Market Structure and the Diffusion of Electronic Banking[*]

Jason Allen
Bank of Canada

Robert Clark
HEC Montréal

Jean-François Houde
University of Wisconsin-Madison

February 12, 2008

Abstract

This paper studies the role that market structure plays in affecting the diffusion of electronic banking. Electronic banking represents a process innovation since it reduces the cost of performing many types of transactions for banks. However, electronic banking (and electronic commerce more generally) is particular since the full benefits for firms from adoption only accrue once consumers begin to perform a significant share of their transactions online. Since it is costly for consumers to switch to the new technology (they must learn how to use it) banks 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 since 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 bank. Based on the Beggs and Klemperer (1992) model of price competition, 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 a measure of branch quality (namely branch density).

PRELIMINARY. PLEASE DO NOT CITE

JEL classification: D14, D4, G21, L1

[*]Correspondence to Jean-François Houde: University of Wisconsin-Madison, Madison, Wisconsin; 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 as well as Peter Kascor at Credit Union Central of Canada for information on credit unions. We thank the Big 6 Canadian banks for giving us access to IT executives who patiently answered many of our questions. We thank Gautam Gowrisankaram and Randy Wright for comments and suggestions as well as seminar participants at the Bank of Canada, the Competition Bureau, and HEC Montréal. The views in this paper do not necessarily reflect those of the Bank of Canada. All errors are our own.

to our knowledge, has not been studied. There has, however, been some work examining the effect that 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. But 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 affect the relative attractiveness of online versus offline transactions in order to encourage consumers to adopt the less costly technology. Evidence suggests that offline price and the local availability of offline outlets can affect the use of electronic commerce by consumers (see Goolsbee (2000), Prince (2006), and Forman, Ghose, Goldfarb (2006)). 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 (apparently this was the approach employed by banks in Scandinavia to encourage consumers to switch to online banking (The Economist, June 14th 2007)).

The ability of firms to make these adjustments depends on the level of competition in the local market. There is evidence that competition plays a role in affecting banks' reorganization decisions. For instance, Cohen and Mazzeo (2005) analyze the effect of market structure on branching decisions and find that branch networks are larger in more competitive markets. Therefore, in more competitive markets, reducing the attractiveness of traditional retail stores by closing branches involves the risk of losing customers (or potential customers) to competitors, whereas, this is less of a concern for a more dominant bank. In the case of e-banking, instead of encouraging a pre-emptive technology adoption motive, increased competition generates a business stealing effect, slowing the penetration of the cost-reducing technology.[4]

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 usage/adoption of electronic banking. We find that competition tends to increase the quality of branch networks offered by banks

[4] The relative concentration of banking markets in Scandinavian countries has been put forth as an explanation for the high rates of adoption of other types of electronic payment technologies (Milne 2005).

and therefore decrease 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, in contrast with our hypothesis, 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. Over the past decade, the largest Canadian banks have profoundly changed their way of offering retail banking services. The Canadian industry features a small number of large banks that traditionally provided an extensive network of branches for their clients. However, between 1998 and 2006 the top eight Canadian banks on average reduced the number of retail branches they operated by 21 per cent.[5] 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 online operations. Canadians have quickly become among the world's heaviest users of electronic payments. The number of transactions performed electronically increased from 47 million to over 300 million from 2000 to 2006 (Canadian Bankers Association), while the share of consumers who did at least some online banking increased from 3 per cent in 1998 to 43 per cent in 2006.

In order 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 first is the Canadian Financial Monitor (CFM) database compiled by Ipsos-Reid Canada. This data set contains information on the usage of different banking channels in the period immediately following the introduction of online banking in Canada (1999-2006), 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 produced by 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.[6] With this information we construct measures of branch density (number of branches per capita) 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 and automated bank machines (ABM's) (See Kiser (2004), Bernhardt and Massoud (2004), and Grzelonska (2005). In the case of Canada, a recent study found that 56 per cent of respondents chose a bank because if its convenient branch

[5] To be precise, it is the top eight banks other than TD Bank Financial Group which we exclude from this measure since it closed many branches as a result of the 2000 merger with Canada Trust.

[6] For the most part, we will define a local market to be a census division, of which there are 288 in Canada.

and ABM network (Deutsche Bank (2005))).[7]

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 initial market structure affects the change in the number of branches per capita in the market. In more concentrated markets and in markets with more dominant banks there are more branch closures. Having shown this, we confirm that this translates into an effect on e-banking by establishing that a significant relationship exists between branch closures (or changes in the number of branches per capita) and e-banking usage. We study this relationship first at the market level and then we provide further evidence by performing a household-level analysis in which we consider the effect of changes in branch density in a household's local neighbourhood on their usage and adoption of e-banking. We show that branch closures cause increased usage and adoption.

