NETWORK EXTERNALITIES
AND
SHARED ELECTRONIC BANKING NETWORK ADOPTION

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Network Externalities and Shared Electronic Banking Network Adoption

Abstract

A unique data set is used to examine the determinants of membership in the Yankee 24 shared Automated Teller Machine (ATM) network. Recent work suggests that the presence of demand side network externalities influences the decision to join a network. A model is constructed in which characteristics of the bank and the market affect the value of the network externality. A hazard function is estimated to gauge the strength of these various influences in determining network membership. The results accord with the theoretical model and show that the size of the existing network and the number of expected locations in the network, proxied by the number of branches in a bank's market, are both strong influences on network adoption that are external to the individual bank.

Network Externalities and Shared Electronic Banking Network Adoption

1. Introduction

In the last decade information and physical networks in banking and other services have consolidated greatly. In particular, Automated Teller Machine (ATM) networks have managed to increase the number of their cardholders and transactions overall, while ATM activity has become concentrated in fewer and larger networks.[1] The presence of network economies on both the demand and cost side, which may be external to an individual network member, can contribute to the growth and consolidation of the industry.[2] With positive network externalities, the value of network participation to a potential member grows as the network grows. The incentive to take advantage of substantial network externalities can result in rapid growth of a network under the expectation that others will participate in the network. In this paper we will test the hypotheses that the size of the network influences the adoption decision and that rapid growth of an individual ATM network will occur in markets that are expected to generate large network externalities.

Related work on adoption of ATMs is found in Hannan and McDowell (1984, 1987), who use a hazard function to estimate the factors that influenced banks to adopt ATMs in the 1970s, before the advent of shared ATM networks. Saloner and Shepard (1992) use a hazard function approach to test for the presence of an internal "network effect" in the ATM adoption decision for banks in the 1970s using the size of the individual bank's branch network as a proxy for the expected size of the bank's proprietary ATM network.

This paper faces a different task because in a shared ATM network the

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[1]McAndrews (1991) documents the extent of the consolidation in shared ATM networks.

[2]See Heal (1990), for example.

network effects are external to the firm. The number and location of other participants who install ATMs in the network affect the convenience that a bank's own customers can enjoy when that bank is a member of the network. As a result of this feature of shared networks, multiple equilibria may exist in the adoption process. A small or large network may be the outcome of the adoption decisions of the potential members depending on whether the potential adopters expect that few or many others will adopt network membership.

To test whether network externalities influence network participation, we use the size of the existing network and characteristics of the markets in which the banks participate as explanatory variables. If a market is one in which there is expected to be many locations from which a bank customer can access her account through the ATM network (for any given expectations on adoption decisions), then the external benefits of network participation are greater than they would be in a market in which few network locations are expected. This, in turn, will make more probable a high-participation equilibrium in the market with many expected locations.

Yankee 24 offers a good case to characterize the adoption process. Yankee 24 (often abbreviated to "Yankee" in what follows) started in 1983 and restricted membership to Connecticut banks until 1987.[3] During that time it grew to become the largest network in New England in number of affiliated ATMs. In 1987 membership was offered to all the depository institutions in the other five New England states. Yankee 24 was the most prominent network offering its services to the upper New England depositories. Competitive pressure, although increasing during the sample period, was relatively light.

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[3]This restriction was not as a result of regulation, but rather a management decision.

Our sample includes the five upper New England states over the period 1987 through 1991. We group our sample into 96 local banking markets: 31 MSAs and 65 counties. We eliminate Connecticut from consideration to avoid the issue of start-up of the network, and the fact that the Connecticut banks had a longer period over which to adopt Yankee membership. We limit our study to commercial and savings banks because these institutions are the largest and most important members of Yankee in terms of cardholders and ATM deployers, and because we can obtain consistent data on their characteristics over the sample period. Figure 1 shows the adoption pattern in our sample of banks. Over the course of the sample, approximately 47 percent of the banks in the sample adopted Yankee membership.

The remainder of the paper is organized as follows. In Section II a model of network adoption is developed. In Section III the history of Yankee 24 and other features of the markets are reviewed. Section IV presents the estimation method and explains the data. The results of the empirical estimation are presented in Section V, and Section VI concludes.

2. Model

There are many useful models of network adoption; Katz and Shapiro (1986) and Farrell and Saloner (1986) both examine the issue. To test for the presence of network externalities on the adoption process, we will adopt the model of Cabral (1990), that allows for heterogeneity in the benefits available from network membership, and is explicitly dynamic. The benefits flowing from membership upon adoption are $B(h,N,t)$, where N is the measure of adopters at time t, h is a parameter that characterizes an individual bank (the higher the h for a bank, the higher is the benefit from adopting Yankee membership, all other things remaining equal), and t is time. We assume that B is smooth, that the first partial derivatives exist, and that h has a smooth c.d.f., F(h).

The assumption that there are externalities in network participation is captured by $B_N > 0$. We further have that $B_h > 0$, and $B_t > 0$. The latter assumption reflects the exogenous trend to increased benefits from adoption of the shared network technology, reflecting improvements in the technology itself.

