Market Structure and the Diffusion of Electronic Banking*

Jason Allen
Bank of Canada

Robert Clark
HEC Montréal

Jean-François Houde
University of Wisconsin-Madison

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Abstract

This paper studies the role that market structure plays in affecting the diffusion of electronic banking. Electronic banking (and electronic commerce more generally) reduces the cost of performing many types of transactions for firms. The full benefits for firms from adoption, however, only accrue once consumers begin to perform a significant share of their transactions online. Since there are learning costs to adopting the new technology firms may try to encourage consumers to go online by affecting the relative quality of the online and offline options. Their ability to do so is a function of market structure. In more competitive markets, reducing the relative attractiveness of the offline option involves the risk of losing customers (or potential customers) to competitors, whereas, this is less of a concern for a more dominant firm. We develop a model of branch-service quality choice with switching costs meant to characterize the trade-off banks face when rationalizing their network between technology penetration and business stealing. The model is solved numerically and we show that the incentive to lower branch-service quality and drive consumers into electronic banking is greater in more concentrated markets and for more dominant banks. We find support for the predictions of the model using a panel of household survey data on electronic payment usage as well as branch location data, which we use to construct measures of branch quality.

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*Correspondence to Jean-François Houde: University of Wisconsin-Madison, Madison, Wisconsin and CIRANO; Phone: (608) 262-3805; Email: houdejf@ssc.wisc.edu, Robert Clark: HEC Montréal, CIRANO and CIRPÉE, Montreal, Quebec; Phone: (514) 340-7034; Email: robert.clark@hec.ca, and Jason Allen: Bank of Canada, Ottawa, Ontario; Phone (613) 782-8712; Email: jallen@bankofcanada.ca. Robert Clark thanks the FQRSC and HEC Montréal for funding. We thank Micromedia Proquest, Peter Kascor and Credit Union Central of Canada, and Marion Wrobel and the Canadian Bankers Association for their help on branch locations. We thank Victor Aguirregabiria, Avi Goldfarb, Gautam Gowrisankaran, Kim Huynh, and Teodora Paligorova for comments and suggestions as well as seminar participants at the Bank of Canada, Competition Bureau, FTC, HEC Montréal, IIOC (Washington) and The Economics of ICT conference (Paris). We thank Thomas Carter for excellent research assistance. The views in this paper are those of the authors and do not necessarily reflect those of the Bank of Canada. All errors are our own.

1 Introduction

This paper studies the diffusion of a new cost-reducing technology. As the final stage of the research and development process, the diffusion of new technologies represents an important contribution to productivity growth. We are particularly interested in the role that market structure plays in affecting this diffusion. Our focus is on the retail banking industry and on the diffusion of electronic banking (e-banking). E-banking represents a cost-reducing technology since for many types of day-to-day transactions it is cheaper for banks if consumers perform them online.[1] Understanding the effect of market structure on diffusion is important since in retail banking markets throughout the world there has been considerable consolidation in recent decades.

The relationship between market concentration and the diffusion of a new process innovation (a technology that reduces the cost of production) has been studied extensively.[2] The focus of this literature is on the trade-off that firms face between the incentive to delay adoption, since the cost of adoption is expected to fall over time, and the incentive to adopt early in order to prevent or delay adoption by competitors in the case of strategic rivalry. The evidence is somewhat mixed, but generally competition is found to speed up diffusion since it gives rise to a preemptive technology adoption motive. In the literature it is assumed that once firms adopt the new technology, any increase in returns is immediately realized. There are instances, however, where the realization of the full benefits from the introduction of a new technology depends on the extent to which consumers use it rather than the old technology. In the day-to-day banking market, despite the fact that banks have adopted electronic payment mechanisms, their full benefits can be realized only if consumers decide to perform transactions electronically rather than at traditional bricks-and-mortar branches. This is true in general for innovations in electronic commerce.[3]

The fact that diffusion is consumer-driven potentially implies a different role for market structure in affecting firm incentives and the resulting diffusion of new technologies such as e-commerce. In

[1] For instance, using internal data from 20 of the top U.S. banks, Boston Consulting Group (2003) concludes that banks could double profits if customers switched from offline to online bill payment. Also, DeYoung, Lang, and Nolle (2007) report a positive correlation between community bank profitability and early adoption of an operational website.

[2] See Reinganum (1981a), Reinganum (1981b), and Fudenberg and Tirole (1985) for theoretical analyzes of the effect of market concentration on the speed of adoption. Kamien and Schwartz (1982) survey the early empirical work looking at this relationship. See Forman and Goldfarb (2006) for a review of the literature on the adoption and diffusion of information and communication technologies. See also early work by Levin, Levin, and Meisel (1987), Hannan and McDowell (1984), and Karshenas and Stoneman (1993). More recently this question has been studied by Hamilton and McManus (2005), Schmidt-Dengler (2006), Gowrisankaran and Stavins (2004) (for technologies featuring network externalities), and Seim and Viard (2006).

[3] Another example is self-serve kiosks at airports and grocery stores. Airlines/grocery stores may invest in the installation of electronic kiosks, but the benefits from adoption are only realized once consumers start checking in/checking out electronically.

markets where firms operate both online and offline channels they may have an incentive to affect the relative attractiveness of the two channels in order to encourage consumers to adopt the less costly one. Whether or not firms are able to engage in this type of behavior depends on local market structure.

To our knowledge, this role has not been studied. There has, however, been some work examining the effect that the diffusion of e-commerce has on market structure. For instance, Emre, Hortaçsu, and Syverson (2006) look at the effect of the introduction of e-commerce on market reorganization in a number of industries. They find that in the auto dealer and book store industries small stores exited local markets where the use of e-commerce channels grew fastest. However, the underlying assumption in their analysis is that the diffusion of e-commerce is an exogenous process. This may not be an appropriate assumption in markets where firms operate both online and offline channels. In such markets firms may have an incentive to adjust the relative price or quality of the two channels. Evidence suggests that offline price and the local availability of offline outlets can affect the use of electronic commerce by consumers (see Goolsbee (2000), Ellison and Ellison (2006), and Prince (2007)). Therefore banks may try to encourage consumers to switch to the new technology by adjusting the relative prices of online and offline banking and/or by reorganizing their retail networks. The latter approach was apparently adopted by several Scandinavian banks (The Economist, June 14th 2007).

A firm's ability to employ these strategies depends on the level of competition in the local market. There is evidence that local competition plays a role in affecting banks' reorganization decisions. For instance, Cohen and Mazzeo (2007) analyze the effect of market structure on branching decisions and find that branch networks are larger in more competitive markets.[4] Therefore, reducing the attractiveness of traditional retail stores by closing branches involves a greater risk of losing customers (or potential customers) when the local market is more competitive. In the case of e-banking, instead of the preemptive technology adoption motive, increased competition generates a business stealing effect, which slows the penetration of the cost-reducing technology.

We develop a dynamic model of branch-quality competition that characterizes the tradeoff banks face between (i) making branch banking relatively less attractive to encourage consumers to switch to electronic banking – we refer to this as the *technology penetration* incentive –, and (ii) maintaining quality for fear of losing consumers to rivals – we refer to this as the *business stealing* incentive. The model generates testable predictions about the effect of competition on the usage/adoption

[4]This relationship between market structure and quality has been documented in other industries as well. Mazzeo (2003) finds that more competitive airline routes feature better on-time performance. Hoxby (2000) finds that metropolitan areas with more school districts have higher quality public schools (greater student achievement levels).

of electronic banking. We find that competition tends to increase the quality of branch networks offered by banks and therefore decreases the usage rate of electronic transactions. This prediction is in contrast to that found in the literature that has examined the relationship between market concentration and the diffusion of a new process innovation. As mentioned above, the traditional view is that adoption is typically faster in more competitive markets since competition encourages a preemptive technology adoption motive.

Our empirical analysis focuses on the Canadian retail banking industry. The Canadian industry features a small number of large banks that traditionally provided an extensive network of branches for their clients. E-banking was introduced was widely introduced by 1998, offering consumers an opportunity to conduct most of their day-to-day banking activities online. To study the substitution between online and offline banking channels and the role that branch quality and market structure play in affecting this substitution we combine two unique data sets. The "Canadian Financial Monitor" (Ipsos-Reid) contains information on the usage of different banking channels in the period (1999-2006) immediately following the introduction of online banking in Canada, along with detailed information on the demographic characteristics of respondents. To measure the quality of the branch network we use location data from the "Financial Services Canada" directory (Micromedia Proquest). The directory provides information on branch locations in all local markets for all of the years in our sample as well as years prior to the introduction of electronic banking. With this information we construct measures of branch density to reflect the quality of the offline option since there is convincing evidence that consumers care strongly about the extent of a bank's network of branches (Kiser (2004), Cohen and Mazzeo (2007) and Grzelonska (2005)).[5]

Our empirical work supports the prediction that banks can rationalize their networks in order to encourage adoption and that it is easier to do so in less competitive markets and for more dominant banks. We first show that online banking diffusion is strongly correlated with market structure. Having shown this, we then show that initial market structure affects the change in the average number of branches in a market. In more concentrated markets and in markets with more dominant banks there are more branch closures. We then provide evidence that closures led to an increase in e-banking along both the extensive and intensive margins by performing a household-level analysis. That is, we consider the effect of changes in branch density in a household's local neighborhood on

[5]We could also look at operating hours or number of tellers. However, number of branches affects wait times and travel distances while these other quality measures affect only wait times.