We conclude that initial market structure and branch network reorganization have an effect, therefore, on e-banking usage. Our results do not suggest that the mechanism described in Emre, Hortaçsu, and Syverson (2006), whereby firms reorganize their retail network in response to the diffusion of e-commerce, does not exist. Rather, we provide evidence of an additional incentive to reorganize one's retail network. In markets such as banking, where firms offer both an online and offline channel, closures can encourage adoption.

very satis¯ed), and the reason they bank online is convenience (in 2004 78 per cent of Canadians said they adopted because online banking was more convenient).[14]

3 Model

In the literature studying the adoption of process innovations ¯rms must decide when to incur the cost of adopting a new technology. The focus has been on the trade-o® that ¯rms 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 faster in more competitive markets.

In the context of markets where the bene¯ts from a new technology only accrue once consumers have switched to it, the primary 'adoption cost' that ¯rms 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 (so we can think of these resources as spending on promotion or on enhancing 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 di®usion of ebanking. To do so, we develop a model of bank competition with switching costs based on Beggs and Klemperer (1992) in which consumers must decide where to periods and are assumed to never switch away from the bank they patronized in previous periods.[16] Competition, therefore is in order to attract new consumers.

When banks employ the Online-Quality mechanism they have incentive to spend on 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 (in other words, spending on online quality bank j will be allowed to switch away. The utility maximization problem is the following:

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

$$\Rightarrow \mu(Q_b) = \frac{p_b - p_e - Q_b}{\lambda}; \quad (2)$$

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

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

The problem of new consumers is first to decide which bank to patronize, and then the proportion of transactions performed 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, $z(\mu_0; \mu_1)$:

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

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:

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

where $p_e - c_e > p_b - c_b$ (i.e. the markups on electronic transactions is higher than on teller 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 exit (switch) and it captures a fraction $z(\mu_0;\mu_1)$ of the exiters (switchers) from both banks ($(1-\rho_0)x$ of its own switchers and $(1-\rho_1)(1-x)$ from bank 1)). The first term in (5) represents bank 0's current revenue from the two channels since current period sales are given by $F($ $)$ 5iz 1.11471.49TD[())-37666ycJ-35 by ρ_0 to condition on the survival rate at bank 0). The problem of bank 1 is defined symmetrically, replacing x by $1 - x$ and z by $(1 - z)$.

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

$$\begin{aligned} 0 = {} & \left(\frac{1}{\rho_0}\frac{\partial F(x|\mu_0,\mu_1)}{\partial \mu_0}\right)\left[(1-\mu_0)(p_b - c_b) + \mu_0(p_e - c_e)\right] \\ & + \left(\frac{F(x|\mu_0,\mu_1)}{\rho_0}\right)(p_e - c_e - (p_b - c_b)) - C\frac{\partial Q_b(\mu_0)}{\partial \mu_0} + \delta \frac{\partial V_0(F(x|\mu_0,\mu_1))}{\partial F(x|\mu_0,\mu_1)}\frac{\partial F(x|\mu_0,\mu_1)}{\partial \mu_0} \end{aligned}$$

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 when reducing the quality of branching services between *technology penetration* and *business stealing*. The first term represents the business stealing effect and is negative since $z(\mu_0,\mu_1)$ is decreasing in μ_0 (increasing quality causes usage to decrease and market share to increase). The second term represents the technology penetration effect and is positive since when μ_0 increases more transactions are performed using the more profitable channel. Note also that since greater usage is associated with lower quality, the third term is 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:

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

$$\Rightarrow \mu(Q_o) = \frac{P_b - P_e + Q_o}{\lambda}. \tag{7}$$

Writing the indirect utility function solely as a function of $\mu(Q_o)$ (by replacing $Q_o(\mu) = -P_b + P_e + \lambda\mu$) 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, we can write bank 0's Bellman equation as follows:

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

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

$$\begin{aligned} 0 \;=\; & \left(\frac{1}{\rho_0}\frac{\partial F(x|\mu_0,\mu_1)}{\partial \mu_0}\right)\left[(1-\mu_0)(p_b-c_b)+\mu_0(p_e-c_e)\right] \\ & +\left(\frac{F(x|\mu_0,\mu_1)}{\rho_0}\right)(p_e-c_e-(p_b-c_b)) - C\frac{\partial Q_o(\mu_0)}{\partial \mu_0} + \delta\frac{\partial V_0(F(x|\mu_0,\mu_1))}{\partial F(x|\mu_0,\mu_1)}\frac{\partial F(x|\mu_0,\mu_1)}{\partial \mu_0}. \end{aligned}$$

In contrast with the first order condition given above 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 usage to increase 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. Note here that that 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 as long as the profit from an e-banking transaction (π_e) is greater than for a branch transaction (π_b) and that the consumer price of an e-transaction is less than that same transaction performed at a branch.