We assume that banks have alternatives to network membership that yield the flow of benefits per unit of time that we set equal to zero. This is a convenient normalization, and without loss of generality so long as all potential adopters face similar opportunity costs of adoption.

In equilibrium, all types h for which $B(h,N,t) \geq 0$ will adopt membership. The set of static equilibrium adopters is then described as follows. Let the level of h of the potential adopter who is indifferent to adopting given N and t be denoted by i(N,t); that is $B(i(N,t),N,t) = 0$. Define $H(N,t) = 1 - F(i(N,t))$. H(N,t) is the set of potential adopters who have levels of h high enough to make it worthwhile for them to adopt in period t, when N total banks adopt. A static equilibrium for time t is a measure of adopters, N, such that $N = H(N,t)$. We define s(t) as the set of static equilibrium measures of adoption for each time t.

It is well known that s(t) is not single valued, that is, there are typically multiple static equilibria. Broadly speaking, the equilibria can vary from one in which there is wide participation, encouraging even low-benefit (low h) types to adopt early, to low participation, in which only the high-benefit types adopt. Furthermore, there are multiple equilibrium adoption paths. An equilibrium adoption path is a function $N^*(t)$ such that $N^*(t) \in s(t)$ for all t. The equilibrium paths vary from one with a strong bandwagon effect in which many quickly join, encouraging even low-benefit types to join, to slow inertial paths, in which only high-benefit types join early, discouraging low-benefit types from joining until the network has grown larger. Cabral shows that if there is a slight delay in observing the adoption decision of others, then there is a unique adoption path, the lower envelope of the set s(t) for all t.

Our empirical results center on three features of Cabral's model of adoption. First, one's adoption decision is influenced by the number of other adopters. Second, in any static equilibrium, directly as a result of the definition of equilibrium, the adopters have higher levels of h than the nonadopters. Third, in any equilibrium adoption path, the sets of adopters (if we are observing an equilibrium with adoption) at times $t_2 > t_1$ are such that $N^*(t_1) \subseteq N^*(t_2)$, that is, the set of adopters is cumulative. Because we assume that $B_t > 0$, along any equilibrium adoption path there will be no reversals of adoption. Because of this feature, and because $B_N > 0$, it is also true that those who adopt earlier have a higher level of h than those who adopt later.

These three features of the model of adoption yield the hypotheses for our empirical investigation of the adoption of Yankee 24 membership. First, we expect that a measure of the size of the network will be a significant influence in the adoption decision. Second, those banks that adopt Yankee 24 membership will be those who will derive greater benefits from the network, independently of the number of other adopters, than those who do not join during our sample period. Third, high-benefit banks will adopt earlier than other banks.

What bank types will enjoy high benefits from network participation? In other words, what is the form of the function B(h,N,t)? ATMs are used to provide services to bank customers; shared ATM networks allow one bank's customer to access his or her account at machines owned by other network-members at ATM locations that might be convenient for the customer at a given time. Network benefits to a bank's customer per period have been modeled by Saloner and Shepard (1992) as being equal to [a(X) + b(m)], where a(X) is the "stand-alone" benefit from the network, X is a vector of characteristics of a bank and its market, and b(m) is the benefit the customer gets as a result of being able to access her account at the m network-affiliated machine locations. The function b(m) is increasing in m. Machine deployment requires expenditure of a fixed cost, so that it requires a minimum expected number of customers to deploy a machine. Hence the number of machines and machine locations, both for an individual bank and for the network, depends positively on the number of banks that have joined the network; that is, m is an increasing function of N. Finally, a bank, through fees charged to its own customers, can capture some portion, λ, of these benefits that flow to its n customers. Following Saloner and Shepard, we expect these benefits to grow over time at the rate g^t, where g is the rate of technical progress.

Banks may also experience indirect benefits from adoption by substituting the Yankee provision of services for costly labor or branches that it would otherwise have to use to provide services. These savings can be thought of as being equal to $C(w,r,Q) - C_Y(w,r,Q)$, where $C(w,r,Q)$ is the cost function for a bank that does not adopt Yankee membership, evaluated at wage rate w and capital rental rate r, and at output level Q, and C_Y is the cost function of a Yankee member bank.

The costs of adoption of Yankee 24 are twofold. There is an adoption fee, fees for bringing ATMs on-line, and regular assessments for network services. Adoption fees for Yankee were equal to $5000 for the first six months of the sample period, $0 for the next three months, $5000 for the next nine months, and $50 thereafter. We will denote the adoption fee by P(t). There were no direct dividends paid to owner-members during the sample period. Fees for bringing ATMs on line will be related to the number of ATMs a bank has before joining Yankee, which we will proxy by the size of a bank's branch network. We assume that transaction fees are paid by the bank customers. Second, there may be opportunity costs if a bank, before adoption of membership, already has a proprietary ATM network from which it enjoys internally generated network benefits, or if there is a strong rival network in the bank's market. These costs we will denote $C_o(B,R,t)$, where B is a bank's own branches, and R is a measure of the presence of rival networks. Because banks place ATMs in their branches (see Saloner and Shepard(1992)), it is more likely that banks with large branch networks had active proprietary networks in 1987, hence their opportunity costs of Yankee network membership would be higher. If a large rival network is present in a bank's market, then Yankee faces more effective competition and the opportunity costs of Yankee membership in that market are higher than in a market without such strong competition (the level of competition may change through time so C_o is time-varying).[4]

