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by

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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.

JEL classification: D14, D4, G21, L1
Bank classification: Financial institutions; Market structure and pricing

Résumé

Les auteurs étudient le rôle de la structure de marché dans la diffusion des services bancaires électroniques. Ces services (et plus largement le commerce électronique) permettent aux entreprises d'économiser sur de nombreuses transactions. Cependant, les avantages que procure l'adoption de cette technologie ne deviennent complets qu'à partir du moment où les consommateurs effectuent en ligne une part significative de leurs opérations. Compte tenu des coûts d'apprentissage de cette nouvelle technologie, les entreprises sont tentées d'inciter leurs clients à aller sur le Web en modifiant la qualité respective des services qu'elles proposent en succursale et en ligne. La réussite de cette stratégie dépend de la structure de marché. Sur les marchés très concurrentiels, les entreprises qui diminuent l'attrait relatif de la succursale s'exposent à une perte de clientèle (ou de clientèle potentielle), risque dont se soucient moins, par contraste, les sociétés occupant une position dominante. Les auteurs construisent un modèle qui formalise la détermination de la qualité des services offerts en succursale et intègre, pour changer d'établissement, des coûts destinés à représenter l'alternative devant laquelle les banques sont placées quand elles rationalisent leur réseau, à savoir assurer la pénétration d'une technologie ou perdre des clients. Les auteurs résolvent le modèle numériquement et montrent que les banques sont plus enclines à réduire la qualité de leurs services en succursale et à pousser leur clientèle vers les services électroniques lorsqu'elles évoluent sur des marchés à forte concentration et si elles sont dominantes. Les prévisions du modèle sont corroborées à l'aide de données d'enquête longitudinales concernant l'usage des moyens de paiement électronique par les ménages et de données relatives à l'emplacement des succursales, lesquelles statistiques ont servi à mesurer la qualité des succursales.

Classification JEL : D14, D4, G21, L1
Classification de la Banque : Institutions financières; Structure de marché et fixation des prix

1 Introduction

This paper studies the diffusion of new cost-reducing technologies. As the final stage of the research and development process, the diffusion of new technologies represents an important contribution to productivity growth. We are interested in innovations in e-commerce such as self-serve electronic check-in/out kiosks, online retail outlets, and online customer service centers that reduce the cost for firms of servicing customers relative to their old, non-electronic technology. Our analysis focuses on the diffusion of a specific e-commerce technology, namely the online channel in the retail banking industry. Online banking represents a cost-reducing technology since it is cheaper for banks if consumers perform day-to-day transactions online rather than at the teller.[1]

We are particularly interested in the role that market structure plays in affecting this diffusion. 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. This is particularly true for innovations in e-commerce. Airlines and retail outlets may invest in the installation of electronic kiosks, but the benefits from adoption are only realized once consumers start checking in/out electronically. The same holds for online banking. Despite the fact that banks have adopted these mechanisms, their full benefits can be realized only if consumers decide to perform trans-

[1]Using internal data from twenty 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).

actions electronically rather than at traditional bricks-and-mortar branches. This situation also exists for online customer-service centers and for online retail outlets.

The fact that diffusion is consumer-driven implies a different role for market structure in affecting firm incentives and the resulting diffusion of new e-commerce technologies. In markets where firms operate both the e-commerce technology (we will refer to this as the online option) and the old non-electronic technology (the offline option) they may have an incentive to manipulate the relative attractiveness of the two options in order to encourage consumers to adopt the less costly one. Evidence suggests that offline price and the local availability of offline outlets can affect the use of e-commerce by consumers (see Goolsbee (2000), Ellison and Ellison (2006), and Prince (2007)). Whether or not firms are able to engage in this type of behavior depends on local market structure. There is evidence that local competition plays a role in affecting firms' quality decisions.[3] Therefore, reducing the attractiveness of traditional retail stores by closing offline outlets, reducing staff, or decreasing operating hours involves a greater risk of losing customers (or potential customers) when the local market is more competitive. In the case of e-commerce technologies, instead of the preemptive technology adoption motive, increased competition generates a business stealing effect, which slows the penetration of the cost-reducing technology.

To our knowledge, this role for market structure 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, Goldmanis, Hortaçsu, Syverson, and Emre (2008) 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.

To study this issue we focus on the retail banking industry and the diffusion of online banking. 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 e-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 predictions about the effect of competition

[3]See for instance Cohen and Mazzeo (2007) who analyze the effect of market structure on bank branching decisions and find that networks are larger in more competitive markets, Mazzeo (2003) who finds that more competitive airline routes feature better on-time performance and Hoxby (2000) who finds that metropolitan areas with more school districts have higher quality public schools (greater student achievement levels).

on the usage/adoption of e-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, much of the literature has found 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. Since 1998, however, the average bank's branch network shrunk by 23 per cent and the total number of branches fell by 29 per cent. Over the same time period, Canadians became some of the world's heaviest users of electronic payments. In December 1997, The Royal Bank of Canada became the first Canadian bank to offer some banking services online and soon after the major Canadian banks all had operational websites. In 2006, 300 million transactions were performed electronically. To study the substitution between online and offline banking channels and the role that branch quality and market structure play in 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 e-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)).[4]

Our empirical work supports the prediction that banks can rationalize their networks in

[4] As mentioned above there are other mechanisms that firms can use to degrade the quality of their offline option such as decreasing the amount of staff or reducing operating hours. In the case of retail banking manipulating the number of branches in operation affects both 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.

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. We then provide further evidence that the mechanism is indeed the one that we hypothesize. We start by showing 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. We do so by performing a household-level analysis. That is, we consider the effect of changes in branch density in a household's local neighborhood on its adoption and usage of e-banking. We show that branch closures cause increased adoption and usage. 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, including a discussion of the degree of branch rationalization seen in Canada since 1998 and the changing banking behavior of Canadians. Section 3 presents a model of quality competition with switching costs. Section 4 describes the data and Section 5 outlines our empirical approach and presents our results. Finally, Section 6 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.[5] The industry is best described as a stable oligopoly (Bordo 1995), with almost no exit and little entry, at least on the retail side.[6] The major banks provide similar products and services and are not dissimilar 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-Canada Trust.

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; (iii) the remainder of the Canadian banking

[5]The top five banks are: Royal Bank Financial Group, Bank of Montreal, Canadian Imperial Bank of Commerce, TD-Canada Trust, and Bank of Nova Scotia.

[6]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, including ING Canada, a virtual bank. Note that by 2006 neither ING or any of the other virtual banks had a strong presence in the Canadian market. ING's share of deposits was about 1.5% in 2006.

Table 1: Summary of Branch Network Reorganization: 1998-2006

		Local market concentration		
VARIABLE	Total	Low	Medium	High
Change in Branch density	-29.5%	-11.1%	-22.4%	-55.1%
Change in Avr. Branch density	-23.2%	-11.3%	-14.9%	-43.4%

Note: We present the mean for four groupings: total as well as High, Medium, and Low levels of concentration in the census divisions. Sorting was by the HHI in 1998. Branch density is the total number of bank-branches per square kilometer; Avr. Branch density is the average number of branches a bank owns per square kilometer.

industry is characterized by a large number of foreign and domestically owned small banks, as well as provincially regulated credit unions; and (iv) there is considerable variation in the level of competition in the census divisions. Figure 3 presents the distribution Herfindahl-Hirschman indices (HHI) across census divisions for 1998.[7] 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.