The results of the numerical exercise are summarized in Figure 1, which shows steady-state

Table 1: Numerical values for the model parameters

Technological familiarity:	λ	$[1.5, 3]$
Bank fixed cost:	C	2
Switching cost:	ρ_j	$\{0.5, 0.8\}$
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

usage rates when banks employ the two mechanisms for different values of λ (i.e. the technological familiarity parameter) and ρ_j (i.e. the switching cost). The top two figures characterize what happens when banks employ the Branch-Quality mechanism, the bottom two characterizes behaviour for the Online-Quality mechanism. In each figure, the solid line represents the usage in the situation where switching costs are symmetric across banks ($\rho_0 = \rho_1 = \rho$), while the dotted and the dashed lines are usage of the firms with high and low switching costs respectively. The first thing to note is that, for both mechanisms and regardless of the cost of switching, as λ falls, usage increases. This is not surprising as we would expect online usage to increase 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, using the Branch-Quality mechanism we observe that as ρ increases (moving from the left panel to the right panel), usage increases. This is because in less competitive markets branch quality is lower and this generates higher usage. The opposite is true when banks use the Online-Quality mechanism. As ρ increases, we see that usage decreases. In less competitive markets online quality is lower and usage is lower. What is going on 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 the only thing preventing banks from lowering quality is 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, and therefore usage is as well.

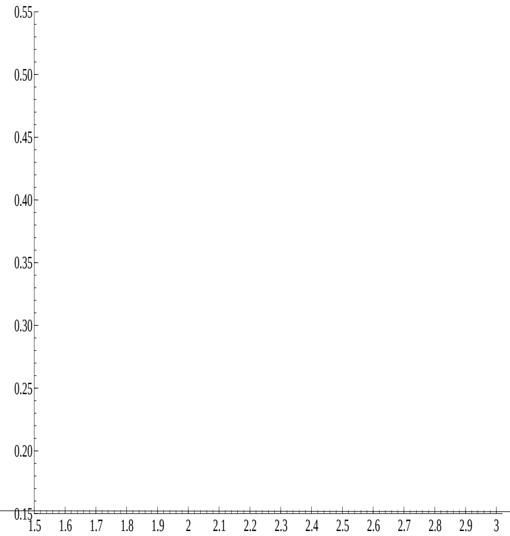
Second, we study the effect of increasing the dominance of one of the banks. We consider the situation with asymmetric switching costs. For the Branch-Quality mechanism we find that the bank with the higher switching cost generates higher usage. Since its switching cost is higher, it worries less about losing customers to its rival and so can afford to lower quality resulting in higher usage. Again, 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. Again, 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.*

Figure 1: Steady state usage rates



(a) Branch quality model with high switching cost (b) Branch quality model with low switching cost

(c) Online quality model with high switching cost (d) Online quality model with low switching cost

4 Empirical Analysis

In this section we present empirical evidence that suggests that banks employ the Branch-Quality mechanism (rather than the Online-Quality mechanism). The model predicts that if using the Branch-Quality mechanism, banks that operate in less competitive markets or that are dominant will lower branch service quality in order to encourage consumers to use the online channel. To test this prediction we combine two unique data sets. The ¯rst contains information on the usage of di®erent banking channels, along with detailed information on the demographic characteristics of respondents. The second contains the location information of all branches in our sample period and is used to construct a measure of branch density with which we proxy for 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 electronic payment technologies as well as banking relationships and detailed demographic characteristics. This is done by combining Census information with household ¯nancial data obtained from the \Canadian Financial Monitor" (CFM) survey results compiled by Ipsos-Reid.

We use the complete survey results { 1999 to 2006. On average there are approximately 12,000 Canadians surveyed per year (staggered evenly by quarter), with a non-trivial number of individuals staying in the survey for more than 1 year and up to 8 years.[17] 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.

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.[18] 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 internet bill payments were more likely to be conducted by younger households, those with

[17] There are a total of 76204 people in the sample. Of these, we observe 24 113 just once, 15 600 twice, 11 238 three times, 8 676 four times, 6 645 ¯ve times, 4 764 six times, 3 3(to)-347(u12(¨ .4wcboox)-3(.4e13ristics.)54(4)-)-3are4o-9v2427(too-9)27(v6923.

high income and home ownership, those with better education and those who hold white collar jobs. Summary statistics are presented in Table 2. Summary statistics are conditioned on the respondent's sex {which, the majority of time, is female (approximately 76 per cent).

