (2011) document that the average discount that a mortgage broker can derive for a borrower is about 20 basis points, or approximately \$16 per month on a \$140,000 loan. These savings correspond to the median search cost in specifications (1) and (2), and the 25th-percentile in specifications (3) and (4). The magnitude of our search-cost estimate therefore matches fairly well with an interpretation of the role of mortgage brokers as an intermediary whose objective is to reduce consumer search cost.

In addition, Hall and Woodward (2010) calculate that a U.S. home buyer could save an average of \$900 on origination fees by requesting quotes from two brokers rather than one (unlike in Canada, in the U.S. brokers act like financial institutions in that they can originate loans and do not have fiduciary duties). Our estimate of the search cost is consistent with this estimate.

Depending on the specification, the home bank premium estimates ranges from \$13.80 to \$29.40. This is the amount consumers are willing to pay every month to combine their mortgage with their day-to-day banking service provider. Over five years, this corresponds to an upfront cost of between \$759 and \$1,617. Assuming that this utility gain originates from avoiding the cost of switching bank affiliations, our results suggest that switching costs are large, and of a similar order of magnitude to the cost of gathering multiple quotes. Adding heterogeneity in the value of the home bank nearly doubles the switching cost estimate. We estimate that 72% of consumers have a positive home bias.

The remaining parameters associated with the firms' profit function suggest that firms are more or less symmetric when it comes to the cost of lending. Most of the unobserved heterogeneity between consumers is common across firms, since the variance of the unobserved match value (i.e.  $\sigma_u$ ) is four times smaller than the common shock (i.e.  $\sigma_{\epsilon}$ ). Using our lending cost estimates, we can decompose the total variance into four components: (i) idiosyncratic shock (i.e.  $L_i \times u_{ij}$ ), (ii) fixed differences across lenders (i.e.  $L_i \times \bar{c}_j$  or fixed-effect), (iii) unobserved consumer heterogeneity (i.e.  $L_i \times \epsilon_i$ ). The standard-deviation in lending cost across consumers, including the contribution of financial characteristics, is equal to \$390. Fixed differences across lenders account for a small

<sup>11</sup>The search cost is measured in terms of monthly payment units. Since the contract is written over a 60 month period, the discounted value of the search cost is equal to  $\sum_{t=0}^{60} \frac{\kappa_i}{(1+r)^{60}}$ . With an annual discount factor of 0.96 the monthly interest rate is 0.3%.

fraction of this dispersion: \$8.37. The standard-deviation of the idiosyncratic match values is equal \$14.10, and the standard-deviation of the common component is equal to \$77.03. Cost differences across banks, observed and unobserved, therefore account for a small fraction of the total variance in lending cost.

This decomposition has important implications for competition. Abstracting from loyalty issues, the average difference between the first and second highest surplus is close to zero in the average market with six lenders. Moreover, our bank fixed-effect estimates imply very little systematic differences across lenders. As a result, the market for “non-loyal” consumers is very competitive: banks are nearly homogeneous and have similar cost structures, which leads to a Bertrand-type equilibrium.

This is not to say that every consumer is benefiting from this favorable structure. The number of available lenders varies greatly across consumers, and we estimate that about 30% of consumers only consider dominant lenders in their choice-set. For these consumers the average number of lender drops to three, which can significantly increase the profit margin of banks.

**6.3. Market power and efficiency.** Overall, our results suggest that search costs and consumer loyalty are the two main sources of market power in the Canadian mortgage market. Absent these factors, the model would predict a nearly competitive market, especially for consumers in neighborhoods with a larger number potential lenders. Lenders with a large consumer base have substantial control over prices because they receive a larger fraction of “first-visits”. This allows them to exploit consumer search costs and serve a larger proportion of non-searchers. The second source of market power originates from brand loyalty or switching costs, and implies that, even conditional on facing competition, a home bank is more likely to retain consumers.