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 23 per cent, despite a 37 per cent increase in deposits. In contrast, in the period 1982-1997, the top six Canadian banks closed only 2.3 per cent of their branches. This suggests that the pre-e-banking period was characterized by a relatively stable steady-state level of branches.

Summary statistics regarding branch network reorganization are reported in Table 1 for all markets. On average the change from 1998 to 2006 in the average number of own branches per square kilometer is -23.2 per cent. On average the change in total branch density is -29.5 per cent. For both the average number of own branches and the total number of branches, the rate of rationalization is higher the more concentrated the market (ranked according to HHI in 1998). This pattern provides a preview of our empirical results regarding the relationship between closures and market concentration.

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

[7]Because of data restrictions, we define the HHI of a market using the number branches owned by each bank rather than deposits. As one would expect, however, the number of branches and the value of deposits are highly correlated, with a correlation coefficient of 0.9 when computed at the Province level.

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.

Table 2 documents Canadian banking habits.[8] We 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 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, 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 2005 there are more e-bankers than phone-bankers. The fraction of households having adopted PC-banking has risen quite substantially, from 17.3 per cent in 1999 to nearly 60 per cent in 2006.

The share of PC-transactions has followed a similar pattern over the sample period, increasing from 4.4 per cent to 22.9 per cent, while the shares 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.[9] Table 2 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.

3 Model

In this section we develop a model of branch-quality competition with switching costs based on Beggs and Klemperer (1992), which characterizes the tradeoff banks face between technology penetration and business stealing. We determine the equilibrium level of service quality that banks choose to offer at their branches when this choice affects both the consumer's

[8] These data are from the CFM survey described in further detail in Section 4.

[9] The majority of e-banking is for day-to-day purposes – bill payment and transfers (roughly 77 per cent compared to only 4 per cent who use e-banking for investment activities) – tasks that have typically been conducted in a branch.

decision about whether to adopt the new technology, and their decision about which bank network to subscribe.

In each of infinitely many discrete time periods two banks non-cooperatively and simultaneously choose 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 existing consumers.[10] Existing consumers have already bought banking services in earlier periods and are assumed never to switch banks.[11] Banks therefore compete for new consumers only.

All-else equal, higher quality attracts a bigger share of the new consumers and so banks have an incentive to increase the quality of their service (*business stealing* effect). However, at the same time that they choose their bank, consumers must also decide on the fraction of their transactions to perform online versus at the branch. Lower quality branching service encourages more adoption on the part of consumers and so this gives banks an incentive to decrease quality (*technology penetration* effect).

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 the resulting usage rates. The model is developed as follows, and then solved numerically.

3.1 Consumer problem

The problem of existing 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:

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

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

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

[11]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.

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 first decide 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, $z(\mu_0, \mu_1)$:

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

3.2 Firm problem

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 existing 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:

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

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 static 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. Similarly the dynamic business stealing effect (third term) is negative and capture the incentive of firms to build up a larger stock of consumers. 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.

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 Figure 1, which show steady-state usage rates for different values of λ (the technological familiarity parameter) and ρ_j (the switching cost). The left panel characterizes what happens when banks face symmetric switching costs, while the right panel characterizes what happens when banks face asymmetric switching costs. Regardless of switching cost, usage increases as λ falls. That is, online

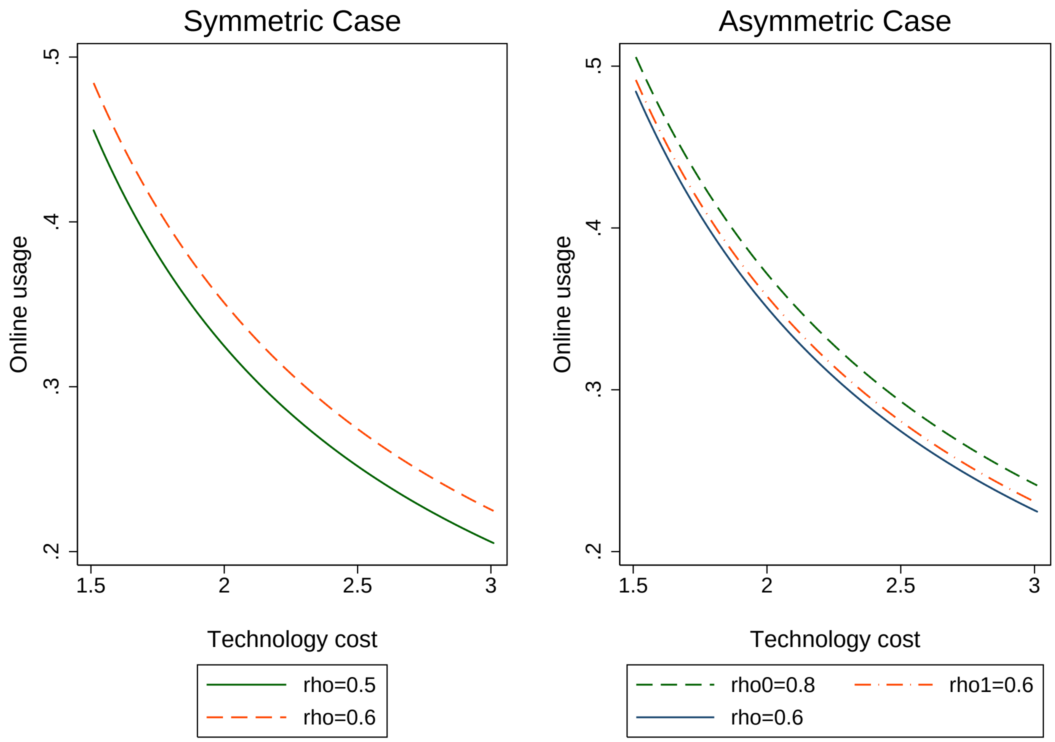

Figure 1: Steady-State Usage Rates

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. 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. What occurs is that, as ρ increases, the business-stealing effect becomes less important relative to the technology-penetration effect since consumers are more captive. 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.

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

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 in less competitive markets (higher ρ) quality is lower and usage is higher.*

2. *Suppose the cost of switching is asymmetric across banks, then a bank that faces less competition (higher ρ_j) will have lower quality and higher usage.*

3.4 Online-Quality mechanism

Rather than making the old technology less attractive, an alternative mechanism via which banks could encourage penetration of the new technology is to make the latter more attractive (for instance by devoting resources to the promotion of the online option or investing in the quality of the website).

It is worthwhile to contrast the impact that using this mechanism instead of the branch-quality reduction mechanism might have on the diffusion of e-banking. This is because an alternative explanation for the diffusion of e-banking is that rather than *encourage* online banking, branch closures *follow* increases in online banking (as in Goldmanis, Hortaçsu, Syverson, and Emre (2008)). We are interested in knowing something about the relationship between market structure and diffusion under this alternative. If closures follow increases in online banking, something else must explain the increase in online banking. One example is that banks may devote resources to making it more attractive for consumers to engage in e-banking.