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
Maximum: age	51.9	51	15.1
Maximum: education	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:†

of PC-transactions has increased substantially over the sample period, from 4.2 per cent to 19.5 per cent of total transactions. Table 4 breaks down the e-banking activities of Canadians into four main categories. The majority of e-banking is for day-to-day purposes, typically bill payment and transfers. Online banking is therefore a substitute for teller-banking. The second most popular use of banking websites is to gather information. This includes gathering information on mortgages, investments, and credit cards. Most Canadians do not perform credit or investment activities online.

Table 3: Summary of Banking Channel Usage

TYPE	1999	2000	2001	2002	2003	2004	2005	2006
Adoption rates								
Respondent: PC at work	52.7	58.1	67.7	71.0	72.0	72.5	75.0	75.7
Maximum: PC at work	58.2	62.4	71.1	74.1	75.3	75.7	77.9	78.3
Teller	82.8	80.7	78.0	77.1	77.0	76.4	71.8	75.4
ABM	72.0	71.6	72.3	73.0	71.8	71.2	70.9	69.8
Phone	30.3	31.7	32.3	31.6	30.6	30.6	30.3	29.2
PC	13.4	17.3	25.8	32.5	34.7	36.8	41.3	42.8
Share of Total Transactions								
Teller	27.8	28.1	26.6	25.7	25.7	26.4	24.8	26.1
ABM	57.5	55.5	54.1	53.0	51.0	48.8	48.7	46.5
Phone	10.5	10.3	10.0	9.4	9.3	9.5	8.2	8.2
PC	4.2	5.9	9.2	11.9	14.0	15.3	18.3	19.2

Note: Rates and shares are reported in percentage points.

Table 4: Summary of e-banking Activities

Activity	2001	2002	2003	2004	2005	2006
Share day-to-day	66.2	69.7	72.9	75.2	76.5	77.1
Share information gathering	24.8	22.2	18.9	16.2	14.6	14.7
Share credit	3.8	3.9	4.0	4.0	4.5	4.2
Share investment	5.2	4.2	4.1	4.5	4.4	3.9

Note: Usage rates and shares are reported in percentage points.

4.1.2 Branch Density

Our measure of bank quality is the density of its branch network. This seems like a realistic approximation given the empirical evidence provided in Kiser (2004), Bernhardt and Massoud (2004), and Grzelonska (2005). Branch location information on all ¯nancial institutions in Canada has been scanned and transferred to electronic ¯les 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 via the Accountability Act), and location data provided directly by some of the banks. In what follows we provide a description of the data.[20]

At the market level we want to examine the impact of density variables on bank-channel adoption. Summary statistics are reported in Table 5. The average number of branches in a market is 4 per square kilometer and 5.7 per 100 000 people. The average change in branches per capita (*dbranchcap*) is -21 per cent. The average change in branches per square kilometer (*dbranchdens*) is -17 per cent. Rationalization of branches (most precisely measured as *dbranchdens*) is consistently high for the di®erent group sizes, although highest for the largest banks. We include these variables in the regression analysis reported in section 4.2.[21]

Table 5: Summary of Bank Statistics: 1998-2006

	Total		Large		Medium		Small	
VARIABLE	Mean	SD	Mean	SD	Mean	SD	Mean	SD
branchdens	4.0	14.9	11.6	24.6	0.69	0.33	0.11	0.08
dbranchdens	-0.17	0.43	-0.22	0.43	-0.14	0.44	-0.14	0.41
branchcap	5.71	6.65	12.5	9.1	4.27	0.79	1.73	0.83
dbranchcap	-0.21	0.43	-0.18	0.50	-0.19	0.35	-0.24	0.45

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.

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.[22] With the acquisition TD acquired approximately 600 branches. We can assume that many of these branches were closed to save costs. Similarly we can

[20] At the time of this paper we do not have access to all of the banks ABM network, limiting the 10mTJET0-327(to)-498(branc)29(s)]TJ-1

assume some of the TD branches were closed in favour of keeping open a more e±cient Canada Trust branch. Fortunately TD Bank has provided us with a list of closures, including dates, for these type of branches. We therefore control for closures by TD Bank that are likely to be merger-related.

4.1.3 General Market 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, and employment. Summary statistics on key variables are reported in Table 6. We use this information to control for local market activities which might a®ect a bank reorganization decisions.