In sum, banks are likely to enjoy net discounted benefits from Yankee adoption in time period T according to a function

$$\pi=\sum_{t=0}^{\infty} \delta^t \lambda n[a(X) + b(m(N))]g^{T+t} + C(w,r,Q) - C_Y(w,r,Q) - F(T) - C_o(B,R,T)$$

where the sum is taken over the period from 0 to infinity, and where δ^t is the discount factor. We can express this simply as $\pi = B(h,N,T)$; where $h = h(X,n,w,r,Q,F,B,R)$. The benefit function is increasing in the number of

[4]Another possible benefit from network adoption is that individual members may expect to earn "interchange" revenue from other member banks by deploying ATMs that other member-banks' customers use. In our view, this transfer among members is a more significant issue for ATM deployment than for adoption of membership itself.

locations at which a bank's depositors can conveniently access their accounts, a factor related to the number of other adopters of network membership. It is also increasing in the current wage rate paid by the bank, in the cost of and need for new branches, and in the number of one's own customers, and decreasing in the number of one's own branches. This last effect suggests that geographically small banks, that is, those with a small branch network, are likely to benefit most from network membership. Net benefits to Yankee adoption are reduced by the presence of rival networks, and are influenced by bank size and other features of the banking market, such as concentration, denoted by X.

3. Yankee 24

New England Network Inc. is the Connecticut-based owner of the Yankee 24 shared electronic fund transfer network. The network was officially organized in August 1983 by the nine largest banks in Connecticut. Together they accounted for more than 50 percent of the state's banking assets and had more than 400 ATMs. The network organization was then called Connecticut Switch Inc., and was established as a nonstock, nonprofit membership corporation. The nine founders secured permanent control of the governance of the network for themselves. In July 1984, Yankee 24 went into operation and began to seek other banking firm members.

In 1985, Yankee 24 became the largest New England shared electronic banking network in terms of number of ATMs shared and interbank ATM transactions. However, there were some other shared networks in New England.[5] We will

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[5]Significant shared networks in Massachusetts included MONEC owned by Bank of Boston, X-PRESS 24 owned by BayBanks, Inc., and CASHNET owned by Shawmut Corp., Boston. INSTACARD, owned by Maine National Bank, operated in Maine, and the POCKETBANK shared network in New Hampshire was owned by 7 members. The ACCESS shared network owned by The Howard Bank, Burlington, was dominant in Vermont.

explicitly include the presence of these competitive networks in our estimation to observe the effects of the presence of competition on the growth of Yankee.

By the fourth quarter of 1986, two years after the network went into operation, the Yankee 24 shared electronic fund transfer network had 127 members and 789 ATMs. In February 1987, banking firms in other New England states were allowed to join the shared network organization, when the network's marketing staff were actively soliciting new members in those states, based on prior approval by the network's board of directors. Throughout the sample period Yankee 24 continued to be the dominant shared electronic banking network in New England. By April 1991 it included more than 700 network members, in which 500 were active and on-line, and had more than 4,000 ATMs accessible to all members' ATM cardholders.

Our study will examine the factors that raised the probability of early adoption by banking firms in the five upper New England states: Massachusetts, Maine, New Hampshire, Rhode Island, and Vermont. The restriction to these states allows us to focus on the growth of Yankee starting in January 1987, when membership was offered to depositories in these states, and to focus on the growth of a network that was, in effect, the focal network to begin with. Yankee's prior success in Connecticut showed depositories in neighboring states that the Yankee management was capable and that the Yankee services were in demand in markets much like their own. Yankee's installed base of membership in 1987 was already larger than that of any competing network. Hence, Yankee offered a network technology that had many advantages over its rivals. Yankee, we believe, was the clear leader among shared network alternatives for those institutions considering such a move. We will not assume, however, that competitive pressure on Yankee was constant over the sample period. In fact, with the introduction of the MAC and NYCE networks to New England in the late 1980s, competitive pressure was increasing.

4. Estimation and Data

Recall that the net discounted benefits received by a bank from adoption at time T, when N other banks are in the network, are

$$\pi = \sum_{t=0}^{\infty} \delta^t \lambda n[a(X) + b(m(N))] g^{T+t} + C(w,r,Q) - C_Y(w,r,Q) - F(T) - C_o(B,R,T)$$

$= B(h,N,T)$; where $h = h(X,n,w,r,Q,F,B,R)$ The larger the h, the greater the net benefits that will flow from the Yankee adoption decision, for any given level of other adopters. Hence for any given set of expectations on the adoption level of other potential adopters, there will be a threshold level of h so that all those with h_i above that level will adopt in that time period, while those with h_i below that level will wait to adopt. Because we've assumed that $g > 0$, $B(h_i,N,T+1) \geq B(h_i,N,T)$. For a given bank, if $B(h_i,N,T) \geq 0$, then that bank adopts membership.