In contrast with the branch-quality reduction mechanism described above, banks no longer face a tradeoff when increasing quality (now of the online option). Increasing the quality of the online option increases the utility of consumers (by making online banking more attractive) and therefore ultimately increases a bank's market share (*business stealing* effect). The investment in online quality also 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. This can be seen if we write the first order condition for bank 0's equilibrium level of usage assuming that branch quality is normalized to zero and banks choose the online quality Q_o:

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

Increasing online quality causes usage to increase and $z(\mu_0,\mu_1)$, is increasing in μ_0 so that market share increases. The technology penetration effect is also positive since when μ_0 increases more transactions are performed using the more profitable channel.

Using the same set of parameters as above and solving using this first order condition, we find that, in contrast with the branch-quality reduction mechanism, as ρ increases, usage decreases. We present the results graphically in Figure 2 of the Appendix. The reason is the double incentive banks have to increase quality. 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. If we assume asymmetric switching costs, the bank with the lower switching cost has higher usage. This implies that weaker firms choose higher online quality. As ρ_j increases, the business-stealing effect becomes less important relative to the technology-penetration effect.

Since the relationship between usage and market structure predicted for the two mechanisms is different, so too will the relationship between branch closures and market structure. The Online-Quality mechanism implies less e-banking usage in less competitive markets; if closures are the result of increased adoption and usage of e-banking (and not the cause thereof), there should be fewer closures in less competitive markets when banks employ the Online-Quality mechanism.

Our empirical analysis in the next section reveals that this is not the relationship between market structure and online usage/online quality that actually exists in the data. However, it should also be pointed out that this was to be expected since features of the Canadian retail banking market would make any practical attempt at using the so-called online-quality mechanism very difficult. First, since the large banks operate nationally, their websites are also common across the country. Therefore, it is not possible to link diffusion at the local market level with improvements in the online option. Second, prices and fees are also set nationally and so it is not possible to offer discounts in order to lower the transaction costs of going online at the local level.

4 Data

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 Household data

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 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.[12] 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 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.

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, higher education, and white collar jobs. Summary statistics are presented in Table 4.

[12] There are a total of 76,204 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.

From Table 4 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.[13]

To characterize our markets we use 2001 and 2006 Canadian Census data on population, age, income, and employment. We also use business data (average business sales per employee in a market in 2004), provided by InfoCanada, as an additional measure of market characteristics. Summary statistics on key variables are reported in Table 6. We use this information to control for local market characteristics that might affect reorganization decisions.

4.2 Branch data

Our measure of bank quality is the density of its branch network.[14] This seems like a realistic approximation given the evidence provided in Kiser (2004) and Cohen and Mazzeo (2007). 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.[15]

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

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

[14] 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.

[15] We do not have access to data on all of the banks' ABM networks. This limits the analysis to branch location choice. However, a substantial fraction of brand-name ABM machines (as opposed to white-label machines), are located in branches. Furthermore, 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.

(rather than a concentration ratio) 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-e-banking market structure.

5 Empirical analysis

In this section, we analyze the diffusion of online banking technologies in Canada between 1998 and 2006 in relation to the structure of local markets. Our objective is to provide a set of empirical facts supporting the assumptions and predictions of the branch-quality reduction mechanism described in the model above. In particular, if banks can manipulate locally the relative quality of online and offline services, then those operating in less competitive markets, or those with dominant positions, should lower branch-service quality in order to encourage consumers to use the online channel. As a result, the most concentrated local markets should exhibit the highest online banking penetration rates. We look for support for 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 begin by showing that the diffusion of online banking was indeed greater in more concentrated markets. We then examine this relationship more closely, following the insights of our model. We first present evidence suggesting that the largest decreases in the density of branch networks were for dominant banks and in more concentrated local markets. Then, we analyze the decision of households to adopt and use e-banking focusing on the response of individuals to changes in the density of retail branches in their immediate neighborhood. This allows us to analyze the substitutability between online and offline banking services.

Result 1: Aggregate e-banking diffusion and market structure

We begin by analyzing the diffusion of e-banking at the market level. Our definition of market is a census division. There are 288 census divisions in Canada. For our empirical work we restrict ourselves to 245 of these, since the others are very small and relatively unpopulated.[16]

Our objective in this subsection is to relate the penetration of e-banking with the pre-

[16] We eliminate those markets where the population density is less than one household per square kilometer.

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. Since branch services represent the relatively more expensive channel for banks, we also report results related to the proportion of teller transactions. Notice that these variables are aggregated using the households surveyed in each local market.

Table 7 reports results using changes (between 1999 and 2006) in e-banking as dependent variables. Table 8 reports similar results using the 2005/2006 levels.[17] Both tables present the estimation results of the following specification:

$$Y_m = \theta HH98_m + X_m\beta + \epsilon_m, \tag{6}$$

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. 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 in the CFM data.

An important concern for the estimation of θ is the fact 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 and the number of banks in a local market are related to characteristics of demand for banking services that could affect the usage of online banking. We know for instance 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. Francophones represent about 23 per cent of the Canadian population. Historically, most francophone regions of the country were dominated by one credit union, Caisses Populaires Desjardins, and one bank, the Banque Nationale. Very early in the economic development of the Province of Québec, these institutions established large networks of retail branches. To a considerable extent, the success of Desjardins and Nationale is due to the fact the other important banks were controlled by anglophone managers, while these were almost exclusively francophone and closely linked with the Catholic Church. To-

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

day, Desjardins and Nationale behave similarly to other commercial banks, but still dominate most local markets in Québec and francophone communities in New-Brunswick. 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.[18]

The results from Tables 7 and 8 offer similar conclusions regarding the relationship between e-banking diffusion and initial market concentration. All specifications lead us to conclude that the diffusion of e-banking was more important in 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 access to 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.

Result 2: Reorganization of branch networks

In this section we analyze the change in the average number of branches per square kilometer from 1998 to 2006. 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-banking. Our theoretical predictions suggest that more dominant banks should close more branches, and 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.[19]

[18] Statistically, the instrument easily passes a weak instrument test (Stock, Yogo, and Wright (2002)). Also, using the household-level usage data introduced later in the results section, we cannot reject the hypothesis that francophones behave in the same way as the rest of the population with respect to the decision to use and adopt e-banking, once we condition on bank affiliation and other demographic characteristics. These results are available upon request.

[19] In order to control for the effect of the merger between Toronto Dominium and Canada Trust we assume that the merger actually took place at the beginning of our sample (i.e. 1998 instead of 2000), and re-set the

Bank level results

In Table 9 we present regression results for the change in the number of bank j's branches per square kilometer in market m ($branchdens_{jm}$) over the sample period on market structure variables:

$$\log\left(\frac{branchdens_{jm06}}{branchdens_{jm98}}\right) = \alpha share98_{jm} + \theta HH98_{jm} + Z_m\gamma + X_m\beta + \epsilon_{jm}, \tag{7}$$

where $share98_{jm}$ is bank j's own initial share of market m and $HH98_{jm}$ is the initial level of concentration amongst j's rivals in the market. Z_m is a vector of demographic variables expressed in growth rates, including the fraction of people aged 20-34 residing in the market, the average income, and the average level of employment. X_m is a set of internet-related variables. The results provide support for the following prediction from our model: The most dominant banks have the largest incentive to lower branch-service quality. We find that a larger initial market share is associated with more branch closures. This result is robust across specifications. From this table we can also see the effect of rival attractiveness/competitiveness on a bank's closure decisions. In column (2) we report the effect of the Herfindahl index of bank j's rivals in 1998 ($HH98_{jm}$). Holding fixed bank j's share of branches, an increase in $HH98_{jm}$ either means fewer competitors or the presence of one or more dominant rival banks. As such, this variable measures the attractiveness of competitors. The results show that conditional on j's market share, the more concentrated j's rivals are, the fewer branches j closes. Therefore, not only do bigger/more dominant banks close more branches, but they close even more when there is less risk that consumers will be attracted to their rivals.