4.2 Analysis

The theoretical model presented above predicts that if using the Branch-Quality mechanism, banks that operate in less competitive markets or that are dominant will lower branch-service quality in order to encourage consumers to use the online channel. We test this prediction by proxying for branch service quality with the number of branches per capita in the market, and by studying the relationship between market structure, branch-service quality, and di®usion of e-banking. As mentioned above, we de¯ne a market as being a census division of which there are 288.

We start by studying the e®ect of initial market structure on branch-network rationalization to con¯rm that banks operating in less competitive markets and more dominant banks have a greater incentive to lower quality. Having shown this, we con¯rm that this translates into an e®ect on e-banking by establishing that a signi¯cant relationship exists between branch closures (or changes in the number of branches per capita) and e-banking usage. We study this relationship ¯rst at the market level and then provide further evidence by performing a household-level analysis in which we consider the e®ect of changes in branch density in a household's local neighbourhood on their usage of e-banking.

4.2.1 E®ect of initial market structure on changes in branch-service quality

At the market level, de¯ned at the census division level (288 markets), we study factors in°uencing the change in branch service quality, (proxied for by branches per capita). In order to control for the year 2000 merger between TD Bank and Canada Trust we attribute all TD Canada Trust closures to the merger. In effect, we assume that TD Bank's decision to close branches was never in order to encourage its consumers to adopt online banking.

Table 7 presents regression results for the change in the number of branches per capita in market m ($branchcap_m$) over the sample period on market structure variables:

$$\log(\frac{branchcap_{m06}}{branchcap_{m98}}) = \theta HH98_m + \lambda nbcomp98_m + Z_m\gamma + \epsilon_m; \qquad (9)$$

where $HH98_m$ is the initial (1998) level of concentration of all the banks in the market, $nbcomp98_m$ is the initial number of competitors in the market, and Z_m is a vector or market variables that includes the average age of individuals living in the market, their average income, and the average employment level.

From column (1) we see that the initial market structure variables, $HH98_m$ and $nbcomp98_m$; are both negative and significant which implies that when the market is initially more concentrated, more branches are closed. Controlling for the initial number of banks, an increase in the initial Herfindahl index implies that the market is less competitive. Controlling for the initial Herfindahl index, an increase in the number of competitors makes the market less competitive in the sense that it implies the existence of at least one more dominant firm. These results provide empirical evidence in support of the Branch-Quality mechanism. The number of branches per capita is smaller in more concentrated markets.

Columns (2) through (5) of Table 7 include controls for changes in PC banking or PC/Phone banking (Home banking) usage and/or adoption levels during the sample period. We can see that the market structure result does not change.[23] We discuss the relationship between e-banking and branch closures in further detail in Section 4.2.3 below.

In Table 8 we present regression results for the change in the number of bank j's branches per capita in market m ($branchcap_{jm}$) over the sample period on market structure variables:

$$\log(\frac{branchcap_{jm06}}{branchcap_{jm98}}) = \alpha share98_{jm} + \theta HH98_{jm} + \lambda nbcomp98_m + Z_m\gamma + \epsilon_{jm}; \qquad (10)$$

[23] We instrument for changes in e-banking usage or adoption with change in web access since this variable is highly correlated with e-banking usage and adoption but should not affect closures independently. Note that there are only 84 observations in these regressions since we can only calculate a reliable measure of e-banking usage rates for 84 of the census divisions in 1998.

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. Our results provide further support for the second prediction of the model, that if using the Branch-Quality mechanism, more dominant banks have more incentive to lower branch-service quality. We ¯nd that a larger initial market share is associated with more branch closures. This result is consistent regardless of speci¯cation. We consider three di®erent speci¯cations to capture the e®ect of rival attractiveness/competitiveness. From column (3) we see that the more rivals bank j has initially ($nbcomp98_m$) the more it closes over the sample period. This is because, given j's market share, the more rivals j has, the fewer branches each has, thus making them less attractive. Similarly, in column (2) we report the e®ect of the Her¯ndahl index of bank j's rivals in 1998 ($HH98_{jm}$). The more concentrated are j's rivals, the fewer branches j closes. In column (1) we control for the Her¯ndahl index and the number of rivals simultaneously. When doing so, the coe±cient on the Her¯ndahl index is no longer signi¯cant while the coe±cient on ($nbcomp98_m$) is still negative and signi¯cant. The interpretation of this coe±cient is di®erent than when ($nbcomp98_m$) enters on its own. Controlling for the initial Her¯ndahl index, an increase in the number of rivals implies the existence of at least one more dominant rival for bank j. One might therefore expect this coe±cient to be positive and for bank j to close fewer branches, but it may be that rivals are less attractive to consumers on average if one is quite large and others are small, or that the more dominant rival is more attractive and branch closures are strategic complements (if j faces a more attractive rival and its rival closes more branches, j can close more branches also).