In this section, we use the parameter estimates from specification (4) in Table 7 to measure the implied lender profit margins, and infer the importance of search cost frictions in distorting the allocation of contracts. Recall that this specification includes two sources of consumer heterogeneity not in the baseline specification: (i) a fraction of consumers ( $\hat{\mu} = 28.4\%$ ) facing a restricted consideration set, and (ii) a fraction of consumers ( $1 - \hat{\eta} = 28\%$ ) with zero switching costs. This allows us to contrast profits among different groups of consumers facing different levels of competition. This is because, on average, consumers with zero switching costs and a full choice-set benefit the most from competition, while consumers with positive switching costs and restricted choice-sets benefit the least.

Recall that a lender’s profits from a transaction are given by the realized transaction price (i.e. monthly payment), and its cost:

$$\pi_{ij} = P_i - L_i \times (Z_{ij}\gamma + \epsilon_i - u_{ij}). \quad (22)$$

We calculate this profit level for a transaction between borrower  $i$  and lender  $j$  by simulating the random shocks which determine the outcome: (i) the common shock  $\epsilon_i$ , (ii) the idiosyncratic match value  $u_{ij}$  for each  $j \in \mathcal{N}_i$ , (iii) the identity of the home bank  $E_{ij}$ , and (iv) the search cost value  $\kappa_j$ . The first three shocks determine the transaction surpluses for each lender in  $\mathcal{N}_i$ , which in turn identify the first and second best options and the value of the competitive price (i.e. outside option

$W_i$ ). The search-cost realization determines whether or not the consumer pays the competitive price, or the initial quote. We also sample a consumer's type from two binomial distributions: (i) full or restricted choice-set, (ii) zero or positive switching cost.

Conditional on a choice-set, the competitive profit level is determined by the switching cost parameter and the cost difference between the bank with the highest surplus offer and the bank with the second highest surplus offer. The level of the switching cost raises the profits of the home bank, and decreases the profits of competing lenders. This is because loyal consumers who gather multiple quotes pay a premium proportional to their switching cost, while "switching" consumers are compensated for not remaining loyal:

$$\pi_i^c = \begin{cases} \lambda + C_{(2)} - C_{i,h_i} & \text{If } V_{i,h_i} = V_{(1)}, \\ -\lambda + C_{i,h_i} - C_{(1)} & \text{If } V_{i,h_i} = V_{(2)}, \\ C_{(2)} - C_{(1)} & \text{Otherwise.} \end{cases} \quad (23)$$

The profit function is written in terms of costs rather than surpluses since for every lender other than the home bank the ranking of that lender depends on its cost ranking. Expression (23) therefore highlights the importance of the cost differences between lenders: the deterministic component (i.e. bank fixed-effects), and the idiosyncratic match values ( $u_{ij}$ ). The latter is driven by the size of consumers' choice-sets, and the variance of match values (i.e.  $\sigma_u$ ).

Non-competitive transactions are generated by consumers accepting the initial quote (see equation 10). If the home bank offers the "best-match", the transaction profit is increasing in the average private-value search cost of consumers (i.e.  $\sigma_\kappa$ ), and in the cost difference relative to the next-best alternative. Otherwise, when consumers are initially matched with a low-ranked home bank, the transaction profit margin is constant and equal to  $\sigma_\kappa$ . Therefore, unlike in the competitive case, the profits from non-search transactions are bounded below by the search-cost parameter.

$$\pi_i^n = \begin{cases} \sigma_\kappa + \lambda + C_{(2)} - C_{i,h_i} & \text{If } V_{i,h_i} = V_{(1)}, \\ \sigma_\kappa & \text{Otherwise.} \end{cases} \quad (24)$$