Market level results

Table 10 presents the results of a similar analysis at the market level, aggregating over all banks active in each census division. We estimate the relationship between the change in the average number of branches per square kilometer in market m ($branchdens_m$) over the sample period on market structure variables:

$$\log\left(\frac{branchdens_{m06}}{branchdens_{m98}}\right) = \theta HH98_m + \lambda dbank_m + Z_m\gamma + X_m\beta + \epsilon_m, \tag{8}$$

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.

where $HH98_m$ is the initial (1998) level of concentration of all the banks in market m, $dbank_m$ is the change in the number of competitors in market m,[20] and Z_m are demographic variables. The variables in X_m correspond to variables related to the diffusion of e-banking. These include the proportion of municipalities with DSL (digital subscriber line) access, the change in the proportion of households with internet access, and the change in usage/adoption of e-banking. We use each variable sequentially in order to examine the robustness of our results across different proxies.

There are two potential concerns with this specification. The first is that there may be measurement error in our e-banking variables, since we are using a small number of households to compute our e-banking usage variables (i.e. at least 25 households). The second is that there may be simultaneity in the decisions of banks to close/open branches and the diffusion of e-banking at the local market level that could bias our estimate of the effect of initial market structure. We use change in internet access as an instrument in an effort to deal with these potential problems. Note, however, that if consumers' decisions to subscribe to the internet are related to the quality of banking services, our instrument will not correct for the simultaneity in the decision of consumers to use PC-banking and the decision of banks to close retail branches. The estimated coefficients will then reflect the correlation between the change in average density of branch networks and the usage of online banking, which is both due to consumer reactions to branch closures and to the banks' technology penetration incentive. In the next section we use our household-level data to study the causal effect of branch density on usage and adoption.

Looking at columns (1) through (8) of Table 10 we see that the market concentration variable, $HH98_m$, is negative and significant. This 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 more in more concentrated markets.

Columns (2) through (6) of Table 10 separately include controls for high-speed internet access in 2006, change in web access, change in PC banking (adoption and usage) and change in Teller usage – the result linking market structure with branch closures does not change even after controlling for these factors.[21] In addition, we find that all of the internet access and e-

[20]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 than incumbent banks.

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

banking related variables are significantly related to 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, we find that 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 Goldmanis, Hortaçsu, Syverson, and Emre (2008). 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 from ours, both results suggest that online and offline retail channels are substitutes. In addition, our results suggest that e-commerce diffusion is not be an exogenous process, as more concentrated markets experienced a larger rationalization of branches and a faster diffusion of electronic banking. 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 less-costly (for them) channel by reducing the quality of the other one.

Result 3: Household e-banking usage and adoption

So far our empirical results have shown that market structure affects the extent of branch network reorganization, but it remains to be shown that changes in branch density affect diffusion. A key assumption behind the technology penetration incentive faced by banks is that consumers' decisions to adopt and use e-banking depend on the structure of their bank's network of branches. When banks decide to rationalize their network, some consumers must incur a larger transportation cost to visit a branch and some must wait longer in line to visit a teller. As a result, if e-banking is a substitute for branch banking (i.e. at tellers and ATMs), some consumers will change their day-to-day banking habits opting more (or more often) for e-banking. Our objective in this section is therefore to measure the extent to which online and offline services are substitutes by studying consumers' usage and adoption of e-banking following changes in the density of branches in their neighborhood.

We take advantage of the fact that the CFM survey identifies each household by its postal code in order to construct household-specific measures of branch density. We now define branch density 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. The mean number of own-bank branches in a 1 kilometer neighborhood, for example, is 0.44 with a variance of 0.82.

We consider two specifications for this analysis. The first set of regressions estimates the change in online usage and teller usage 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 (along with their interactions) in order to control for unobserved factors that are common to all customers of a given bank (e.g. national transaction costs, website quality, advertisement, etc.). The second specification studies the adoption decisions of consumers. In particular we use a linear Probit model to estimate the transition probability of adopting e-banking conditional on not having adopted in the past, as function of the change in the presence of branches in households' neighborhood and demographic characteristics.[22]

Usage OLS regression results

Table 11 presents OLS estimates for the household-level regressions where the dependent variable is either the change in online usage ($D.PC$) or teller usage ($D.Tell$). Two sets of results are presented for each neighborhood specification, resulting in eight 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, while 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, in the Users sample regressions the size of the coefficient on the closure variables is about twice what it is in the Full sample regressions. This could reflect the presence of a learning cost, since consumers who already used PC-banking in the past appear to be more responsive to the closing/opening of a neighboring branch.[23]

The results are similar with respect to the effect of branch changes on teller usage. In both neighborhood specifications the share of banking done at a teller increases with the number of branches. Therefore, closing a branch lead to less branch banking. In the face of branch closures households are switching out of teller banking and into online banking. Contrary to PC-banking, the effect does not appear to be different for the group of online

[22] We exclude from our analysis households that do not report the same postal code in consecutive years or that have changed banks in consecutive years. We also exclude the most dense 1 per cent of markets – where the density is greater than $23,000$ households per square km – because the neighborhood size in some very small neighborhoods is measured imprecisely.

[23] Lambrecht, Seim, and Tucker (2007), also find 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.

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, $Dweb00$).

Usage IV regression results

Of concern in our analysis is any potential correlation between the decision of banks to close/open branches and consumers' unobserved characteristics that could bias our estimate of the effect of local branch density on e-banking diffusion. Banks may, for example, base their closure/opening decisions on unobserved (to the econometrician) neighborhood-level factors affecting the adoption/usage decisions of consumers. For instance, after the introduction of high-speed internet in a community, banks might have anticipated a sudden shift out of branch banking and into e-banking and therefore may decide to close a branch. An observed increase in usage could reflect this anticipation effect, and not consumer reaction to a change in the availability of offline services.

Another potential source of correlation is the fact that we are not controlling for some aspects of the quality of branch-level services. For instance, prior to closing a branch a bank may first reduce opening hours or the number of tellers. This lowering of service quality by means other than branch closure may motivate consumers to start using e-banking even before the branch has actually been closed. These omitted variables will then create a negative correlation between the change in neighborhood branch density variable and the residuals, thereby downplaying the effect of branch presence on e-banking usage and adoption (i.e. bias the coefficient towards zero). Similarly, the likely presence of measurement error in the neighborhood definition could attenuate the effect.