4.2.2 E®ect of changes in branch-service quality on e-banking usage and adoption

We know from our ¯rst set of regressions that initial market structure a®ects closures. Having shown this, we con¯rm that this translates into an e®ect on e-banking. We do so by establishing that a signi¯cant relationship exists between branch closures (or changes in the number of branches per capita) and e-banking usage. We study this relationship ¯rst at the market level and then provide further support by performing a household-level analysis in which we consider the e®ect of changes in branch density in a household's local neighbourhood on their usage of e-banking.

In Table 9 we report results for the following regression

$$\log(\frac{ebanking_{m06}}{ebanking_{m98}}) = \beta \log(\frac{branchcap_{jm06}}{branchcap_{jm98}}) + Z_m \gamma + \epsilon_m; \qquad (11)$$

where $ebanking_{mt}$ is either PC or PC and Phone (Home) banking usage or adoption in market m

in period t. We test the e®ect of the change in the number of branches per capita in the market on the change in e-banking usage and adoption rates. We ¯nd that initial market structure a®ects the change in Home banking usage and adoption but does not have a signi¯cant e®ect on the change in PC banking. These results suggest that the closures that occur in less competitive markets are driving consumers into both PC and Phone banking. The results are qualitatively similar if we instrument for closures using the initial market structure variables ($HH98$ and $nbcomp98$).

To con¯rm that e-banking usage depends on closures we look deeper into the data to determine whether at the household level, branch density in°uences the decision to use e-banking. As mentioned above our measure of branch quality is branch density. Branch density is made household-speci¯c by counting the number of branches of a particular household's bank in a circle with a 1 kilometer radius around the centroid of that household's postal code (nbh). The mean number of own-bank branches per neighborhood of this type is 0.44 with a variance of 0.82. The minimum is zero and the maximum 21.

Parameter estimates from the following Tobit regressions are estimated for the share of PC and Home banking. Parameter estimates are reported in Table 10.

$$share^*_{it} = \max(0; \theta nbh_{ijt} + X_{ijt}\beta + Z_{jt}\gamma + \epsilon_{ijt}); \quad share^*_{it} = \begin{cases} \text{Share-pc} \\ \text{Share-Home} \end{cases}; \qquad (12)$$

where $share^*_{it}$ is household i's usage of either PC or Home banking in period t, the X_{it} are household control variables, and the Z_{it} market control variables. We ¯nd that PC and Home usage are both negatively correlated with the bank-branch density variable.[24,25] The result is qualitatively the same as we extend the size of a household's neighborhood.

Another advantage to the household level analysis is that it allows us to address the simultaneity bias that may exist since not only may branch closures lead to adoption and usage of e-banking by consumers, but adoption and usage of e-banking by consumers (or the anticipation thereof) may lead

[24] Our results regarding the impact of the various demographic variables are consistent with those reported in Stavins (2001).

[25] We have come across one other paper that looks at the e®ect of distance to branch on adoption of electronic banking, Khan (2004). Our results di®er from Khan (2004) along a number of dimensions. Most importantly, Khan ¯nds that distance does not matter for adoption. However, we have a much larger and richer data set. For example, we know the location of each of the household's bank's branches in their neighborhood which allows us to construct a measure of quality that captures the density of the branch network. Khan only uses the reported "distance to main branch" as the hypothesized explanatory variable. We also ¯nd that younger Canadians are more likely to adopt online banking than older Canadians. Khan ¯nds that older Americans are the more likely adopters. This result is hard to rationalize given what is known about the adoption of new technologies more generally - younger individ8(tt8rcv)30(er,)-360(w)29e

to branch closures. To address this problem we restrict attention to the sub-sample of consumers whose main financial institution was TD Bank or Canada Trust. Most TD or CT branch closures during our sample period were the result of the merger of these two institutions and were not the result of e-banking. If, following the merger, branches were located within two kilometers of each other, generally one was closed down. PC and Home usage are both still negatively correlated with branch density in the restricted sample.