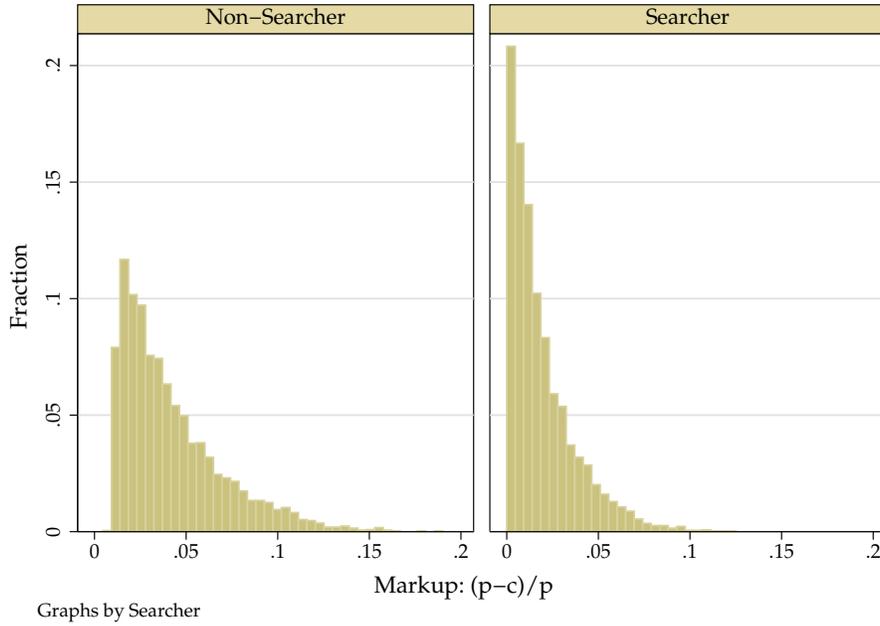
Table 8 presents summary statistics on profit margins and other transaction characteristics, for a simulated sample of consumers. We measure market power using monthly profit margins, and the implied markups. Notice that, on average, searchers incur larger monthly payments than non-searchers despite the fact that profit margins on searchers are smaller. These differences are due to the fact that consumers financing larger loans are more likely to search (see column 5). Not surprisingly, we estimate that the market is very competitive, since lenders exhibit little heterogeneity in costs. This is especially true for consumers choosing to gather multiple quotes. The unconditional average markup is equal to 3%, the average among searchers is 2%, and the average among non-searchers is 4%.

Although markups are on average small, there is substantial dispersion, especially among competitive transactions. Figure 5 illustrates the distribution of markups for searchers and non-searchers. Since the idiosyncratic match value shock is small, we estimate that nearly 25% of searchers receive a quote that is very close to the perfectly competitive level. The distribution is

TABLE 8. Summary statistics on the distribution of profit margins and transaction characteristics

Statistics	Payment \$/month	Profit \$/month	Markup $(p - c)/p$	Loan \$ × 1000	Switch	Highest surplus
<b>Non-Searchers</b>						
Mean	966	32	.041	135	0	.67
Std-dev	378	14	.027	55	0	.47
$p_{10}$	517	19	.015	69	0	0
$p_{90}$	1504	51	.08	213	0	1
<b>Searchers</b>						
Mean	975	16	.019	140	.45	1
Std-dev	388	14	.018	56	.5	0
$p_{10}$	512	2	.0021	72	0	1
$p_{90}$	1541	33	.044	222	1	1

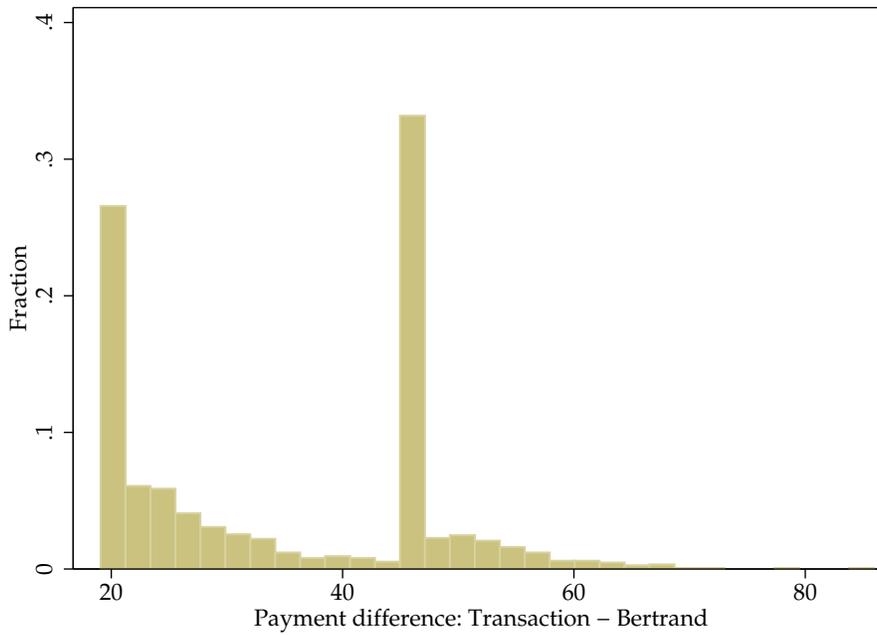
FIGURE 5. Distribution of markups for searchers and non-searchers



highly skewed, with nearly 10% of competitive transactions generating more than 5% markups (up to 14%). The markup distribution among non-competitive transactions is also skewed, but is less concentrated around the lowest profit level.