In order to deal with these problems we use an IV strategy. In particular we construct variables that are correlated with the closing/opening of branches, but uncorrelated with factors affecting the decision to adopt and use e-banking. We first consider characteristics of neighborhoods that are correlated with branch presence. For instance, throughout the branch network reorganization process, banks were more likely to keep open branches in densely populated neighborhoods and in commercial districts. We therefore use measures of population and retail trade density as instruments.[24]

[24] In particular we use the population per square kilometer and the average retail sales per employee in the smallest census area of each household (i.e. dissemination area). We normalize each variable with respect to

Further, as mentioned earlier in the paper, in 2000 the Canadian Government authorized the merger of TD Bank with Canada Trust. The new entity (TD-Canada Trust) progressively closed duplicate branches, mainly between 2001 and 2003. We take advantage of this "exogenous" reorganization of branch networks by constructing an IV which indicates whether both TD **and** CT branches were present in a 1 kilometer neighborhood surrounding each branch prior to the merger (i.e. 1999), since these branches were more likely to be closed. We also interact this dummy variable with an indicator equal to one for households patronizing TD or CT, as the non-merging banks likely reacted differently to the merger.

Results for the IV change regressions are presented in Table 12. The previous results showing that branch closures affect the usage of e-banking are amplified once we use our instrumental variables. Columns (1) and (2) in particular show that the effect of the opening/closing a local branch on $D.PC$ is about ten times larger in absolute value than the OLS estimates. This reveals the presence of important omitted variables in the OLS specifications, but does not support the hypothesis that the correlation is caused by banks anticipating future consumer usage decisions (i.e. downward rather than upward bias).[25] Looking at the group of people who used e-banking in the past (columns (5) and (6)), the coefficients on closures are less precisely estimated, but the qualitative implications are the same. This lack of precision is in part explained by the fact that conditioning on past users shrinks the sample by a third, which weakens our instruments. The IVs are particularly weak with respect to the smaller neighborhood definition (i.e. 1/2 kilometer), since the IVs are measured over a relatively large neighborhood which is better approximated by a 1 kilometer radius. Note also that it is difficult to find strong instruments in our context, since the timing of closures in a given neighborhood is not easily explained by variables varying only at the cross-sectional level.

The IV results are slightly different with respect to the usage of tellers. In particular, in Table 12 the comparison between the sub-sample of past teller users (i.e. columns (7) and (8)) and the full sample (i.e. columns (3) and (4)) indicates that only the sample of households who visited a teller in the previous year are affected by a change in their neighborhood branch network. For the sub-sample of past teller users, the effect of changing the density of branches on the teller-usage is positive and much larger in magnitude once we

their region average in order to control for regional differences (e.g. most Toronto neighborhoods are denser than almost any other neighborhood in the country).

[25]For the anticipation effect to be important we would need the presence of an unobserved variables affecting jointly the adoption/usage decisions of many households in the same neighborhood. Our results suggest either that households are sufficiently heterogeneous, or more likely that these spatially correlated unobservable variables are very persistent over time and are differenced out by our first-difference specification.

use the instrumental variables (as with PC-banking usage). For the full sample, however, the effect is not statistically different from zero, contrary to the OLS specification.

While it is intuitive that only consumers who frequently visit a teller would be affected by a change in the presence of a neighborhood branch, it is harder to understand why the full-sample estimates are positive and significant with OLS, but null in the IV specification. One interpretation is that households in the two samples behave differently with respect to unobservables, such that the correlation between the residuals and the change in neighborhood branch density is different between the groups (i.e. positive for the sub-sample of non-users and negative for the sub-sample of users). To see this, note that for past non-users, the observed positive correlation between branch density and $D.Teller$ must necessarily be coming from households who start visiting a teller after the opening of a new branch (i.e. *D.teller* is either zero or positive for past non-users). If new branch openings are planned such that demand for teller services is expected to grow, this correlation would be spurious, which would bias the OLS coefficient upward in columns (3) and (4) of Table 11. By using valid instruments this correlation should therefore vanish, as we observe in columns (3) and (4) of Table 12. For the user sub-sample, the comparison between the IV and OLS results reveal that the bias is more likely caused by an omitted variable which is negatively correlated with the change in branch density variables (i.e. reduction in hours of service prior to a closure), as in the PC-banking usage specifications.

Adoption probability results

Next we report results for the Probit regressions in Table 13. We estimate the transition probability that a particular household goes from not-having-adopted to having-adopted e-banking as a function of the change in its immediate neighborhood branch density. As before, we control for changes 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 of online services. Since Canadian banks are not allowed to price discriminate across regions and web interface is common, we are confident that our branch density variables are not correlated with any form of price discrimination strategy.

In addition to reporting results on the full sample of households (F, for full), we also present results estimated on a sub-sample of consumers whose local neighborhood contained both TD and CT branches prior to the merger. Analyzing the sub-sample of individuals whose local neighborhood contained both a TD and CT branch prior to the merger allows us to more cleanly identify the closure effect on adoption. This is because, as mentioned earlier, the merger between TD and CT resulted in branch closures exogenous to the diffusion of e-banking.

For both samples the decision to adopt online banking is positively correlated with changes 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. Note also that the effect of a change in neighborhood branch density is larger in the TD/CT subsample than in the full sample. This result is similar to the IV/OLS comparison discussed above, and suggests that the impact of $Dnbh$ is downward biased in the full sample. 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.

6 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. Since banks operate both online and offline channels, they have an incentive to manipulate the relative quality of the channels in order to drive consumers into the cheaper one. This is true in general for innovations in e-commerce. This paper sheds light on how firms can affect the relative attractiveness of their offline and online channels to encourage consumer adoption of innovations in e-commerce. We show that firms can encourage online adoption by rationalizing their retail network, but that their ability to do so depends on the level of competition in local markets.

To summarize our empirical results, we find support for the predictions from our model that banks can rationalize their branch networks in order to encourage adoption and that it is easier to do so in less competitive markets and for more dominant banks. We have shown that online banking diffusion is strongly correlated with market structure. We have done so in two ways. First, we show this correlation directly by regressing various measures of diffusion on initial market structure. We find that diffusion is fastest in more concentrated markets. We then use a two-stage approach in which we (i) show that initial market structure affects the changes in branch density (in more concentrated markets and in markets with more dominant banks there are more branch closures), and (ii) consider the effect of changes in branch density in a household's local neighborhood on its adoption and usage of e-banking. In this second stage, we show that branch closures have led to increased adoption and usage over the period 1999 to 2006.

Note that, though our analysis implies that the online and offline technologies are substitutes, banks cannot reduce their branch network to zero since there are many services that cannot be performed online (for instance cash withdrawals). In fact, as alluded to above, the data suggest that Canadians are not embracing internet-only (virtual) banks – less than 5 per cent of those surveyed report banking with a virtual bank and ING, the leading virtual bank in Canada, had deposits representing less than 1.5 per cent of total deposits in Canada by the end of our sample period. This fact also allows us to rule out an alternative explanation of the pattern of diffusion that we have uncovered here, namely that diffusion of online banking is led by virtual banks and traditional banks are responding to the inroads of virtual banks, when they promote their online channel.