We also test whether usage changes as a function of branch closures. We estimate the following regression:

$$\Delta share_{ijt} = \theta \Delta nbh_{ijt} + X_{ijt}\beta + Z_{jt}\gamma + \epsilon_{ijt}; \; share_{ijt} = \begin{cases} \text{Share-pc} \\ \text{Share-Home} \end{cases} \quad (13)$$

and present results in Table 11. We find that a change in the number of branches inside of a household's local neighbourhood is correlated with a change in PC usage. Column (3) includes only TD and CT customers and the results are unchanged.

mechanism), then it should be faster in more competitive markets, and therefore the closures that might result from the fact that consumers are less in need of branches would also occur faster in more competitive markets.

5 Conclusion

In this paper we have studied the relationship between market structure and the di®usion 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 bene¯ts from its introduction depends on the decisions of consumers to perform electronic transactions. This is true in general for innovations in electronic commerce. This paper sheds light on how banks can a®ect the relative attractiveness of their o²ine 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

References

Allen, J. and W. Engert (2007). E±ciency and competition in canadian banking. *Bank of Canada Review*, Summer 2007.

Beggs, A. and P. Klemperer (1992). Multi-period competition with switching costs. *Econometrica*, 651{666.

Bernhardt, D. and N. Massoud (2004). Endogenous ATM location and pricing. mimeo.

Bordo, M. (1995). Regulation and bank stability: Canada and the united states, 1870{1980. World Bank Working Paper No. 1532.

Boston Consulting Group (2003). Online bill payment: A path to doubling pro¯ts.

Cohen, A. and M. Mazzeo (2005). Investment strategies and market structure: An empirical analysis of bank branching decisions. Mimeo, Federal Reserve Board.

Deutsche Bank (2005). E-banking snapshot.

DeYoung, R., W. Lang, and D. Nolle (2007). How the internet a®ects output and performance at community banks. *Journal of Banking & Finance*, 1033{1066.

Emre, O., A. Hortaçsu, and C. Syverson (2006). E-commerce and the market structure of retail industries. NBER working paper 2005-24.

Fudenberg, D. and J. Tirole (1985). Preemption and rent equalization in the adoption of new technology. *The Review of Economic Studies 52* (3), 383{401.

Gowrisankaran, G. and J. Stavins (2004). Network externalities and technology adoption: Lessons from electronic payments. *Rand Journal of Economics*, 678{693.

Grzelonska, P. (2005). Bene¯ts from branch networks: Theory and evidence from the summary of deposits data. Manuscript.

Hamilton, B. and B. McManus (2005). Technology adoption and market structure: Evidence from infertility treatment markets. mimeo, Olin School of Business.

Hannan, T. and J. McDowell (1984). The determinants of technology adoption: The case of the banking ¯rm. *Rand Journal of Economics*, 328{335.

Kamien, M. and N. Schwartz (1982). *Market Structure and Innovation*. Cambridge: Cambridge University Press.

Karshenas, M. and P. Stoneman (1993). Rank, stock and order e®ects in the di®usion of new process technologies: An empirical model of adoption duration. *Rand Journal of Economics*, 503{528.

Khan, B. (2004). Consumer adoption of online banking: Does distance matter? University of California at Berkeley working paper E04-338.

Kiser, E. (2004). Predicting household switch behavior and switching costs at depository institutions. *Review of Industrial Organization*, 349{365.

Levin, S., S. Levin, and J. Meisel (1987). A dynamic analysis of the adoption of new technology: the case of optical scanners. *Review of Economic Studies*, 12{17.

Milne, A. (2005). What's in it for us? network e®ects and bank payment innovation. Bank of Finland discussion paper 16-2005.

Reinganum, J. (1981a). Market structure and the di®usion of new technology. *Bell Journal of Economics*, 618{624.

Reinganum, J. (1981b). On the di®usion of new technology: A game theoretic approach. *Review of Economic Studies*, 395{405.

Schmidt-Dengler, P. (2006). The timing of new technology adoption: The case of mri. working paper.

Seim, K. and B. Viard (2006). The e®ect of market structure on cellular technology adoption and pricing. working paper.

Stavins, J. (2001). E®ect of consumer characteristics on the use of payment instruments. *New England Economic Review*, 19{31.