Relative prices could also have an effect in some banking markets, but not at the local market level since the Canadian retail banking industry features a small number of very large national institutions that dominate most local markets. Although day-to-day banking is done locally, posted banking fees of each individual bank are standardized across regions.

their usage and adoption of e-banking. We show that branch closures cause increased usage and adoption. We conclude, therefore, that initial market structure and branch network reorganization have an effect on e-banking usage.

The paper proceeds as follows. Section 2 provides a condensed overview of the Canadian banking industry. Section 3 presents a model of quality competition with switching costs. Section 4 presents our empirical analysis. Section 5 concludes.

2 The Canadian banking market

The Canadian retail banking industry features a small number of very large federally regulated national institutions that dominate most local markets.[6] The industry is best described as stable (Bordo 1995) with almost no exit, and little entry, at least on the retail side of banking.[7] The major banks provide similar products and services and are not dis-similar in terms of standard measures of productivity and efficiency (Allen and Engert 2007). There has been one substantial merger during our sample period. In 2000 TD Bank and Canada Trust merged to become TD Bank Financial Group. We control for this merger in our empirical analysis.

The industry is characterized by several key facts: (i) 85 per cent of banking assets are held by the five largest banks; (ii) at least one of these banks operates in 98 per cent of the census divisions, and at least two in 81 per cent;[8] (iii) the remainder of the Canadian banking industry is characterized by a large number of small banks, both foreign and domestically owned, as well as provincially regulated credit unions;[9] and (iv) there is considerable variation in the level of competition in the census divisions. A Figure of the Herfindahl-Hirschman indices (HHI) averaged across census divisions and smoothed using a kernel estimator is presented in the appendix for 1998.[10] There is a large mass slightly over 2000 as well as a substantial mass beyond that, indicating a high degree of concentration in some markets.

[6] These banks are Royal Bank Financial Group, Bank of Montreal, Canadian Imperial Bank of Commerce, TD Bank Financial Group, and Bank of Nova Scotia.

[7] There has been a large inflow of foreign banks into the Canadian market but mostly on the corporate side of banking. A few foreign banks have made inroads in the retail market, most notably ING Canada, a virtual bank.

[8] There are 288 census divisions in Canada.

[9] Some credit unions have a strong presence in a particular set of local markets and are therefore important to include in our analysis. Examples include Caisse Desjardins (Quebec), ATB Financial (Alberta), and Vancity (British Columbia).

[10] We define the HHI of a market j as the sum of market shares squared, where the market share of bank i, for example, is the fraction of branches owned by bank i in market j. In many U.S. studies of banking, deposits at the branch level are usually taken us the measure of market share. Given data restrictions we can only tabulate total deposits for each bank at the provincial level. As one would expect, however, the number of branches controlled by a bank in a province and the value of deposits by that bank are highly correlated, with a correlation coefficient of 0.9.

Over the past decade, the largest Canadian banks have profoundly changed their way of offering retail banking services. Between 1998 and 2006 the top eight Canadian banks have on average reduced the number of retail branches they operate by 20 per cent, despite a 37 per cent increase in deposits.In contrast to the rationalization of branches found from 1998 to 2006, in the period 1982-1997 the top six Canadian banks closed only 2.3% of their branches.[11] This suggests that the pre-electronic banking period was characterized by a relatively stable steady-state level of branches. From 1998 to 2006 Canadians quickly became some of the world's heaviest users of electronic payments. The number of transactions performed electronically increased from 47 million per year to more than 300 million from 2000 to 2006, while the share of consumers who did at least some online banking increased from 3 per cent in 1997 to 49 per cent in 2006. We also know through a number of different surveys that the majority of Canadian consumers are satisfied with the provision of new banking technologies (83 per cent of Canadians reported in 2004 of being either satisfied or very satisfied), and the reason they bank online is convenience (in 2004 78 per cent of Canadians said they adopted because online banking was more convenient).[12]

3 Model

In the literature studying the adoption of process innovations, firms must decide when to incur the cost of adopting a new technology. The focus has been on the trade-off that firms face between the incentive to delay adoption, since the adoption cost is expected to fall over time, and the incentive to adopt early in order to prevent or slow the adoption by competitors in the case of strategic rivalry. Adoption should therefore be quickest in more competitive markets.

In the context of markets where the benefits from a new technology only accrue once consumers have switched to it, the primary 'adoption cost' that firms must incur is the cost of encouraging consumers to switch. In other words, banks devote resources to making it more attractive for consumers to engage in e-banking (we can think of these resources as spending on promoting the online option or investments in the quality of the website). Rather than making the new technology more attractive, an alternative mechanism via which banks can encourage penetration of the new technology is to make the old technology less attractive by reducing the quality of branching service. The aim of this section is to contrast the impact of these two mechanisms on the diffusion of e-banking. To do so, we develop a model of bank competition with switching costs based on Beggs

[11] Prior to 1998 only national branch numbers are available, and only for the six largest banks.

[12] Canadian Bankers Association, "Technology and Banking: A Survey of Canadian Attitudes 2004."

and Klemperer (1992) in which consumers must decide where to bank and what fraction of their day-to-day transactions to perform online. Banks can influence these decisions in one of two ways: (i) by spending an amount Q_o to make the online option more attractive for consumers (we will refer to this as the Online-Quality mechanism), *or* (ii) by reducing the quality of branching services Q_b (we will refer to this as the Branch-Quality mechanism).[13]

In each of infinitely many discrete time periods two banks non-cooperatively and simultaneously choose either the quality of online service or the quality of branch service in an effort to maximize their total expected future discounted profits. In each period a cohort of new consumers enters the market to join a group of old consumers.[14] Old consumers have already bought banking services in earlier periods and are assumed never to switch banks.[15] Banks therefore compete for new consumers only.

When banks employ the Online-Quality mechanism they have incentive to spend Q_o for two reasons. First, doing so increases the utility of consumers (by making online banking more attractive) and therefore ultimately increases a bank's market share (*business stealing* effect). Second, the investment Q_o lowers costs since a greater proportion of transactions will be done using the less expensive technology (*technology penetration* effect). In other words, spending on online quality has a positive influence on both the business stealing and technology penetration effects.

In contrast, when banks employ the Branch-Quality mechanism they face a tradeoff between *technology penetration* and *business stealing*. By lowering quality, they attract a smaller share of new consumers. However, at the same time, consumers (both new and old) are encouraged to do more banking online, which reduces costs.

In order to analyze the effect that competition has on these incentives we consider the effect of adjusting the cost of switching. If switching away from a bank is more costly, competition is reduced since consumers are more captive. We are interested in determining the effect of changing the cost of switching on steady-state online or offline quality levels and resulting usage rates. The model is developed as follows, and then solved numerically.

[13]Of course, in reality banks might make use of both of these mechanisms simultaneously. We do not permit them to do so since the goal of this section is to contrast the outcomes that arise when banks use the two mechanisms.

[14]To maintain a stationary environment a fraction of old consumers exogenously die and are replaced by a cohort of new consumers.

[15]Dube, Hitsch, and Rossi (2006) set up a model in which all consumers are able to switch. We think that the fact that there is no switching is not restrictive in our case since, as we show in Section 4, there are very few switches observed in the data.

3.1 Branch-Quality mechanism

The problem of old consumers affiliated with a bank of branch quality Q_b is to choose the proportion of transactions done online, μ, by trading off the relative cost of e-banking over branch-based transactions. This problem is static, and with a probability $(1-\rho_j)$ a customer of bank j will be allowed to switch away. The household utility maximization problem is the following:

$$u(Q_b) = \max_{\mu} \quad \delta + (1-\mu)(Q_b - p_b) + \mu(-p_e) - \frac{\lambda}{2}\mu^2 \tag{1}$$

$$\Leftrightarrow \quad \mu(Q_b) = \frac{p_b - p_e - Q_b}{\lambda}, \tag{2}$$

where $p_b - p_e > 0$ is the price differential between transactions performed at a branch and transactions performed electronically, and λ represents a technological-familiarity parameter (consumers are less familiar with or less able to access technology when λ is large). It is useful to write the indirect utility function as a function of μ only, with the substitution $Q_b(\mu) = p_b - p_e - \lambda\mu$ such that:

$$u(\mu) = \delta - p_e - \lambda\mu + \frac{\lambda}{2}\mu^2. \tag{3}$$

The problem of new consumers is to decide first which bank to patronize, and then what proportion of transactions to do online. New consumers are assumed to be uniformly distributed along the unit line, and a consumer located at i must incur a "transportation" cost $t|i-j|$ to choose a bank located at point j. Consumers have two banks from which to choose. Bank 0 is located at 0, while bank 1 is located at 1. Demand for each bank is determined by an indifferent type, $z(\mu_0, \mu_1)$:

$$z(\mu_0, \mu_1) = \frac{\lambda(\mu_1 - \mu_0) + \frac{\lambda}{2}(\mu_0^2 - \mu_1^2)}{2t} + \frac{1}{2} \tag{4}$$

The firms' problem is a dynamic game in quality (or equivalently in the proportion of online-transactions, μ_j). Assuming that firms base their strategies only on current payoff relevant state variables (i.e. Markov strategies), the Bellman equation of bank 0 is given by:

$$V_0(x|Q_1^b) = \max_{\mu_0} \quad (\frac{F(x|\mu_0, \mu_1)}{\rho_0})\big[(1-\mu_0)(p_b - c_b) + \mu_0(p_e - c_e)\big] - \frac{C}{2}Q_b(\mu_0)^2 + \delta V_0(F(x|\mu_0, \mu_1)|\mu_1), \tag{5}$$

where $p_e - c_e > p_b - c_b$ (i.e. the markup on electronic transactions is higher than that on branch transactions) and where $F(x|\mu_0, \mu_1) = ((1-\rho_0)x + (1-\rho_1)(1-x))z(\mu_0, \mu_1) + \rho_0 x$ represents bank 0's stock of old consumers next period if its current stock is x; a fraction ρ_0 of its current stock do not switch and a fraction $z(\mu_0, \mu_1)$ of switchers from both banks choose it as their new bank. The first term in (5) represents bank 0's current revenue from the two channels since current period sales are given by $\frac{F(x|\mu_0,\mu_1)}{\rho_0}$ (we divide by ρ_0 to condition on the survival rate at bank 0). The problem of bank 1 is defined symmetrically, replacing x with $1-x$ and z with $1-z$.