In future work we will extend the analysis to focus more on consumer behavior and the substitution between branch and electronic banking. In particular, we might allow the cost of adopting e-banking 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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A Figures and Tables

Table 2: 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	50.0	58.1	62.3	61.8	66.5	70.3
Teller	80.6	77.4	75.2	73.5	72.1	74.5	67.1	73.2
ABM	90.4	90.4	90.2	90.5	88.9	89.4	89.0	90.5
Phone	43.5	46.6	47.6	47.8	45.8	48.7	47.7	45.9
PC	17.3	25.8	33.2	40.6	44.5	45.7	53.0	57.6
				Average Number of Transactions				
All channels	13.5	12.7	12.6	12.8	12.4	12.4	12.5	12.8
				Share of Total Transactions				
Teller	30.5	27.8	27.0	25.2	25.1	25.9	23.2	24.3
	[0.99]	[1.12]	[1.13]	[1.20]	[1.22]	[1.20]	[1.34]	[1.27]
Branch	83.3	79.8	76.9	73.9	72.3	70.7	68.1	66.9
	[0.27]	[0.30]	[0.33]	[0.35]	[0.37]	[0.38]	[0.41]	[0.42]
Phone	12.2	13.0	13.0	12.7	11.9	12.5	11.0	10.2
	[1.59]	[1.52]	[1.48]	[1.49]	[1.61]	[1.52]	[1.69]	[1.79]
PC	4.4	7.2	10.1	13.4	15.7	16.8	20.9	22.9
	[3.06]	[2.28]	[1.98]	[1.62]	[1.47]	[1.44]	[1.25]	[1.15]

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. Web access denotes the rate of household access to the internet from work and from home.

Table 3: 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

Table 4: Summary of Household Characteristics: 1999-2006

CHARACTERISTICS	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.

Table 5: Variable Description

	Name	Description
Dependent Variables:		
	D.PC use	1999 to 2006 log change in the intensity of online banking
	D.PC adopt	1999 to 2006 log change in online banking adoption
	D.Teller use	1996 to 2006 log change in the intensity of teller banking
	PC use	Intensity of online banking
	PC adopt	Adoption of online banking
	Teller use	Intensity if teller banking
	dbranchdens	1998 to 2006 log change in the number of branches per square kilometer in a market
Independent Variables		
Census division:		
	HH1998	Herfindhl-Hirschman index in 1998
	dhomeweb	log change in home internet access
	dworkweb	log change in workplace internet access
	avgdsl	Dummy variable for CD that have DSL access in 2006
	dpop	2001 to 2006 log change in population
	dshare2034	2001 to 2006 log change in the share of the population aged 20 to 34
	davgemp	2001 to 2006 log change in average level of employment
	davgincome	2001 to 2006 log change in average income level
Household:		
	Dnbh1	For each household i this is the change in the number of branches of household i's main bank within a circle with a 0.5Km radius centered on the households postal code
	Dnbh2	For each household i this is the change in the number of branches of household i's main bank within a circle with a 1.0Km radius centered on the households postal code
	Dweb01	Dummy variable for households that went from no internet access in 1999 to access in 2006
	Dweb11	Dummy variable for households that went from internet access in 1999 to access in 2006
	agecat2	Dummy variable for household respondent who is between the ages of 25 and 25 in 1999
	agecat3	Dummy variable for household respondent who is between the ages of 35 and 50 in 1999
	agecat4	Dummy variable for household respondent who is older than 50 in 1999
	school	Maximum level of education attained within a household

Table 6: Summary of Market Characteristics: 2001, 2004, 2006

	2001	2004	2006
Census:			
Population			
mean	106272		112132
median	38931		39817
sd.	253958		268366
Income			
mean individual	25459		30488
median individual	25062		29929
sd individual	4241		5489
Age			
mean share under 20	21.4%		20.0%
mean share 20-24	6.2%		6.1%
mean share 25-34	12.4%		11.8%
mean share 35-49	26.2%		24.1%
mean share 50-64	18.8%		22.1%
Employment			
mean	45.5%		47.7%
median	46.0%		48.1%
Share French			
mean	35.3%		35.1%
median	3.8%		3.7%
Business:			
Retail businesses / 10000 persons			
mean		16.3	
sd.		14.6	
Number of employees / business			
mean		10.8	
sd.		6.0	
Sales / employee (2001 CDN$)			
mean		1,540,022	
sd.		491,939	