Within the non-competitive markup distribution, transactions associated with constant profits are associated with “inefficient” matches, since the transaction surplus is lower than the higher surplus option (i.e.  $V_{(1)} > V_{i,h}$ ). In Table 8 we estimate that 67% of non-searcher transactions are efficient. Therefore, the search-cost friction implies that 33% of non-searcher transactions are misallocated, or 17% of all transactions. This proportion is relatively small, compared to the number

FIGURE 6. Distribution of payment differences relative to competitive prices for inefficient matches



of lenders in consumers’ choice-sets (i.e. six on average). The presence of a large switching cost raises significantly the probability that the home bank is ranked first in the surplus distribution, which greatly reduces the number of inefficient transactions. In this sense, the timing of the model is optimal for consumers with positive home-bank bias.

Figure 6 illustrates the distribution of payment differences between each simulated transaction price, and the counter-factual competitive quote for inefficient matches. The difference is bounded below by the average search cost, and exhibits two modes. The first mode corresponds to consumers who do not incur switching costs (i.e. either consumers with no home-bank in their neighborhood, or more likely consumers with zero home-bank premium), and the second to consumers who have positive switching costs and therefore must incur a much higher payment differential. The low density beyond these two points is a reflection of the low dispersion in  $u$ ’s across lenders, and the fact that among inefficient matches, the home bank is most likely to be ranked second (i.e. the winning bank would have to compensated consumers for switching).

## 7. CONCLUSION

Although mortgage markets have recently been under great scrutiny, researchers have largely ignored the degree of competition among lenders in their analysis. However, knowing the extent of market power is crucial for evaluating policies designed to regulate mortgage markets. These include antitrust policies regarding the approval of bank mergers, restrictions on the compensation of financial intermediaries, regulations constraining the scope of bank activities, and

policies affecting banks' costs of funding such as those targeting capital or securitization. Moreover, the degree of market power can also affect the transmission mechanism of monetary policy and the effectiveness of macro-prudential tools such as mortgage insurance guidelines and/or down-payment requirements.

Our analysis suggests that much of the market power in the mortgage market stems from consumer's search and switching costs. Policies designed to increase competition, such as restrictions on merger activity, may therefore be ineffective for those consumers unwilling to search or unable to negotiate. Instead, policies designed to increase information about the market, contracts, or the availability of different lenders would be beneficial to consumers. Similarly, policies that encourage consumers to consider lenders other than their main financial institutions would reduce overall market power.

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TABLE 9. Definition of Household / Mortgage Characteristics

Name	Description
FI	Type of lender
Source	Identifies how lender generated the loan (branch, online, broker, etc)
Income	Total amount of the borrower(s) salary, wages, and income from other sources
TSD	Ratio of total debt service to income
Duration	Length of the relationship between the borrower and FI
R-status	Borrowers residential status upon insurance application
FSA	Forward sortation area of the mortgaged property
Market value	Selling price or estimated market price if refinancing
Applicant type	Quartile of the borrowers risk of default
Dwelling type	10 options that define the physical structure
Close	Closing date of purchase or date of refinance
Loan amount	Dollar amount of the loan excluding the loan insurance premium
Premium	Loan insurance premium
Purpose	Purpose of the loan (purchase, port, refinance, etc.)
LTV	Loan amount divided by lending value
Price	Interest rate of the mortgage
Term	Represents the term over which the interest rate applies to the loan
Amortization	Represents the period the loan will be paid off
Interest type	Fixed or adjustable rate
<i>CREDIT</i>	Summarized application credit score (minimum borrower credit score).

Some variables were only included by one of the mortgage insurers.