Differentiating (5) with respect to μ_0, we obtain the first order condition for bank 0's equilibrium level of online usage:

$$0 = \underbrace{\left(\frac{1}{\rho_0}\frac{\partial F(x|\mu_0,\mu_1)}{\partial \mu_0}\right)\left[(1-\mu_0)(p_b - c_b) + \mu_0(p_e - c_e)\right]}_{\textit{business-stealing incentive}}$$
$$+ \underbrace{\left(\frac{F(x|\mu_0,\mu_1)}{\rho_0}\right)(p_e - c_e - (p_b - c_b)) - C\frac{\partial Q_b(\mu_0)}{\partial \mu_0}}_{\textit{tecnhnology-penetration incentive}} + \delta \frac{\partial V_0(F(x|\mu_0,\mu_1))}{\partial F(x|\mu_0,\mu_1)}\frac{\partial F(x|\mu_0,\mu_1)}{\partial \mu_0},$$

where $\frac{\partial F(x|\mu_0,\mu_1)}{\partial \mu_0} = ((1-\rho_0)x + (1-\rho_1)(1-x))\frac{\partial z(\mu_0,\mu_1)}{\partial \mu_0}$. From the first order condition, we can see the tradeoff banks face between *technology penetration* and *business stealing* when reducing the quality of branching services. The first term represents the business stealing effect and is negative since $z(\mu_0, \mu_1)$ is decreasing in μ_0; higher branch quality causes online usage to decrease but market share to rise. The second term represents the technology penetration effect and is positive since a greater share of transactions are performed using the more profitable channel as μ_0 grows. Since greater online usage is associated with lower branch quality, the third term is also positive.

3.2 Online-Quality mechanism

Rather than lower Branch-Quality, banks can adjust Online-Quality by choosing how much to spend on Q_o. The consumer problem then becomes:

$$u(E) = \max_{\mu} \quad \gamma + (1-\mu)(-p_b) + \mu(Q_o - p_e) - \frac{\lambda}{2}\mu^2 \tag{6}$$
$$\Leftrightarrow \quad \mu(Q_o) = \frac{P_b - P_e + Q_o}{\lambda}. \tag{7}$$

Writing the indirect utility function solely as a function of μ (with the substitution $Q_o(\mu) = -P_b + P_e + \lambda\mu$), we can solve for the indifferent new consumer:

$$z(\mu_0, \mu_1) = \frac{\lambda(\mu_0^2 - \mu_1^2)}{4t} + \frac{1}{2}.$$

Using this result, we can write bank 0's Bellman equation as follows:

$$V_0(x|\mu_1) = \max_{\mu_0} \quad (\frac{F(x|\mu_0,\mu_1)}{\rho_0})\big[(1-\mu_0)(p_b - c_b) + \mu_0(p_e - c_e)\big] - \frac{C}{2}Q_o(\mu_0)^2 + \delta V_0(F(x|\mu_0,\mu_1)|\mu_1). \tag{8}$$

Differentiating (8) with respect to μ_0 we obtain the first order condition for bank 0's equilibrium level of usage:

$$\begin{aligned} 0 \quad = \quad & \underbrace{\left(\frac{1}{\rho_0}\frac{\partial F(x|\mu_0,\mu_1)}{\partial \mu_0}\right)\big[(1-\mu_0)(p_b - c_b) + \mu_0(p_e - c_e)\big]}_{\textit{business-stealing incentive}} \\ & + \underbrace{\left(\frac{F(x|\mu_0,\mu_1)}{\rho_0}\right)(p_e - c_e - (p_b - c_b)) - C\frac{\partial Q_o(\mu_0)}{\partial \mu_0}}_{\textit{technology-penetration incentive}} + \delta \frac{\partial V_0(F(x|\mu_0,\mu_1))}{\partial F(x|\mu_0,\mu_1)} \frac{\partial F(x|\mu_0,\mu_1)}{\partial \mu_0}. \end{aligned}$$

In contrast with the first order condition when banks use the Branch-Quality mechanism, from the first order condition for the Online-Quality mechanism we observe that the *technology penetration* and *business stealing* effects operate in the same direction. When banks use the Online-Quality mechanism, $z(\mu_0, \mu_1)$ is increasing in μ_0; increasing online quality causes both usage and market share to increase. The technology penetration effect is also positive since when μ_0 increases more transactions are performed using the more profitable channel. Since greater usage is associated with higher online quality, the third term is negative.

3.3 Model Results

We solve the model numerically. To do so we follow Beggs and Klemperer (1992) and assume that the value function of the banks takes a known parametric form. Since the function $z(\mu_0, \mu_1)$ is quadratic in the decision variable of firms (instead of linear as in Beggs and Klemperer (1992)), we conjecture that the value function will be a cubic function of the state variable x. The solution of the problem then involves finding values for the parameters of the value functions that satisfy the Bellman and Nash conditions.

The numerical values for the parameters used to compute the solution are given in Table 1. Our qualitative results hold under two conditions: (1) the profit from an e-banking transaction (π_e) is greater than from a branch transaction (π_b) and (2) the consumer price of an e-transaction is less than of a transaction performed at a branch.

The results of the numerical exercise are summarized in Figures 1 and 2, which shows steady-

Table 1: Numerical values for the model parameters

Technological familiarity:	λ	$[1.5, 3]$
Bank fixed cost:	C	2
Switching cost:	ρ_j	$\{0.5, 0.6, 0.8\}$
Branch price:	p_b	1.25
E-banking price:	p_e	0.5
Branch transaction profit:	π_b	0.25
E-banking transaction profit:	π_e	0.5
Utils from banking:	γ	1
Unit transportation cost:	t	1/4
Discount factor:	δ	0.8

state usage rates when banks employ the two mechanisms for different values of λ (the technological familiarity parameter) and ρ_j (the switching cost). The top two panels characterize what happens when banks face symmetric switching costs, the bottom two characterizes what happens when banks face asymmetric switching costs. For both mechanisms and regardless of switching cost, usage increases as λ falls. That is, online usage increases as the cost of performing online transactions falls.

First, we investigate the effect of decreasing the level of competition in the market. We consider the situation where the cost of switching is symmetric across banks and examine what happens as ρ increases. In this case, for the Branch-Quality mechanism we observe that increasing ρ (moving from the solid line to the dotted line) causes usage to increase. This is because banks prefer lower branch quality in less competitive markets, which encourages higher online usage. The opposite is true for the Online-Quality mechanism: as ρ increases, usage decreases. In less competitive markets, both online quality and usage are lower.

What occurs here is that, as ρ increases, the business-stealing effect becomes less important relative to the technology-penetration effect since consumers are more captive. With the Branch-Quality mechanism banks are restrained from lowering quality by the fear of losing customers to rivals via the business-stealing effect, and this effect becomes less important as ρ increases. In contrast, with the Online-Quality mechanism, banks have a double incentive to increase quality since the two effects work in the same direction. As ρ increases, the incentive to increase quality to steal customers from rivals is diminished and so online quality is lower, as is online usage.