There may be idiosyncratic variation in the value banks place on network membership after accounting for all the observable influences mentioned above. To take account of these idiosyncracies, let ϵ_i, represent the per period deviation of bank i's valuation of membership from the average of banks with the same levels of the other variables in π, where $E(\epsilon_i) = 0$. Hence, we have that when $B(h_i,N,T) + \epsilon_i \geq 0$, or when $\epsilon_i \geq -B(h_i,N,T)$, then the bank adopts. We define the critical level of ϵ_i, by the equation

$$e_i^*(h,N,T) = \sum_{t=0}^{\infty} \delta^t \lambda n[a(X) + b(m(N))] g^{T+t} + C(w,r,Q) - C_Y(w,r,Q) - F(T) - C_o(B,R,T).$$

Then ϵ_i^* is the ϵ_i of the bank with the level of h_i that is just indifferent to joining Yankee when it expects N banks to be members of Yankee at the end of the period.

The probability that a bank will adopt membership in period T given that it expects there to be N Yankee members at the end of the period, and given that it has not adopted membership in previous periods, is

$$(2)\quad \frac{G[e^{*}(X,n,w,r,Q,F,B,R,T{+}1)] - G[e^{*}(X,n,w,r,Q,F,B,R,T)]}{1 - G[e^{*}(X,n,w,r,Q,F,B,R,T)]},$$

where G(·) is the cumulative distribution function of ϵ_i. This expression is the "hazard rate."

We will estimate equation (2) by means of the Weibull model of duration. It is a standard technique to estimate hazard rates for data sets that have been "right-censored," because not all banks adopted membership by the end of the sample period. The Weibull distribution allows for a monotonic hazard rate, and we will incorporate covariates to test the validity of our model of adoption.

In the hazard model employed, the time to adoption is grouped into quarterly intervals. We let X_i be the vector of characteristics of the bank and β be the coefficients to be estimated, then the probability that bank i adopts before time T is given by

$$G(X_i, \beta, T, \alpha) = 1 - \exp\,[-(e^{X_i B})\,T^{\alpha}]\,.$$

The parameter α is a measure of the rate at which the hazard rate changes over time.[6] The hazard rate is increasing as α is less than one, and decreasing as α is greater than one. The hazard rate is then given by $\alpha\exp(X_i\beta)t^{\alpha}$. As Saloner and Shepard (1992) point out, the Weibull offers a useful

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[6]The Weibull distribution function is typically written as

$$F(t) = 1 - \exp(-\lambda t^{\alpha}).$$

We let $\lambda = \exp(X_i\beta)$ to incorporate the effects of explanatory variables; see Kiefer (1988).

interpretation of the coefficients; the estimated coefficients measure the derivative of the log of the hazard rate with resect to X. The likelihood function to be estimated will be

$$\prod_{i=1}^{m} g(X_i B, T, \alpha)^{d_i} [1 - G(X_i B, T, \alpha]^{1-d_i}$$

where g(•) is the density function, and G(•) the cumulative distribution function for the Weibull distribution. The dummy variable d_i takes on the value 1 when bank i adopts Yankee membership in the sample period, and it takes on the value 0 if bank i has not adopted Yankee membership by the end of the sample period and is therefore a censored observation.[7]

To determine the impact of factors influencing network membership, we collected data that includes the identity and timing of adoption of all Yankee 24 members; population data from the Bureau of Census, information on deposit accounts and location of branches from the Federal Reserve's Summary of Deposit report; information on expenses and deposits for banking firms operating in New England from the Federal Reserve System's Call Reports. Data on the presence of rival networks in New England during the sample period was obtained from the Bank Network News, a publication of Faulkner and Gray, Publishers. Membership adoption dates and membership fees were provided by New England Network Inc. Call report data, including bank characteristics and financial performance, were obtained from the Federal Reserve Board.

We obtained a list of 577 Yankee 24 members based on 1991 data. For the purpose of this study, the sample was restricted to commercial banks and

[7]In our formulation, as in Saloner and Shepard (1992), a positive coefficient increases the hazard rate, i.e., leads to quicker adoption, and a negative coefficient tends to decrease the hazard rate.

savings banks. Thus, 221 credit unions or savings and loans are excluded, resulting in 356 member banks. We restricted this list further to include only banks whose home office was in the upper New England states excluding Connecticut. We merged this data set with the data on all the banks in the upper New England states that had continuously reported on both the Call Reports and the Summary of Deposits during the sample years of 1987 through 1990. We eliminated those banks that entered or exited the market during the sample period, or those banks that for some other reason, did not have a continuous record of data on the Call Report and Summary of Deposit report during the sample period, and 246 banks and savings banks remained in the sample. Eliminating banks in the upper New England states that were founding members of Yankee 24, or were affiliated with founding members through a bank holding company, yielded 242 banks in the sample as shown in Table 1.