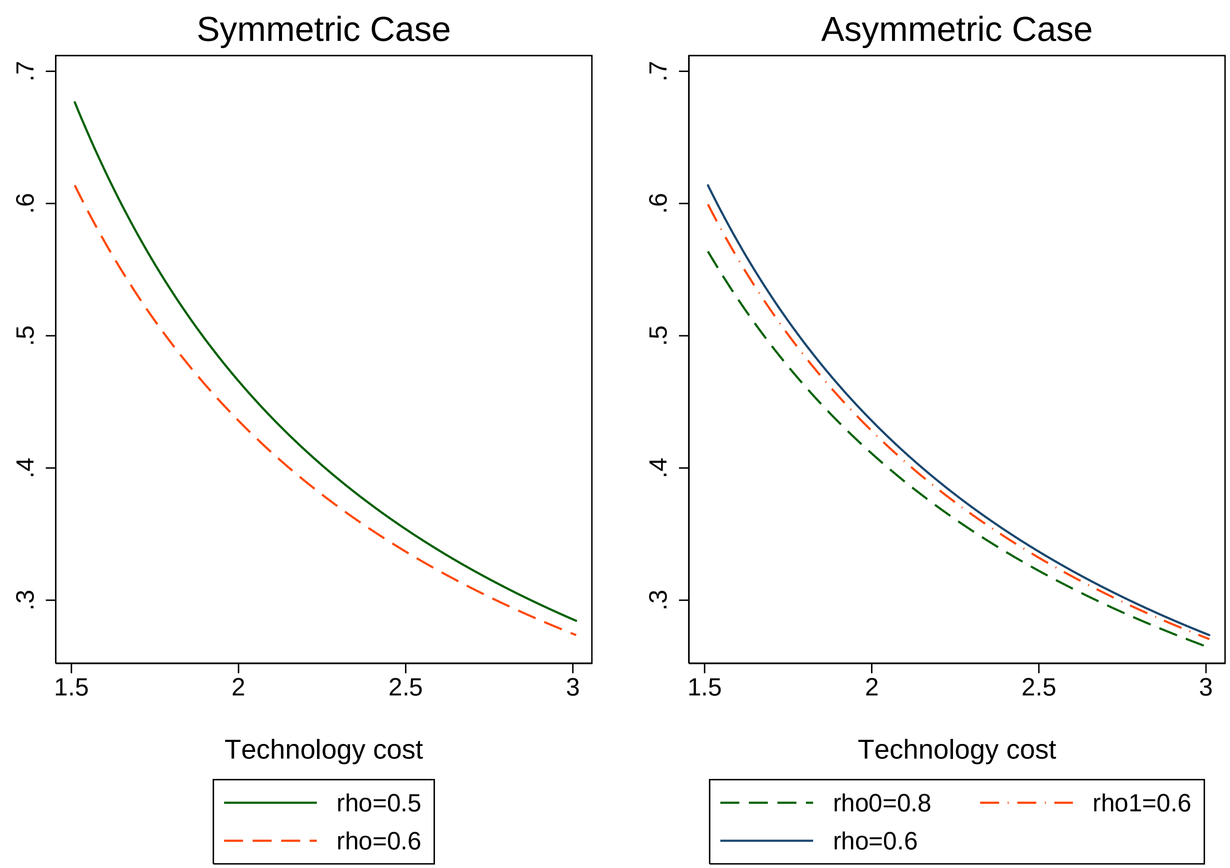

Figure 2: Steady-State Usage Rates for the Online-Quality Mechanism

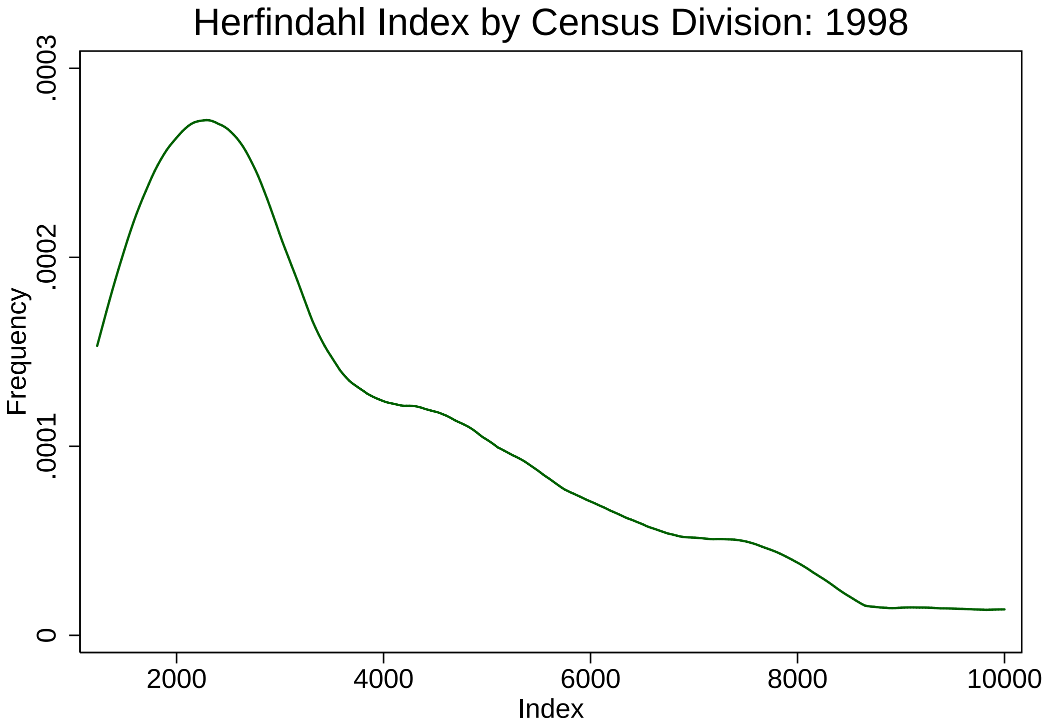

Figure 3: Kernel density of market concentration in 1998

Table 7: 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)	0.0138	0.206	-0.284	0.394	1.008	-0.517
		(0.18)	(2.14)	(-2.94)	(1.65)	(2.25)	(-2.32)
dhomeweb	Δ Home web	0.295	0.425	-0.168	0.264	0.361	-0.149
		(4.26)	(3.89)	(-2.16)	(3.16)	(2.52)	(-1.71)
dworkweb	Δ Work web	-0.0375	0.173	-0.0102	-0.0741	0.0962	0.0123
		(-0.41)	(1.35)	(-0.13)	(-0.85)	(0.70)	(0.14)
dpop	Pop. change	0.0961	0.0288	-0.117	0.140	0.120	-0.144
		(1.47)	(0.32)	(-1.95)	(2.62)	(1.23)	(-2.15)
dshare2034	Δ Share 20-34	-0.0212	-0.0250	-0.00246	-0.0246	-0.0322	-0.000374
		(-2.89)	(-1.81)	(-0.21)	(-2.89)	(-1.97)	(-0.032)
davgemp	Δ Employment	-0.219	-0.493	0.190	-0.318	-0.700	0.250
		(-1.98)	(-2.36)	(1.39)	(-2.35)	(-2.63)	(1.70)
davgincome	Δ Income	-0.00383	-0.0322	0.0357	0.0402	0.0607	0.00863
		(-0.089)	(-0.43)	(0.70)	(0.76)	(0.62)	(0.15)
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 8: 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)
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)
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)
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 9: The Change in the Number of Bank j's Branches per Capita

COEFFICIENT	LABELS	(1) dbranchdens	(2) dbranchdens
share1998	Bank i share of branches (1998)	-0.361	-0.257
		(-4.30)	(-2.64)
dpop	Δ Population (2006/19998)	0.244	0.317
		(2.56)	(3.19)
dshare2034	Δ Share 20-34	-0.0485	-0.0513
		(-2.13)	(-2.24)
demp	Δ Employment	0.229	0.128
		(1.33)	(0.72)
dinc	Δ Income	-0.213	-0.199
		(-1.83)	(-1.75)
share_dsl	DSL access	-0.118	-0.0673
		(-2.15)	(-1.19)
HHi1998	Competitors' HHI (1998)		0.238
			(2.62)
Observations		1229	1229
R^2		0.40	0.41

Robust t statistics in parentheses

Table 10: 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	(9) IV
HH1998	HH index (1998)	-0.987	-1.066	-1.247	-1.234	-1.214	-1.114	-1.081	-0.932	-0.288
		(-9.98)	(-10.7)	(-2.91)	(-3.27)	(-3.19)	(-2.84)	(-2.90)	(-2.37)	(-0.46)
dbank	Δ nb. banks	-0.243	-0.235	-0.391	-0.349	-0.351	-0.385	-0.388	-0.410	-0.524
		(-1.62)	(-1.65)	(-2.77)	(-2.45)	(-2.43)	(-2.51)	(-2.73)	(-2.98)	(-2.90)
dpop	Pop. change	0.224	0.205	0.449	0.515	0.362	0.421	0.700	0.485	0.824
		(1.14)	(1.15)	(1.85)	(2.39)	(1.66)	(1.80)	(3.07)	(2.43)	(2.65)
dshare2034	Δ Share 20-34	-0.141	-0.0887	-0.0499	-0.0651	-0.0674	-0.0865	-0.0663	-0.0810	-0.161
		(-2.06)	(-1.23)	(-0.56)	(-0.67)	(-0.68)	(-0.86)	(-0.69)	(-0.82)	(-1.25)
davgemp	Δ Employment	-0.171	-0.130	0.0958	-0.345	-0.363	-0.363	-0.442	-0.620	-0.738
		(-0.49)	(-0.40)	(0.21)	(-0.82)	(-0.81)	(-0.82)	(-1.06)	(-1.31)	(-1.20)
davgincome	Δ Income	0.804	0.659	0.706	0.704	0.725	0.732	0.643	0.639	0.524
		(4.94)	(3.88)	(3.13)	(3.07)	(2.96)	(3.17)	(3.13)	(2.83)	(2.19)
avgdsl	DSL access		-0.295							
			(-2.79)							
dteller	Δ Teller usage						0.697			3.140
							(1.48)			(2.07)
dpc_adopt	Δ PC adopt.					-0.353			-0.908	
						(-1.48)			(-1.90)	
dpc	Δ PC usage				-1.268			-2.379		
					(-2.88)			(-2.95)		
dhomeweb	Δ Home web			-0.714						
				(-2.60)						
dworkweb	Δ Work web			0.405						
				(1.38)						
Observations		245	245	85	85	85	85	85	85	85