Next, we study the effect of increasing the dominance of one of the banks by assuming asymmetric

Figure 1: Symmetric Case

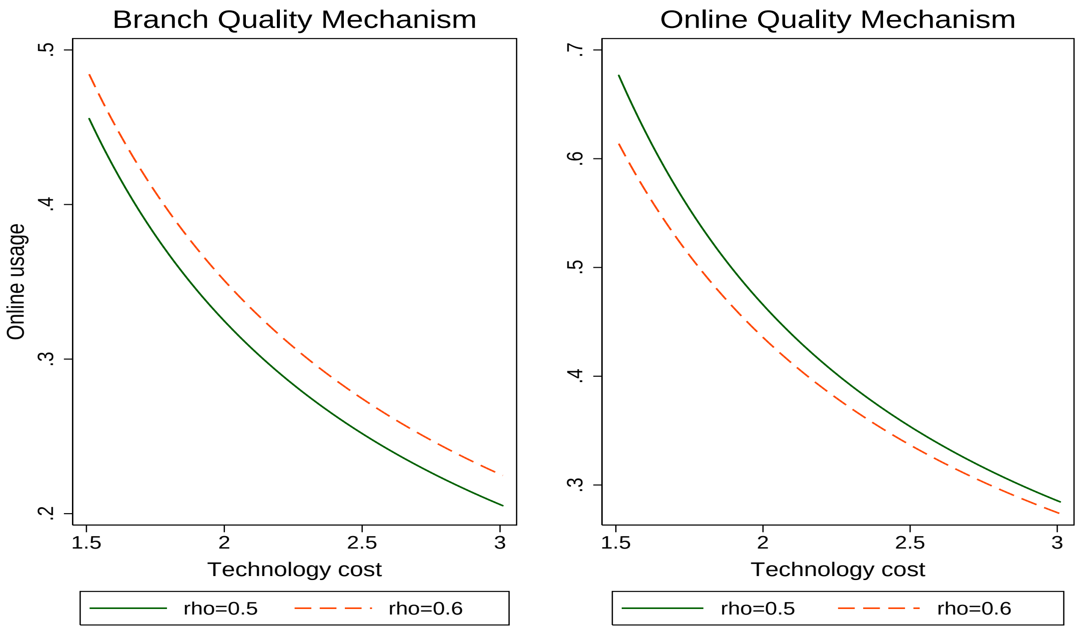
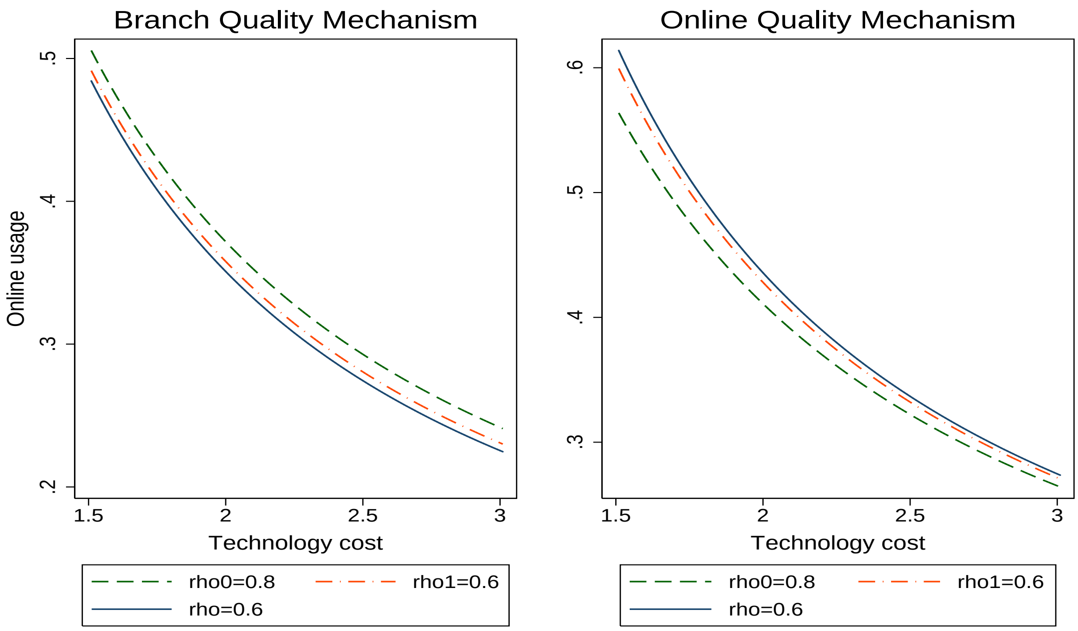


Figure 2: Asymmetric Case



switching costs. For the Branch-Quality mechanism, we find that the bank with the higher switching cost generates higher usage. Since its switching cost is higher, it worries less about losing customers to its rival and so can afford to lower branch quality, resulting in higher usage. The opposite is true for the Online-Quality mechanism. The bank with the lower switching cost has higher usage, implying that weaker firms choose higher online quality. As ρ_j increases, the business-stealing effect becomes less important relative to the technology-penetration effect.

We summarize our results in the following proposition

Proposition 1. *The following comparative static results obtain:*

1. *Suppose the cost of switching is symmetric across banks ($\rho_0 = \rho_1 = \rho$), then*
    - *if using the Branch-Quality mechanism, in less competitive markets (higher ρ) quality is lower and usage is higher.*
    - *if using the Online-Quality mechanism, in less competitive markets (higher ρ) quality is lower and usage is lower.*
2. *Suppose the cost of switching is asymmetric across banks, then*
    - *if using the Branch-Quality mechanism, a bank that faces less competition (higher ρ_j) will have lower quality and higher usage.*
    - *if using the Online-Quality mechanism, a bank that faces less competition (higher ρ_j) will have lower quality and lower usage.*

4 Empirical Analysis

In this section, we analyze the diffusion of online banking technologies in relation to changes in the structure of local markets in Canada between 1998 and 2006. Our objective is to provide a set of empirical facts supporting the assumptions and predictions of the model described above. In particular, if banks can manipulate locally the relative quality of online to offline services, then those operating in less competitive markets, or those with dominant positions, will lower branch-service quality in order to encourage consumers to use the online channel. As a result, the most concentrated local markets exhibit the highest online banking penetration rates. We test these predictions by proxying for branch service quality with the density of branches in the market, and by studying the relationship between market structure, branch-service quality, and diffusion of online banking. We discuss three sets of empirical results.

We begin by showing that the diffusion of online banking was indeed more substantial in more concentrated markets. We then explore the causes of this relationship by studying a particular channel of diffusion – namely local branch closures. We present evidence suggesting that the largest decrease in the density of branch networks were for dominant banks and in more concentrated local markets. Finally, we analyze the decision of households to adopt and use e-banking. This allows us to examine the response of individuals to changes in the density of retail branches in their immediate neighborhood, thereby analyzing the substitutability between online and offline banking services.

To conduct our analysis, we combine two unique data sets. The first contains information on the usage of different banking channels, along with detailed information on the demographic characteristics of respondents. The second contains the location of all branches in our sample period and is used to construct a measure of branch density with which we proxy branch-service quality. We describe these data sets below before turning to our empirical results.

4.1 Data

4.1.1 Canadian Banking Habits

We use detailed consumer-level data characterizing household decisions to adopt/use electronic payment technologies as well as their banking relationships and demographic characteristics. This is done by combining Census information (2001, 2006) with household financial data obtained from the Canadian Financial Monitor (CFM), a survey conducted by Ipsos-Reid (1999-2006).

On average, the CFM consists of approximately 12,000 Canadian households surveyed per year (staggered evenly by quarter), with a non-trivial number of households surveyed in more than 1 year and up to 8 years.[16] The geographical distribution of households in the survey is similar to the total population across all census divisions (CDs), where each census division is labeled a market.

The CFM has 10 sections, the first two sections focus on banking habits and financial delivery services of the household. The survey asks the respondent to list their main institution as well as other financial institutions where they do business. The respondents are asked to fill out the frequency of use for the different banking channels for each institution in the "last month". Options include: not used, 1, 2, 3-5. 6-10, 11+, therefore the number of transactions is right-censored. A

[16]There are a total of 76204 households in the sample. Of these, we observe 24,113 just once, 15,600 twice, 11,238 three times, 8,676 four times, 6,645 five times, 4,764 six times, 3,360 seven times, and 1,808 eight times.

more detailed description of household responses are reported in Section 4.2.1.

Survey responses provide us with a substantial amount of information regarding household characteristics. In our analysis we focus on those characteristics which are most likely to be correlated with bank channel choice. Helpful in this choice are results previously documented by Stavins (2001), who showed, using the limited data available in the 1998 U.S. Survey of Consumer Finances, that younger households were more likely to make online bill payments, as were those with high income, better education, and white collar jobs. Summary statistics are presented in Table 2.

Table 2: Summary of Household Characteristics: 1999-2006

CHARACTERISTIC	Mean	Median	Std. Dev
Respondent: age†	46.7	46	14.9
Respondent: education	15.3	14	2.5
Age (oldest head)	51.9	51	15.1
Education (oldest head)	15.7	16	2.5
Household: income($)	61,568	57,500	35,581
Household: size	2.5	2	1.3
Duration: primary bank*	11.1	12	4.9
Transaction cost‡($)	5.67	2.5	7.4

Note:†The age variable refers to the age of the respondent in 1999. Respondents under the age of 18 in 1999 represent only 0.02 per cent of the sample and were dropped. *Duration is right-censored at 20 years. Therefore, we report the average duration for those reporting less than 20 years, which represents close to 50 per cent of the sample. ‡Transaction costs are almost entirely unreported in the panel prior to 2004. The reported figures are for households surveyed after 2003 and defined as service charges paid in the last month.

From Table 2 we notice immediately that the average duration of a banking relationship is relatively long, the median is 20+ years. The high proportion of households that have a banking relationship exceeding 20 years suggests that switching costs are relatively high. Focusing on those households that are seen repeatedly in the sample, we find that 3.1 per cent of them have switched from their main financial institution to either an institution previously recorded as secondary or to a new institution.[17]

4.1.2 Structure of Local Markets

Our measure of bank quality is the density of its branch network.[18] This seems like a realistic approximation given the evidence provided in Kiser (2004), Cohen and Mazzeo (2007), and Grzelonska

[17]More conservatively, we find that only 1.25 per cent of households record switching to an entirely new bank.