Table 6: 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%	
Occupation		
share management	8.3%	
share business/¯nance/administration	13.8%	
share sales/services	22.9%	

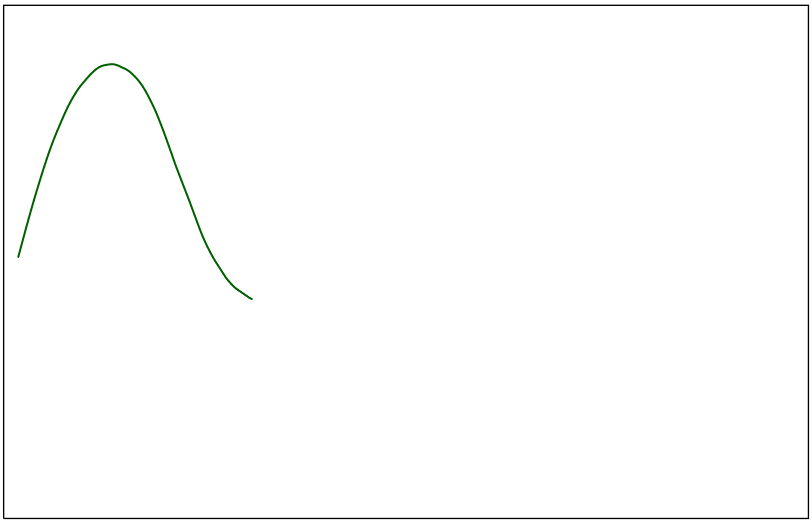


Table 8: The Change in the Number of Bank j's Branches per Capita

COEFFICIENT	LABELS	(1) dbranchcap	(2) dbranchcap	(3) dbranchcap	(4) dbranchcap
share98	Branch share in 1998	-0.556***	-0.348***	-0.541***	-0.308***
		(0.095)	(0.093)	(0.095)	(0.090)
HHi98	Competitors' HH in 1998	-0.121	0.161***		
		(0.078)	(0.059)		
nbcomp98	Nb. competitors in 1998	-0.0530***		-0.0444***	
		(0.0088)		(0.0067)	
dpop	Pop. change (2006/1998)	-0.721***	-0.763***	-0.721***	-0.776***
		(0.15)	(0.15)	(0.15)	(0.15)
age	Age (2001)	-0.00888	-0.00822	-0.00863	-0.00852
		(0.0055)	(0.0057)	(0.0055)	(0.0056)
avgincome	Avg. income (2001)	0.307	-0.323	0.335	-0.600*
		(0.40)	(0.39)	(0.40)	(0.36)
avgemp	Employment (2001)	0.0000924	0.000694	0.000274	0.000514
		(0.0015)	(0.0015)	(0.0015)	(0.0015)
Observations		1116	1116	1116	1116
R^2		0.44	0.42	0.44	0.42

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 9: Change in E-Banking Usage/Adoption as a Function of the Change in the Number of Branches Per Capita

COEFFICIENT	LABELS	(1) D.pc	(2) D.home	(3) D.pcadopt	(4) D.homeadopt
dweb	Change in web access (2006/1998)	1.609***	0.554***	1.509***	0.424***
		(0.49)	(0.16)	(0.23)	(0.14)
dtotbranchcap	Change in total branch per capita (2006/1998)	-0.319	-0.443***	0.0409	-0.486***
		(0.40)	(0.14)	(0.25)	(0.17)
dpop	Pop. change (2006/1998)	0.211	0.237	-0.243	-0.466
		(1.20)	(0.44)	(0.76)	(0.45)
age	Age (2001)	-0.0272	-0.000127	0.00354	0.0133
		(0.058)	(0.024)	(0.036)	(0.021)
avgincome	Avgerage income (2001)	-7.831***	-2.601***	-3.072**	-1.289
		(2.64)	(0.89)	(1.50)	(0.78)
avgemp	Employment (2001)	0.0314*	0.0149	0.0210**	0.0151
		(0.019)	(0.010)	(0.010)	(0.0096)
Observations		84	84	82	84
R^2		0.35	0.33	0.43	0.29

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 10: Household Level E-banking Usage Rates - Tobit

COEFFICIENT	LABELS	(1) PC usage	(2) Home usage	(3) PC usage	(4) Home usage

Table 11: Household Level Change in E-banking Usage Rates

COEFFICIENT	LABELS	(1) D.Home usage	(2) D.PC usage	(3) D.PC usage
Dnbh2	Change in 1 Km nbh.	-0.0364	-0.0550**	-0.0796*
		(0.038)	(0.025)	(0.047)
web	Web access	0.0315***	0.0267***	0.0372***
		(0.0079)	(0.0039)	(0.0080)
age	Age (in 1999)	0.000312	0.0000450	0.0000521
		(0.00031)	(0.00016)	(0.00030)
avgschool	Average HH schooling	0.00107	0.0000487	0.0000696
		(0.0016)	(0.00089)	(0.0021)
Constant		-0.117**	-0.0377	0.00265
		(0.050)	(0.025)	(0.035)
Observations		3626	3626	727
R^2		0.01	0.02	0.04

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

All speci¯cations also include occupation dummies, year/bank ¯xed e®ects

Column 3 includes only CT and TD consumers