The estimation will include various characteristics of the market in which a bank participates. The market areas are defined to be the Metropolitan Statistical Area (MSA) in which a bank branch is located, or if it is not in an MSA, then the county (excluding any part of the county that may be in an MSA) in which the bank branch is located.

Our measures of the base of Yankee membership, the adoption price of Yankee membership, and the degree of competitive presence are all time varying. The other variables are non-time-varying. We now wish to discuss the covariates and how they proxy for the features mentioned earlier.

(1) LAGBASE: the installed base of Yankee members in a market, measured by the percentage of a market's deposits that are in banks that have adopted Yankee membership by the previous quarter. Depending on the nature of the equilibrium path in the adoption game, the sign of the

coefficient can be negative in a strong bandwagon effect equilibrium path when many adopt early, or positive in an inertial equilibrium adoption path, in which the network effects are not expected to accrue until late in the sample period. If there were no network externality present, adoption would be unrelated to the installed base of users, and the coefficient would be zero.[8]

(2) OWNBRANCH: the total number of branch offices operated by the bank. This is a measure of the "internal network effect" that a bank may have been capturing prior to joining a shared network. Saloner and Shepard (1992) found this variable to be positive and significant in explaining adoption of ATMs by banks in the 1970s, prior to sharing. To the extent that it does measure the internal network effect, and therefore an opportunity cost of joining Yankee, we would expect the coefficient on this variable to be negative.

(3) MKTBRANCH: a weighted average of the per capita number of branches (of all the banks) in the markets in which a bank has a branch. This variable is a measure of the number of locations at which a bank's customers can access their accounts once a bank joins Yankee. Why should it be a proxy for Yankee locations? There are three reasons; first banks typically place ATMs in their branch

[8]This variable, as well as the MKTBRANCH, MKTPOP, CONCENTRATION, and POPCHANGE variables, is a weighted average of the values of the variable in the markets in which the bank has a branch. The weights are the shares of the bank's total deposits that the bank has in branches located in each market. For example, if a bank participates in two markets and has 75 percent of its deposits in its branches in market A, and 25 percent of its deposits in branches in market B, then the market variable would be a weighted average of the values of the variables in markets A and B, with the weights being 75 percent and 25 percent for that bank.

offices, and given a constant proportion, regionwide, of Yankee adoption, those markets with a large number of branches should have more Yankee ATM locations than those with few branches. Second, this variable is meant to capture other features (geographic and demographic) of the market that result in more branch service delivery. Finally, it is likely that the use of network locations will be greatest within market, rather than equally distributed across Yankee's service region. In other words, we expect that the externalities generated through Yankee will be primarily local (i.e., within the local banking market). We expect the sign of this variable to be positive.

(4) MKTPOP: a weighted average of the population in the markets in which a bank has a branch in 1980. This variable provides a control for the MKTBRANCH variable, since those markets with high population will have a large number of branches as well. While it is a measure of the size of the market of the bank, it is not clear how this would influence adoption. We have taken the log of population, since the variable is skewed to the right.

(5) POPBRANCH: Because there may be nonlinearities in the relationship of MKTBRANCH and MKTPOP on adoption, we include the product of MKTBRANCH and MKTPOP. Hence, POPBRANCH = MKTBRANCH * MKTPOP.

(6) LNDEP: log of total demand deposits. This is a measure of the number of customers of a bank. The logarithm is used because of the skewed distribution of deposits and because of its correlation with branches. This measure is used because the Summary of Deposit report did not collect data on the number of deposit accounts during the sample period.

We expect the sign of this coefficient to be positive.

(7) PRICE: the price of joining the Yankee network. PRICE equals $5000 for the first nine months of the sample period, $0 for the next three months, $5000 for the next nine months, and $50 thereafter. We would expect that a high adoption price would tend to discourage adoption, and so we expect a negative coefficient on PRICE.

(8) COMPETITION: a measure of the size and number of rival shared ATM networks in New England. COMPETITION is created by counting the total number of network-affiliated ATMs in New England in each state and in each year of the sample. After subtracting the number of Yankee-affiliated ATMs, the remainder is divided by the number of rival shared ATM networks operating in the particular state. Hence the larger are the competing networks, the higher will be COMPETITION. The model suggests that a larger network, other things equal, would be more attractive to a potential member. We expect competition to attract some of the banks who otherwise would have joined Yankee. So we expect the coefficient associated with COMPETITION to be negative.

(9) POPCHANGE: a weighted average of population growth in the markets in which a bank has a branch over the period 1980 to 1990.[9] This proxies for growth in demand for banking services, something that should increase the demand for shared network services. It furthermore represents those areas in which new branches might be called for; hence, Yankee membership, to the extent it can substitute for the building of branches, should be more desirable in the areas in which population

[9]This variable is expressed as the change in population per square mile from 1980 to 1990. Because the geographical areas did not change over this period, it measures only the change in population.

grew. We expect this coefficient to be positive.