[18]By focusing on branch networks we implicity ignore virtual banks, like ING. Empirically this will not have a significant impact on our analysis because less than 5 per cent of households in the survey report a virtual bank as their primary financial institution.

(2005). Branch location information on all financial institutions in Canada has been scanned and transferred to electronic files from the "Financial Services Canada" directory produced by Micromedia Proquest. The directory is cross-listed with branch information provided by the Canadian Payments Association, branch-closing dates reported by the Financial Consumer Agency of Canada, branch closing and opening information provided in the annual reports of Canada's largest banks (a process that started in 2002 because of the Accountability Act), and location data provided directly by some of the banks.[19]

We also use the distribution of retail branches to construct our measure of the degree of concentration by local market. We define the relative dominance of a bank by its share of retail branches in the market. Similarly, we use the Herfindahl index corresponding to the distribution of branches to measure the competitiveness of local markets. This variable is particularly attractive in our context, since the number of banks active in each market does not vary significantly. All banks in our sample are national and most of them are present in all Provinces. We then define the 1998 market structure as the pre-electronic banking market structure.

Summary statistics are reported in Table 3 for all markets and then separately for markets ranking in the top, middle, and bottom thirds based on branch density.[20] The average branch density is 3.9 per square kilometer and 6 per 100 000 people. The average change in branches per capita (*dbranchcap*) from 1998 to 2006 is -20 per cent. The average change in branches per square kilometer (*dbranchdens*) is -15.8 per cent. Rationalization of branches (most precisely measured as *dbranchdens*) is consistently high for the different group sizes, although highest for the largest banks.[21]

[19]At the time of this paper we do not have access to data on all of the banks' ABM networks, limiting the analysis to branch location choice. Moreover, a substantial fraction of brand-name ABM machines (as opposed to white-label machines), are located in branches. Also, according to our CFM survey, more than 60 per cent of ABM transactions are at the branch, a number that has been slowly increasing since 2001. This is likely because of the change in composition of ABMs from largely brand labels to white-labels.

[20]In our analysis we must control for the acquisition of Canada Trust Financial Services by Toronto-Dominion Bank, now called TD Canada Trust or TD Bank Financial Group. TD completed its $8 billion acquisition on February 1st, 2000. With the acquisition TD acquired approximately 600 branches. It is safe to assume that many of these branches were closed to save costs, especially in local markets where both Toronto-Dominion and Canada-Trust were present. In order to control for the effect of the merger we assume that the merger actually took place at the beginning of our sample (i.e. 1998 instead of 2000), and re-set the 1998 number of TD-Canada Trust branches to the maximum of number belonging to either TD or CT. Since the merger mainly affected only a few local markets in Ontario and was highly predictable by competing banks, the correction method does not affect significantly our results.

[21]Unlike in the United States, we do not have branch-specific data on deposits, number of employees, and branch-specific investment in capital, which could potentially be useful in analyzing branch rationalization.

Table 3: Summary of Bank Statistics: 1998-2006

	Total		Large		Medium		Small	
VARIABLE	Mean	SD	Mean	SD	Mean	SD	Mean	SD
branchdens	3.92	13.94	11.01	22.60	0.68	0.32	0.11	0.07
dbranchdens	-15.8	0.41	-22.2	0.41	-12.7	0.42	-12.2	0.39
branchcap	6.02	6.92	12.35	9.11	4.22	0.74	1.76	0.84
dbranchcap	-19.9	0.42	-18.3	0.48	-16.5	0.32	-24.9	0.43

Note: We present the mean and standard deviation (SD) for four groupings: total as well as large (biggest third), medium, and small census divisions. Branch density is in banks per square kilometer and Branches per capita is in branches per 100 000 people.

4.1.3 General Demographic Characteristics

In addition to household survey data and branch location information, we include in our analysis general characteristics of the cross-section of local markets. To characterize our markers we use 2001 and 2006 census data on population, age, income, and employment. Summary statistics on key variables are reported in Table 5. We use this information to control for local market characteristics that might affect reorganization decisions.

4.2 Analysis

4.2.1 The Diffusion of Online-Banking

Before turning to the market-level analysis, we first document the main national trends in the banking habits of Canadians. For this purpose, Table 4 documents the percentage of households using each of the banking options considered in the CFM survey. We also include the rate of household access to the internet from work and from home. Web access is a necessary condition for online banking and a key variable in our analysis. Web access at work increased from 34 per cent to 44.2 per cent between 1998 and 2002, but remained remarkably stable afterwards. Home web access on the other hand steadily increased from 35.3 per cent to more than 70 per cent in 2006.

With respect to bank services, we find that the majority of households continue to visit a teller at least once a month, although this number has fallen over time as more households adopt e-banking. The fraction of phone bankers has remained relatively constant throughout the sample; as of 2003 there are more e-bankers than phone bankers. The fraction of households who adopt PC-banking has raised quite substantially, from 13.4 per cent in 1999 to almost 50 per cent in 2006.

The share of PC-transactions has followed a similar pattern over the sample period, from 4.4 per cent to 22.1 per cent, while the share of Branch (teller and ABM at a branch) and phone transactions have fallen. Interestingly, the average number of transactions per month has not changed significantly over the sample period. This suggests that online banking is substituting for offline banking, and not that the two technologies are complementary. Table 4 also includes the coefficient of variation for the share of the different banking channels. The amount of heterogeneity across households and markets in PC banking and HOME banking (PC and Phone) is much higher than for branch banking, suggesting there exists a lot of heterogeneity across households and regions in the usage rate of the newer technologies.

Table 4: Summary of Banking Channel Usage

TYPE	1999	2000	2001	2002	2003	2004	2005	2006
				Fraction of Users				
Web access (work)	34.0	38.6	41.5	44.2	44.6	45.7	46.5	46.9
Web access (home)	35.3	44.4	50.9	58.1	62.3	61.8	66.5	70.4
Teller	80.6	77.4	75.2	73.6	72.2	74.6	67.2	73.2
ABM	87.1	87.5	86.8	87.5	85.8	85.1	85.5	80.0
Phone	37.5	36.9	36.1	35.3	32.7	34.2	29.8	30.2
PC	13.6	18.2	24.7	32.6	36.5	38.1	45.7	48.8
				Average Number of Transactions				
All channels	13.5	12.5	12.1	12.6	12.1	12.1	12.2	12.6
				Share of Total Transactions				
Teller	30.5	28.3	27.7	25.8	25.7	26.5	23.9	25.0
Branch	83.3	81.2	73.9	75.5	73.9	72.3	70.0	68.6
	[0.27]	[0.29]	[0.32]	[0.34]	[0.36]	[0.38]	[0.40]	[0.41]
Phone	12.2	12.4	11.1	12.0	11.1	11.6	9.6	9.3
	[1.59]	[1.59]	[1.57]	[1.58]	[1.71]	[1.63]	[1.89]	[1.95]
PC	4.4	6.4	15.0	12.5	15.0	16.0	20.3	22.1
	[3.06]	[2.48]	[2.14]	[1.71]	[1.54]	[1.51]	[1.29]	[1.20]

Note: Rates and shares are reported in percentage points. Numbers in square brackets are coefficients of variation. Branch includes teller and ABM transactions at a branch.

We now turn to our market-level analysis of e-banking diffusion. Our objective here is to relate the penetration of e-banking with the pre-online banking market structure, measured by the Herfindahl index in 1998. We test the effect of the initial level of market concentration on the change in banking usage and adoption rates, while controlling for internet access, and other key Census variables such as age, income, employment, and population. In line with the previous discussion, we define e-banking both in terms of the fraction of transactions performed online and the proportion of households using

PC-banking. Moreover, since branch services represent the relatively expensive channel for banks, we also report results related to the proportion of teller transactions. Notice that these variables are aggregated using the household surveyed in each local market. In order to minimize the importance of measurement errors, in all specifications we consider only local markets for which we observe more than 25 households.

Table 6 reports a first set of results using changes (between 1999 and 2006) in e-banking as dependent variables, and Table 7 reports similar results using the 2005/2006 levels.[22] Both tables present the estimation results of the following specification:

$$Y_m = \theta HH98_m + X_m\beta + \epsilon_m, \tag{9}$$

where Y_m is a measure of e-banking diffusion (i.e. PC transactions, fraction of adopters, or Teller usage), and $HH98$ is the concentration level in 1998. All specifications also include measures of internet access at home and work, and various demographic characteristics of the local markets (in changes or levels). A common concern with this type of analysis is that the initial market structure is correlated with omitted factors affecting the diffusion of a new technology. In our context, it is clear that the degree of concentration is related with demand for banking services that could affect the usage of online banking. For instance, we know from the CFM survey that consumers who perform a small number of day-to-day transactions are also less likely to adopt e-banking. If these omitted variables are important we should expect the OLS estimate of θ to be biased downward.