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 11: Household Changes in Banking Habits - OLS

VARIABLES	(1) D.PC (F)	(2) D.PC (F)	(3) D.Teller (F)	(4) D.Teller (F)	(5) D.PC (U)	(6) D.PC (U)	(7) D.Teller (U)	(8) D.Teller (U)
Δ branch (1/2 Km)	-0.0153		0.0185		-0.0301		0.0189	
	(-2.54)		(2.09)		(-2.03)		(1.76)	
Δ branch (1 Km)		-0.0233		0.0416		-0.0646		0.0478
		(-1.58)		(1.98)		(-1.78)		(1.81)
Web ($0 \rightarrow 1$)	0.0487	0.0488	0.00291	0.00287	0.0929	0.0931	-0.00892	-0.00892
	(7.69)	(7.69)	(0.37)	(0.37)	(4.33)	(4.33)	(-1.02)	(-1.02)
Web ($1 \rightarrow 1$)	0.0251	0.0250	-0.00230	-0.00222	0.0812	0.0810	-0.00293	-0.00278
	(11.1)	(11.1)	(-0.73)	(-0.70)	(9.38)	(9.34)	(-0.75)	(-0.72)
Age: $25-35$	-0.0393	-0.0395	0.0204	0.0206	-0.0528	-0.0526	0.0405	0.0405
	(-2.52)	(-2.53)	(1.99)	(2.00)	(-2.11)	(-2.10)	(2.26)	(2.26)
Age: $35-50$	-0.0417	-0.0418	0.0108	0.0109	-0.0536	-0.0532	0.0320	0.0319
	(-2.74)	(-2.74)	(1.08)	(1.09)	(-2.19)	(-2.17)	(1.83)	(1.82)
Age: 50+	-0.0454	-0.0455	0.0130	0.0130	-0.0710	-0.0706	0.0433	0.0432
	(-2.99)	(-3.00)	(1.30)	(1.30)	(-2.89)	(-2.88)	(2.48)	(2.47)
Δ income	0.0112	0.0117	0.0110	0.0104	0.00945	0.0101	0.0203	0.0197
	(0.74)	(0.77)	(0.71)	(0.67)	(0.39)	(0.41)	(1.21)	(1.18)
Schooling	0.000544	0.000561	-0.00122	-0.00124	0.00108	0.00114	-0.00129	-0.00131
	(1.20)	(1.24)	(-2.06)	(-2.10)	(0.98)	(1.03)	(-1.75)	(-1.79)
Observations	12755	12755	12755	12755	4700	4700	9816	9816

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.

Table 12: Household Changes in Banking Habits - IV

VARIABLES	(1) D.PC (F)	(2) D.PC (F)	(3) D.Teller (F)	(4) D.Teller (F)	(5) D.PC (U)	(6) D.PC (U)	(7) D.Teller (U)	(8) D.Teller (U)
Δ branch (1/2 Km)	-0.226		0.0168		-0.677		0.418	
	(-1.86)		(0.13)		(-1.48)		(2.02)	
Δ branch (1 Km)		-0.325		-0.0525		-1.202		0.531
		(-2.04)		(-0.29)		(-1.31)		(1.76)
Web ($0 \to 1$)	0.0482	0.0488	0.00291	0.00287	0.110	0.111	-0.00530	-0.00714
	(7.40)	(7.64)	(0.37)	(0.36)	(4.05)	(4.23)	(-0.53)	(-0.80)
Web ($1 \to 1$)	0.0268	0.0255	-0.00229	-0.00207	0.0909	0.0843	-0.00613	-0.00290
	(10.3)	(11.0)	(-0.68)	(-0.65)	(7.59)	(8.56)	(-1.33)	(-0.73)
Age: $25-35$	-0.0355	-0.0383	0.0204	0.0209	-0.0660	-0.0603	0.0315	0.0365
	(-2.18)	(-2.43)	(1.94)	(2.03)	(-2.17)	(-2.18)	(1.41)	(1.91)
Age: $35-50$	-0.0390	-0.0404	0.0108	0.0113	-0.0701	-0.0591	0.0256	0.0273
	(-2.46)	(-2.63)	(1.07)	(1.12)	(-2.32)	(-2.21)	(1.19)	(1.46)
Age: 50+	-0.0429	-0.0440	0.0130	0.0135	-0.0859	-0.0764	0.0379	0.0392
	(-2.73)	(-2.88)	(1.29)	(1.34)	(-2.85)	(-2.84)	(1.76)	(2.10)
Δ income	0.00445	0.0115	0.0109	0.0103	0.00187	0.0151	0.0316	0.0194
	(0.28)	(0.76)	(0.69)	(0.67)	(0.070)	(0.58)	(1.68)	(1.15)
Schooling	0.000344	0.000587	-0.00122	-0.00123	-0.000695	0.000785	-0.000664	-0.00126
	(0.69)	(1.27)	(-2.01)	(-2.07)	(-0.40)	(0.63)	(-0.77)	(-1.68)
Observations	12755	12755	12755	12755	4700	4700	9816	9816

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.

Instrumental variables = population per square Km, average retail sales, and a TD/CT customer indicator.

Table 13: 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)	-0.259		-0.423	
		(-2.62)		(-2.68)	
Dnbh2	Δ branch (1 Km)		-0.155		-0.256
			(-0.62)		(-0.62)
Dweb01	Web ($0 \rightarrow 1$)	0.763	0.761	0.608	0.596
		(11.4)	(11.4)	(4.34)	(4.26)
Dweb11	Web ($1 \rightarrow 1$)	0.698	0.695	0.728	0.706
		(14.6)	(14.6)	(7.49)	(7.38)
workweb	Web (work)	0.186	0.186	0.298	0.299
		(3.61)	(3.62)	(2.81)	(2.84)
agecat2	Age: $25 - 35$	-0.355	-0.366	-0.641	-0.652
		(-2.18)	(-2.25)	(-1.75)	(-1.79)
agecat3	Age: $35 - 50$	-0.380	-0.389	-0.421	-0.438
		(-2.45)	(-2.50)	(-1.20)	(-1.25)
agecat4	Age: 50+	-0.524	-0.532	-0.620	-0.635
		(-3.41)	(-3.46)	(-1.77)	(-1.81)
hldincome	Hld. income	0.176	0.174	0.0698	0.0671
		(2.65)	(2.63)	(0.52)	(0.50)
school	Schooling	-0.00807	-0.00795	0.00332	0.00363
		(-0.91)	(-0.90)	(0.19)	(0.21)
Observations		7190	7190	1756	1756

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 TD/CT customer indicator.