(10) SAL-EMP: salary per employee, defined as salaries and employee benefits over full-time equivalent employees. This variable is a measure of the wage rate paid by a bank, and to the extent that Yankee membership can substitute for costly bank employees, we would expect it to have a positive coefficient.

(11) OCC-EXP: occupancy expenses per branch per asset, which equals occupancy expense and furniture and equipment divided by the number of bank branches and then by assets (all for 1987). This variable measures the "bricks and mortar" expense of a bank per branch per dollar of assets, and we would expect a positive coefficient to the extent that Yankee membership can substitute for traditional bricks and mortar.

(12) CONCENTRATION: the four-firm concentration ratio. CONCENTRATION provides a measure of the degree of competition in each market at the start of the sample period. The effect of oligopolistic competition in the market on adoption of Yankee membership is uncertain.

(13) BHCDUMMY: a dummy variable that assumes the value 1 if the bank is a member of a bank holding company. As is the case with OWNBRANCH, this variable would be associated with banks that were more likely to have had a proprietary network prior to 1987. For this reason, we would expect a negative coefficient.

Descriptive statistics for variables used in the hazard model appear in Table 2.

5. Results

Results of the estimation of the model are presented in Table 3; standard errors are in parentheses below the estimated coefficient, the t statistics are in the second column, and the significance levels are in the third column. The log-likelihood ratio is -395.8, and the estimator converged relatively quickly. The variables are all of the expected sign, with the exception of the OWNBRANCH and POPCHANGE variables. With the exception of the OCC-EXP, OWNBRANCH, POPCHANGE, SAL-EMP, and LNDEP variables, the coefficients are significant at the 5 percent level.

The negative coefficient on the LAGBASE variable suggests that, consistent with the low level of competition in shared networks in the region in 1987, and the success of Yankee in Connecticut, the sample population expected a high participation equilibrium to occur, and a strong bandwagon effect developed. This inference is supported by the negative coefficient on COMPETITION; the measured competition grew over the sample period. It is further highlighted by the coefficient on α, which reveals that, after taking account of the variables in the estimation, the hazard rate was increasing. This is consistent with the assumption of an increase in the technology of ATMs and broadly consistent with the literature on the diffusion of technology. The strongly negative coefficient on LAGBASE, however, is more novel and is in accord with the network externality theory.

The insignificant coefficient on OWNBRANCH rejects the hypothesis that OWNBRANCH is both a good measure of a bank's proprietary network and that there were significant opportunity costs in joining a shared network. More important, though, the insignificant coefficient on OWNBRANCH suggests that the network effect in a shared network is not derived only at the level of a bank's own branch network, as was found to be true in Saloner and Shepard with regard to proprietary (nonshared) ATM networks in the 1970s.

The positive coefficient on MKTBRANCH reflects the fact that banks in markets that have more branch offices per capita tend to adopt membership sooner than banks in other markets. Combining the effects on the hazard function of MKTBRANCH in both the MKTBRANCH and POPBRANCH variables we can use the fact that the coefficient in a Weibull estimation is the derivative of the log of the hazard rate. Calculating, we have that (dln[hazard])/(dMKTBRANCH) = .012, with a standard error of .00423, and a t-statistic of 2.8. In other words, adding 100 branches to a market, holding other things equal at the mean of the sample, would increase the hazard rate by 120 percent. We interpret this as confirming the expectations of a bank, that in a heavily-branched market its customers will have more Yankee-affiliated locations available than in a sparsely branched market, thus leading to quicker adoption in the heavily-branched market. It may also reflect demographic and geographic factors that create a demand for a larger number of service delivery locations than in other markets. This factor would also tend to make the network externality especially valuable for banks in such a market. We interpret the combination of the signs on OWNBRANCH and MKTBRANCH as strongly confirming the hypothesis of the model, which is that the network effects are external to the individual bank.

The negative coefficient on MKTPOP shows that, in the more populous markets banks had a tendency to adopt membership more slowly than in the less populated markets. The negative coefficient on POPCHANGE shows that in markets that had the strongest population growth in the 1980s, Yankee membership was adopted relatively slowly. This is a puzzling result, but may reflect that most of the growth in population in the 1980s in New England had taken place by 1987. If this were the case, then our measure of demand growth is not a good one. Alternatively, adoption of different shared networks may allow banks to differentiate themselves from one another, an important marketing advantage in appealing to potential new customers (and there are more potential new customers in fast growing areas). If this were the case, we would expect to see slower Yankee adoption in fast growing areas, as some banks would adopt other networks to differentiate themselves from the Yankee banks.

The positive coefficient on SAL-EMP shows that banks with high labor expenses tended to adopt Yankee membership early, which suggests that shared networks did tend to substitute for labor expenses. The positive but insignificant coefficient on OCC-EXP suggests that, to the extent that OCC-EXP measures capital expenses for a bank in 1987, Yankee membership does not substitute for existing capital. This leaves open the possibility that Yankee membership might substitute for new branches. The positive coefficient on LNDEP suggests that larger banks tended to adopt sooner than smaller banks. Since LNDEP proxies for the number of customers a bank itself has, this finding tends to support the idea that banks expect to capture a share of the benefits their customers receive from a shared network.