To circumvent this problem we use an instrumental variable, namely the share of francophones in a local market. Historically, most francophone regions of the country were dominated by one credit union, Caisses Populaires Desjardins. Very early in the economic development of the Province of Québec, Desjardins established a large network of retail branches covering virtually every Catholic Parish. To a large extent, this success is due to the fact the other important banks were controlled by English managers, while Desjardins was almost exclusively francophone and closely linked with the Catholic Church. Today Desjardins behaves similarly to other commercial banks, but still dominates most French local markets in Québec and New-Brunswick, which represents about 20 per cent of the population. As a result the share of francophones in a market is highly correlated with our concentration measure, but uncorrelated with the other key factors affecting demand for banking services.[23] The results from Table 6 and 7 offer similar conclusions relative to the relationship between

[22]For this specification we group the last two years of the survey together in order to improve our measure of e-banking usage.

[23]Statistically, the instrument easily pass a weak instruments test (Stock, Yogo, and Wright (2002)).

e-banking diffusion and initial market concentration. As expected, all specifications lead us to conclude that the diffusion of e-banking was more important is markets that were more concentrated in 1998. The results from the IV regressions show that the usage/adoption of PC-banking is positively related with concentration, while the correlation is negative with usage of tellers. The coefficients associated with $HH98_m$ are also significantly smaller (and sometimes not different from zero) in the OLS specifications, suggesting a negative correlation between $HH98_m$ and ϵ_m as discussed above.

In addition to initial market structure, the adoption and usage of online banking is strongly correlated with the access of internet at home, although not strongly correlated with web access at the office. This suggests most people are conducting their online banking at home and not in the office.

4.2.2 Changes in Branch-Service Quality

In this section we analyze the change in the average number of branches per square kilometer from 1998 to 2006.[24] The change in the average retail network density proxies the change in the relative quality of branch-services from the beginning of the diffusion of e-banking technologies (i.e. 1998) to the end of our sample. Our objective is to relate this variable to the degree of initial concentration (i.e. $HH98$) and to the ability of consumers to use PC-baking. Our theoretical prediction suggests less competitive markets should experience the largest decreases in the quality of branch services, as banks try to induce consumers to use more e-banking services. If branch services and online services are substitutes, the model also predicts that markets where consumers are more likely to use e-banking services (i.e. lower learning/adoption costs) should also see a reduction in branch density.

Table 8 presents ordinary least squares and two stage least squares regression results for the change in the average number of branches per square kilometer in market m ($branchdens_m$) over the sample period on market structure variables:

$$\log\left(\frac{branchdens_{m06}}{branchdens_{m98}}\right) = \theta HH98_m + \lambda dbank_m + Z_m\gamma + X_m\beta + \epsilon_m, \tag{10}$$

where $HH98_m$ is the initial (1998) level of concentration of all the banks in the market, $dbank_m$ is the change in the number of competitors in the market[25], and Z_m is a vector of demographic

[24] As previously mentioned, we define a market as being a census division. Out of the 288 CDs in Canada, we are able to use 246. The remainder have an insufficient number of households to conduct valid inference.

[25] We control for the change in the number of competitors since some local markets experienced entry during the sample. A negative coefficient associated with $dbank_m$ indicates that new entrants have a smaller network of branches

variables expressed in growth rates, including the fraction of under people aged 20-34 living in the market, the average income, and the average level of employment. The variables in X_m correspond to variables related to the diffusion of e-banking. These includes the proportions of municipalities with DSL access, the change in the proportion of household with internet access, and the change in the usage/adopt of e-banking. We use change in internet access as an instrument for change in e-banking to control both for measurement error, and for the simultaneity in the decision of consumers to use PC-banking or tellers and the decision of banks to close retail branches. We use each variable sequentially in order to examine the robustness of our results across different proxies.

From column (1) through to column (8) of Table 8 we see that the market concentration variable, $HH98_m$, is negative and significant. The coefficient on the 1998 Herfindahl index thus implies that more branches were closed in markets that were initially more concentrated. This result provides empirical evidence in support of the theoretical model: The average number of branches (i.e. quality) falls in the more concentrated markets. Columns (2) through (6) of Table 8 separately include controls for high-speed internet access in 2006, changes in web access, changes in PC banking (adoption and usage) and Teller usage. We can see that the result connecting market structure to branch closure does not change across specifications.[26] In addition, we find that all of our "technology proficiency" variables are significantly related with closures. In particular, the coefficients on the change in PC banking adoption and usage (*dpc_adopt* and *dpc*, respectively) are negative and significant. Therefore, even after controlling for the degree of concentration, banks closed more branches in local markets where consumers were more likely to use e-banking. Notice that this result is robust to the control variables and to the sub-sample used.

This result is similar to the one described in Emre, Hortaçsu, and Syverson (2006). These authors conclude that an increase in e-commerce leads to exit of brick-and-mortar establishments. Although the mechanism described in their paper is different than ours, both results suggest that online and offline retail channels are substitutes. Our results suggest in addition that e-commerce diffusion might not be an exogenous process. In situations where online and offline retail services are jointly offered, our empirical results confirm that firms have an incentive to influence the diffusion of the cheapest channel by reducing the quality of the other one.

than incumbents.

[26]Note that there are 85 markets in these regressions since only those markets have at least 25 households in the survey sample both in 1999 and 2006.

4.3 Household-Level Analysis

Next we examine whether e-banking adoption and usage depend on the presence of a retail branch in households' neighborhood. That is, we look deeper into the data to determine whether at the household level, branch density influences the decision to adopt and use e-banking. The objective is to provide stronger evidence that online and offline services are substitutable.

With household level data we can focus on household-specific measures of branch density, by taking advantage of the fact that CFM survey identifies each household by its postal code. Branch density will now be defined as the number of branches of a particular household's primary bank in a circle within either a 0.5 or 1.0 kilometer radius around the centroid of the household's postal code ($nbh1, nbh2$ respectively). The mean number of own-bank branches in a 1 kilometer neighborhood, for example, is 0.44 with a variance of 0.82.

The first set of household regressions focus on the online banking adoption decision. Conditional on not adopting in the past we estimate using a Probit model a households probability of adoption as a function of the change in branch density ($Dnbh1, Dnbh2$), controlling for change in web access, age, education, change in household income, and a full set of bank and year interaction effects. We use bank/year interactions to control for year to year changes in the relative price or quality online services. Since Canadian banks are not allowed to price discriminate across regions and web interface are common, we are confident that our branch density variables are not correlated with price discrimination strategy.

Results are reported in Table 10 for two samples. We consider the full sample of households (F, for full) and a sub-sample affiliated with TD/Canada Trust prior to the merger. For these customers closures were largely due to the 2000 merger that saw TD add 611 Canada Trust branches to their network. Analyzing this sub-sample allows us to address a potential simultaneity bias that may exist between branch closures and adoption. The effect of these branch closures, therefore, can help us more cleanly identify the closure effect on adoption. A caveat is that there are substantially fewer observations. Nevertheless, for both samples the decision to adopt online banking is positively correlated with closures in the 0.5 kilometer neighborhood. The result is qualitatively the same in the 1 kilometer neighborhood but the coefficients are not statistically different from zero. In addition, the effect of gaining access to the internet ($Dweb01$) or maintaining access ($Dweb11$) is strongly positively correlated with online banking adoption. Adoption is also positively correlated with income and negatively correlated with age.

The second set of household-level regressions examine the decision to stop banking with a teller and thus do all of day-to-banking activities at an ABM, on the phone, or online. The neighborhood effects for teller-banking are stronger in the 1 kilometer neighborhood than the 0.5 kilometer neighborhood. Qualitatively, though, in both instances an increase in the number of branches implies a household is less likely to quit teller-banking. Therefore, quitting teller-banking is positively correlated with branch rationalization.

The third set of household-level regressions estimate the change in online usage ($D.PC$) and teller usage ($D.Tell$) related to change in branch density, controlling for change in web access, age, education, change in household income, and a full set of bank and year effects.

Results are presented in Table 12. Two sets of results are presented for each neighborhood specification, resulting in 8 columns of estimates. The first set (F) includes both online adopters and non-adopters at $t-1$, the second set includes only those households that were online adopters at $t-1$ (U). The first sample therefore includes both the extensive and intensive margin effects, and the latter sample isolates the intensive margin. We find that in both instances a change in the number of branches inside of a household's local neighborhood is significantly correlated with a change in online banking. That is, online usage is positively correlated with the closure of a local branch. Interestingly, the size of the coefficient on the closure variables is about twice as big in the Users sample regressions than in the Full sample regressions. This could potentially be due to the presence of a learning cost, as consumer who already used PC-banking in the past are more responsive to the closing of a neighboring branch.[27]

The results are similar with respect to the effect of branch closures on teller banking. In both neighborhood specifications the share of banking done at a teller is increasing in the number of branches. Therefore, closures lead to less branch banking. In the face of branch closures households are switching out of teller banking and mostly into online banking. The effect does not appear to be significantly different for the group of Users and Non-Users.

In addition to the effect of closures on adoption and usage of e-banking, we also find strong effects of web access. In all cases, households going from no access to access ($Dweb01$) or access to access ($Dweb11$) were much more likely to increase online usage than those households without access (base group, $Dweb00$).

[27]Lambrecht, Seim, and Tucker (2007), also finds that the degree of online banking intensity of a consumer strongly depends on whether or not that consumer made an effort immediately upon opening an online account to bank online.

5 Conclusion

This paper analyzes the relationship between market structure and the diffusion of electronic banking. In the day-to-day banking market, despite the fact that banks have adopted electronic payment mechanisms, the realization of the full benefits from its introduction depends on the decisions of consumers to perform electronic transactions. This is true in general for innovations in electronic commerce an it is therefore important to understand why consumers adopt/use new technologies. This paper sheds light on how banks can affect the relative attractiveness of their offline and online channels to encourage consumer adoption of innovations in e-banking. In particular, we show that banks can encourage online adoption by rationalizing their branch network.

A further contribution of this paper is that we show that the ability to rationalize branches depends on market structure in a non-standard way. We show that there are more closures in the most concentrated markets and that larger banks tend to close the most branches. The reason banks do this is to encourage adoption (*technology penetration incentive*) and they are able to do this in less competitive environments because the *business stealing incentive* is weaker in these markets. These results, therefore, provide empirical evidence to support the Branch-Quality model of competition presented in the paper.

In future work we extend the analysis to take into account a number of features currently missing. For example, we currently fix the cost of adoption of e-banking for all consumers. A more realistic approach is to allow this cost to vary according to both household characteristics and the diffusion of internet technologies more generally. This would allow us to measure the welfare costs associated with bank closures and the introduction of e-banking across households facing low and high adoption costs.

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Table 5: Summary of a Few Market (Census Division) Characteristics: 2001, 2006

	2001	2006
Census:		
Population		
mean	106079	111639
median	39196	39765
sd.	253527	267142
Income		
mean individual	25461	
median individual	25089	
sd individual	4233	
mean household	55776	
median household	54786	
sd household	9921	
Age		
mean share under 20	21.4%	20.1%
mean share 20-24	6.3%	6.1%
mean share 25-34	12.4%	11.6%
mean share 35-49	26.2%	24.1%
mean share 50-64	18.8%	22.1%
Education		
share high school degree or less	42.4%	
share with a degree	25.6%	
share with university degree	20.6%	

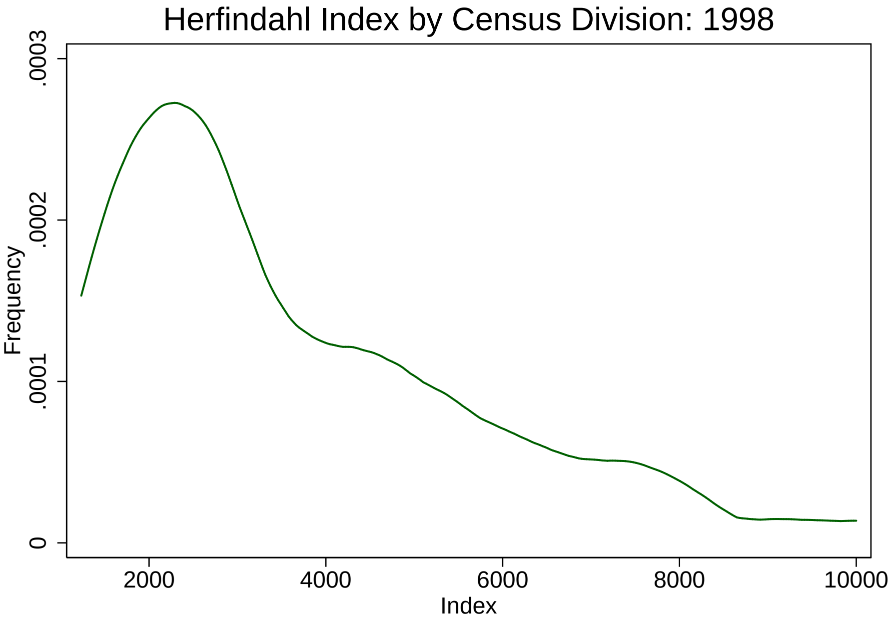
Herfindahl Index by Census Division: 1998
Frequency
0
.0001
.0002
.0003
2000
4000
6000
8000
10000
Index

Table 6: Change in Banking Habits 1999-2006 as a Function of Market Structure

COEFFICIENT	LABELS	(1) D.PC use OLS	(2) D.PC adopt OLS	(3) D.Teller use OLS	(4) D.PC use IV	(5) D.PC adopt IV	(6) D.Teller use IV
HH1998	HH index (1998)	0.000364	0.0466	-0.0722	0.104	0.267	-0.137
		(0.018)	(1.68)	(-3.29)	(1.70)	(2.30)	(-2.37)
dhomeweb	Δ Home web	0.296	0.437	-0.184	0.286	0.418	-0.179
		(4.38)	(4.03)	(-2.41)	(3.50)	(2.97)	(-2.06)
dworkweb	Δ Work web	-0.0364	0.170	-0.000924	-0.0891	0.0579	0.0319
		(-0.40)	(1.31)	(-0.011)	(-0.99)	(0.40)	(0.35)
dpop	Pop. change	0.0948	0.0291	-0.122	0.148	0.141	-0.155
		(1.41)	(0.31)	(-2.02)	(2.60)	(1.33)	(-2.19)
dshare2034	Δ Share 20-34	-0.0211	-0.0250	-0.00209	-0.0252	-0.0339	0.000513
		(-2.87)	(-1.81)	(-0.18)	(-2.81)	(-1.95)	(0.044)
davgemp	Δ Employment	-0.216	-0.500	0.210	-0.351	-0.786	0.294
		(-1.98)	(-2.37)	(1.52)	(-2.42)	(-2.68)	(1.86)
davgincome	Δ Income	-0.00524	-0.0328	0.0326	0.0464	0.0766	0.000463
		(-0.12)	(-0.44)	(0.63)	(0.80)	(0.70)	(0.0073)
Observations		85	85	85	85	85	85

Robust t statistics in parentheses

Instrumental variables = Share of francophone in 1998.

Sample markets include all census divisions with more than 25 households surveyed in 1999 and 2006.

Variables mesured in changes measure the difference in log between 1999 and 2006.

Table 7: Banking Habits 2005-2006 as a Function of Market Structure

VARIABLES	(1) PC use (OLS)	(2) PC adpopt (OLS)	(3) Teller use (OLS)	(4) PC adpopt (IV)	(5) PC adpopt (IV)	(6) Teller use (IV)
HH index (1998)	0.120	0.291	-0.391	0.806	1.544	-3.778
	(1.695)	(2.263)	(-2.820)	(1.837)	(1.949)	(-2.259)
Home web access	0.290	0.590	-0.219	0.403	0.797	-0.778
	(6.687)	(6.665)	(-2.394)	(4.174)	(4.494)	(-2.274)
Work web access	0.0712	0.134	-0.276	-0.00965	-0.0139	0.124
	(1.117)	(1.050)	(-2.227)	(-0.116)	(-0.0915)	(0.399)
Population density	0.00206	0.0145	-0.0312	0.00747	0.0244	-0.0580
	(0.445)	(1.693)	(-1.809)	(0.977)	(1.648)	(-1.604)
Income (2006)	-0.00534	-0.0208	-0.0146	0.0267	0.0379	-0.173
	(-0.417)	(-0.921)	(-0.588)	(1.291)	(1.150)	(-2.473)
Employment (2006)	12.54	27.38	37.53	1.725	7.591	91.00
	(0.926)	(0.981)	(1.304)	(0.0964)	(0.236)	(1.615)
Share 20-34 (2006)	0.240	0.183	-0.133	0.483	0.628	-1.335
	(1.102)	(0.507)	(-0.373)	(1.654)	(1.268)	(-1.344)
Observations	99	99	99	99	99	99
R^2	0.469	0.456	0.304	0.099	0.093	-2.736

Robust t statistics in parentheses

Usage and web access variables are constructed using the pooled sample of respondants for 2005 and 2006.

Sample markets include all census divisions with more than 25 households surveyed in 2005 and 2006.

Table 8: The Change in the Average Number of Branches per Market 1999-2006

COEFFICIENT	LABELS	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) IV	(8) IV
HH1998	HH index (1998)	-0.387	-0.436	-0.291	-0.284	-0.266	-0.242	-0.252	-0.190
		(-10.6)	(-12.2)	(-2.72)	(-2.81)	(-2.50)	(-2.09)	(-2.60)	(-1.79)
dbank	Δ nb. banks	-0.264	-0.256	-0.400	-0.355	-0.360	-0.395	-0.398	-0.417
		(-1.80)	(-1.86)	(-2.70)	(-2.44)	(-2.40)	(-2.44)	(-2.73)	(-2.87)
dpop	Pop. change	-0.0244	-0.00123	0.460	0.530	0.375	0.430	0.734	0.492
		(-0.13)	(-0.0073)	(1.87)	(2.46)	(1.72)	(1.76)	(3.18)	(2.48)
dshare2034	Δ Share 20-34	-0.0705	-0.0585	0.0312	0.00904	0.0283	0.0361	-0.0113	0.0240
		(-1.88)	(-1.61)	(0.75)	(0.21)	(0.66)	(0.89)	(-0.25)	(0.55)
davgemp	Δ Employment	-0.207	-0.153	0.308	-0.197	-0.195	-0.132	-0.329	-0.446
		(-0.59)	(-0.49)	(0.69)	(-0.48)	(-0.44)	(-0.29)	(-0.79)	(-0.92)
davgincome	Δ Income	0.707	0.523	0.667	0.672	0.689	0.699	0.608	0.573
		(4.25)	(3.13)	(3.05)	(2.95)	(2.81)	(3.00)	(3.01)	(2.59)
avgdsl	Communities w/ DSL		-0.397						
			(-3.92)						
dteller	Δ Teller usage						0.625		
							(1.35)		
dpc_adopt	Δ PC bank adopt.					-0.397			-1.069
						(-1.68)			(-2.21)
dpc	Δ PC bank usage				-1.379			-2.707	
					(-3.15)			(-3.46)	
dhomeweb	Δ Home web			-0.805					
				(-2.94)					
dworkweb	Δ Work web			0.450					
				(1.50)					
Observations		246	246	85	85	85	85	85	85
R^2		0.41	0.45	0.38	0.39	0.33	0.33	0.32	0.28

Robust t statistics in parentheses

Dependent variable = Change in the average number of branches per square Km.