The negative and significant signs on the coefficients of PRICE and COMPETITION are reassuring in that they suggest that the membership decision responded typically to the law of demand. The negative coefficient on the CONCENTRATION measure suggests that in more competitive markets adoption was quicker. However, this could be caused by collinearity COMPETITION and LAGBASE. Reestimating the model with LAGBASE measured as the installed proportional base of Yankee deposits at the state level (rather than at the market level), and with no other changes to the variables, results in no changes of signs or levels of significance of any of the variables, with the exception of changing the coefficient on COMPETITION to being insignificant.

The estimation with the state level measure of LAGBASE is important in its own right. If a significant percentage of a market's banks had already joined Yankee, then one might expect a negative coefficient on LAGBASE, not because of a network externality, but rather because of the combination of the arithmetic fact that there are fewer candidates for Yankee membership and a two-tailed distribution of benefits to Yankee membership. By testing the model using LAGBASE measured at the state level, we substantially eliminate the first element of the alternative explanation for a significantly negative coefficient on LAGBASE.

The negative coefficient on BHCDUMMY does suggest, to the extent that larger banking organizations were more likely to have a proprietary network, that there is an opportunity cost in moving from a proprietary to a shared network.

Various sensitivity checks were made and suggest that the results of the model are robust. The model was run using the exponential distribution, with sign, size, and significance of all the coefficients virtually unchanged, with the exception that the hazard rate is assumed to be constant in the exponential model. In order to assess the degree of possible collinearity between MKTBRANCH and MKTPOP, and because MKTPOP is less theoretically based on the model, the estimation was done dropping MKTPOP. With the exception of LNDEP losing significance (but retaining its sign and size), no other variable changed sign, size, or level of significance. This suggests that collinearity is not an important problem in the estimation. A large bank, BayBanks, was dropped from the estimation because it had its own large proprietary shared network. Again none of the results was altered significantly.

6. Conclusion

The model of adoption of a shared network technology presented in this paper, relying on the work of Cabral, takes into account the difficulty of capturing the dynamics of the adoption process. The method chosen here focuses on measuring the relative benefits a bank is likely to enjoy from Yankee membership. In any equilibrium those banks with relatively high benefits will join, while those with benefits below some level will not join.

By modeling the features of banks, and their markets, that enhance the value of network membership, we identified relationships between the probability of joining the network and observable proxies for variables implied by the model. In particular, we found that the installed base of network membership is negatively related to the hazard rate, revealing that there were strong bandwagon effects in network adoption. Furthermore, we found that the number of bank branches in a market is positively related to adoption of Yankee membership, while the number of a bank's own branches is not related to early adoption. These findings are novel for several reasons. As noted above, Saloner and Shepard (1992) find that a bank's own branches are positive and significant in explaining the likelihood of adopting ATMs early, for the decade of the 1970s, prior to the advent of shared networks. Our results complement theirs. The absence of a relationship between adoption and number of own branches suggests that in a shared network benefits are conferred by other members and the locations they provide to one's own customers, rather than arising only in a bank's own branch network.

It is notable that the number of branches in the market in 1987 is not directly related to the number of Yankee nodes, so MKTBRANCH is at best a rough measure and probably understates the network externality involved.

However, the number of branches in a market may act as a device to help potential members to coordinate their adoption decisions. It may also be the case that while more branches in the market may ultimately be related to the number of Yankee locations available (our first explanation), it may also be true that the number of branches in a market reveal geographic, demographic, and migratory facts about the market that make many service locations especially valuable. For example, there may be a high number of branches because people work and live in different locations in the market and need service in both places. In this case, a high number of branches in a market may be related to those institutions that especially value more service locations; again this would confer a high value to the network externality provided by Yankee membership. Finally, the finding lends support to the proposition that in a shared ATM network, although network effects no longer are generated in one's own branch network, the externalities under sharing still retain a strong geographic component. The local (marketwide) externality is strong enough to generate the results.

The relationship between branching and adoption of network membership, and between ATM deployment and network membership are topics for further research.