Instrumental variables = Change in the proportion of household with internet access at home and at work

Sample markets include all census divisions with more than 25 households surveyed in 1999 and 2006.

Variables mesured in changes measure the difference in log between 1999 and 2006.

Table 9: The Change in the Number of Bank j's Branches per Capita

COEFFICIENT	LABELS	(1) dbranchcap	(2) dbranchcap	(3) dbranchcap	(4) dbranchcap
share98	Branch share in 1998	-0.578***	-0.355***	-0.557***	-0.301***
		(0.088)	(0.083)	(0.086)	(0.082)
HHi98	Competitors' HH in 1998	-0.123	0.202***		
		(0.075)	(0.051)		
nbcomp98	Nb. competitors in 1998	-0.0599***		-0.0496***	
		(0.0093)		(0.0063)	
dpop	Pop. change (2006/1998)	-0.657***	-0.693***	-0.657***	-0.713***
		(0.14)	(0.14)	(0.14)	(0.14)
age	Age (2001)	0.199	-0.0331	0.168	-0.0609
		(0.27)	(0.28)	(0.27)	(0.28)
avgincome	Avg. income (2001)	0.638*	0.175	0.668*	-0.154
		(0.38)	(0.37)	(0.38)	(0.35)
avgemp	Employment (2001)	-0.00140	-0.000476	-0.00121	-0.000569
		(0.0015)	(0.0015)	(0.0015)	(0.0015)
land	Land area (square km)		0.00736	-0.00626	0.00522
			(0.020)	(0.019)	(0.020)
pop	Population (X10,000)		-0.000686*	0.0000462	-0.000806**
			(0.00036)	(0.00035)	(0.00037)
Observations		1085	1085	1085	1085
R^2		0.46	0.44	0.46	0.43

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

Table 10: Decision to Start Online Banking

COEFFICIENT	LABELS	(1) PC adopt (F)	(2) PC adopt (F)	(3) PC adopt (TD/CT)	(4) PC adopt (TD/CT)
Dnbh1	Δ branch (1/2 Km)	-0.219		-0.360	
		(-2.23)		(-1.84)	
Dnbh2	Δ branch (1 Km)		-0.122		0.189
			(-0.49)		(0.17)
Dweb01	Web ($0 \rightarrow 1$)	0.744	0.743	0.620	0.642
		(11.2)	(11.2)	(2.28)	(2.36)
Dweb11	Web ($1 \rightarrow 1$)	0.694	0.691	1.059	1.050
		(14.7)	(14.7)	(5.16)	(5.17)
workweb	Web (work)	0.176	0.175	-0.0342	-0.0140
		(3.46)	(3.46)	(-0.17)	(-0.070)
agecat2	Age: $25-35$	-0.270	-0.279	-0.457	-0.486
		(-1.67)	(-1.73)	(-0.69)	(-0.74)
agecat3	Age: $35-50$	-0.318	-0.325	-0.0708	-0.0707
		(-2.06)	(-2.11)	(-0.12)	(-0.12)
agecat4	Age: 50+	-0.464	-0.470	-0.334	-0.332
		(-3.04)	(-3.08)	(-0.57)	(-0.56)
hldincome	Hld. income	0.193	0.191	0.684	0.659
		(2.94)	(2.91)	(2.84)	(2.75)
school	Schooling	-0.00658	-0.00651	-0.0351	-0.0330
		(-0.75)	(-0.75)	(-0.92)	(-0.87)
Observations		7327	7327	504	504

Robust z statistics in parentheses

Standard-errors are clustered at the household level. The explanatory variables include a full set of year/bank indicator variables.

Dependent variable is an indicator variable equal to one if the household has an online banking account.

The full sample - F - of adopters corresponds to the sample of households who did not change bank and used online banking in the previous year.

The sub-sample TD/CT corresponds to the household who had an account with TD or CT before the merger.

Table 11: Decision to End Teller Banking

COEFFICIENT	LABELS	(1) Teller quit (F)	(2) Teller quit (F)	(3) Teller quit (TD/CT)	(4) Teller quit (TD/CT)
Dnbh1	Δ branch (1/2 Km)	-0.0916		-0.193	
		(-1.27)		(-0.58)	
Dnbh2	Δ branch (1 Km)		-0.362		-1.716
			(-2.17)		(-1.99)
Dweb01	Web ($0 \rightarrow 1$)	0.0729	0.0718	-0.267	-0.329
		(1.08)	(1.06)	(-0.77)	(-0.99)
Dweb11	Web ($1 \rightarrow 1$)	0.171	0.170	0.323	0.325
		(4.33)	(4.31)	(2.01)	(2.01)
workweb	Web (work)	0.147	0.146	0.0742	0.0714
		(3.45)	(3.43)	(0.49)	(0.47)
agecat2	Age: $25-35$	-0.0723	-0.0719	-0.194	-0.122
		(-0.53)	(-0.53)	(-0.53)	(-0.32)
agecat3	Age: $35-50$	-0.228	-0.227	-0.406	-0.362
		(-1.77)	(-1.76)	(-1.22)	(-1.03)
agecat4	Age: 50+	-0.532	-0.532	-0.648	-0.584
		(-4.13)	(-4.12)	(-1.94)	(-1.67)
hldincome	Hld. income	-0.0621	-0.0614	-0.270	-0.285
		(-1.14)	(-1.13)	(-1.19)	(-1.24)
school	Schooling	0.0141	0.0142	0.0246	0.0275
		(1.98)	(1.99)	(0.82)	(0.92)
Observations		10700	10700	824	824

Robust z statistics in parentheses

Standard-errors are clustered at the household level. The explanatory variables include a full set of year/bank indicator variables.

Dependent variable is an indicator variable equal to one if the household use tellers

The full sample - F - of users corresponds to the sample of households who used online tellers in the previous year.

The sample TD/CT corresponds to the household who had an account with TD or CT before the merger.

Table 12: Household Changes in Banking Habits

COEFFICIENT	LABELS	(1) D.PC (F)	(2) D.PC (F)	(3) D.Tell (F)	(4) D.Tell (F)	(5) D.PC (U)	(6) D.PC (U)	(7) D.Tell (U)	(8) D.Tell (U)
Dnbh1	Δ branch (.5 Km)	-0.0141		0.0169		-0.0298		0.0193	
		(-2.39)		(1.92)		(-2.03)		(1.83)	
Dnbh2	Δ branch (1 Km)		-0.0236		0.0433		-0.0656		0.0530
			(-1.63)		(2.11)		(-1.87)		(2.06)
Dweb01	Web ($0 \rightarrow 1$)	0.0481	0.0481	0.00222	0.00222	0.0923	0.0925	-0.00911	-0.00906
		(7.70)	(7.70)	(0.29)	(0.29)	(4.34)	(4.35)	(-1.06)	(-1.05)
Dweb11	Web ($1 \rightarrow 1$)	0.0252	0.0251	-0.00262	-0.00254	0.0816	0.0813	-0.00308	-0.00292
		(11.2)	(11.2)	(-0.84)	(-0.81)	(9.55)	(9.51)	(-0.80)	(-0.76)
agecat2	Age: $25-35$	-0.0360	-0.0361	0.0185	0.0186	-0.0520	-0.0518	0.0374	0.0374
		(-2.36)	(-2.37)	(1.83)	(1.85)	(-2.08)	(-2.07)	(2.14)	(2.14)
agecat3	Age: $35-50$	-0.0396	-0.0397	0.0100	0.0101	-0.0540	-0.0536	0.0303	0.0301
		(-2.66)	(-2.67)	(1.02)	(1.02)	(-2.21)	(-2.19)	(1.78)	(1.77)
agecat4	Age: 50+	-0.0432	-0.0432	0.0116	0.0116	-0.0711	-0.0707	0.0410	0.0409
		(-2.92)	(-2.92)	(1.17)	(1.17)	(-2.90)	(-2.88)	(2.41)	(2.40)
Observations		12979	12979	12979	12979	4769	4769	9978	9978
R^2		0.02	0.02	0.01	0.01	0.04	0.04	0.02	0.02

Robust t statistics in parentheses

Standard-errors are clustered at the household level. The explanatory variables include a full set of year/bank indicator variables.

Dependent variable is the change in the usage of PC banking. The full sample - F - includes all household who did not change bank affiliation.

The users sample - U - corresponds to the sample of households who did use online banking or tellers in the previous year.