FIGURE 1

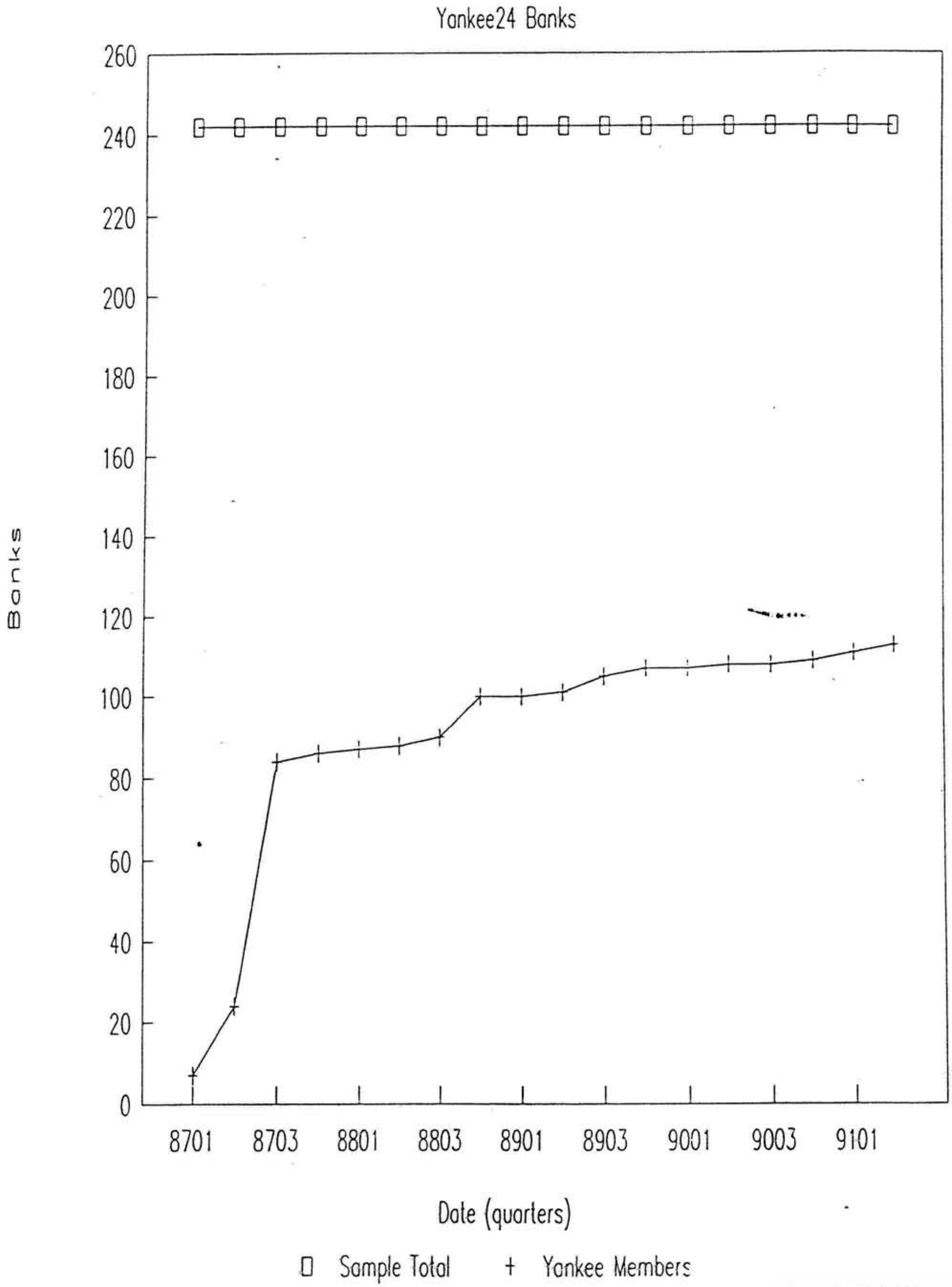
Yankee24 Banks
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Banks
8701
8703
8801
8803
8901
8903
9001
9003
9101
Date (quarters)
Sample Total
+ Yankee Members

Table 1

Sample Distribution of Banks by State

State	Yankee 24	Non-Yankee 24	Total
Maine	20	15	35
Massachusetts	58	51	109
New Hampshire	10	47	58
Rhode Island	8	2	10
Vermont	15	15	30
Total	112	130	242

Table 2

Descriptive Statistics of Study Variables

Variables	Mean values	Standard Deviation
LAGBASE	.2418	.232
OWNBRANCH	8.23	9.81
MKTBRANCH	270.04	387.6
MKTPOP	12.21	1.66
POPBRANCH	3875.3	5801.9
LNDEP	8.71	2.03
PRICE	610.12	1591.3
COMPETITION	88.2	73.1
POPCHANGE	.096692	.087479
SAL-EMP	9.93	1.58
OCC-EXP	10.9	14.47
CONCENTRATION	68.31	14.34
BHCDUMMY	.334	.472

Table 3

	Coefficient estimate and standard error	t-ratio	Probability $\|t\|\geq\beta$
LAGBASE	-2.65 (.673)	-3.93	.000
OWNBRANCH	.007 (.012)	.59	.549
MKTBRANCH	.060 (.022)	2.70	.006
MKTPOP	-.233 (.102)	-2.27	.023
POPBRANCH	-.0039 (.0014)	-2.69	.007
LNDEP	.102 (.060)	1.69	.090
PRICE	-.0002 (.00007)	-2.85	.004
COMPETITION	-.0237 (.0049)	-4.76	.000
POPCHANGE	-1.43 (1.50)	-.95	.33
SAL-EMP	.113 (.067)	1.68	.09
OCC-EXP	.0026 (.0083)	.315	.75
CONCENTRATION	-.014 (.0073)	-1.96	.04
BHCDUMMY	-.724 (.285)	-2.54	.01
α	.885 (.165)	5.35	.00

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