In through the Out Door: The Role of Outsourcing in the Adoption of Internet Technologies by Credit Unions

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Abstract

This paper focuses on the relationship between credit unions' outsourcing of their information systems and their adoption of Internet technologies. Using a dataset that contains semi-annual technology information for 10,390 credit unions from June 1998 through June 2003, the paper estimates a model that includes both the adoption and outsourcing decisions. The model also explicitly accounts for heterogeneity in a firm's ability to utilize IT. The estimation results indicate that 'IT Type' does matter in the outsourcing decision however not in the decision to adopt Internet technology. Outsourcing does not appear to lower the cost of Internet adoption, a result that runs counter to the evidence in the raw data which indicates that Internet technology was adopted faster by credit unions that outsourced their IT. Other determinants of these two decisions are also discussed.

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1 Introduction

In recent years, the diffusion of new information technologies (IT), and more specifically the Internet, has had a variety of effects on economic activity. For example, common wisdom holds that IT has reshaped supply chains, altered the ideal skill mix within firms, and fostered new product innovations. However, the precise direction of these changes is often ambiguous a priori.

As an example, IT is often credited with increasing the economies of scale in the production of some banking services, and as a result fostering the evolution of larger financial institutions. On the other hand, decreased communications costs engendered by the same technologies have decreased the costs of outsourcing, possibly allowing smaller firms to enjoy the same benefits.[1] To examine precisely this issue, this paper focuses on one aspect of this tradeoff: the relationship between credit unions' IT outsourcing and their adoption of Internet technologies.

Credit unions can maintain internal IT systems or choose to outsource those services to an external vendor, depending on which provides the best service for the least cost. The adjustment costs of altering this strategic choice are likely very high, and therefore outsourcing decisions tend to be long term. In fact, the data shows great persistence in a firm's choice. With the arrival of the Internet, credit unions also had to choose if and when to offer Internet banking. Viewing the outsourcing decision as given (at least in the short run), examining the different adoption rates between outsourcing and non-outsourcing firms provides an opportunity to judge whether outsourcing allows firms to more rapidly innovate. This paper asks whether the availability of outsourcing 'levels the playing field' for these institutions?

The basic structure of the empirical model is a two equation system evolving over time incorporating both the decision to adopt Internet banking as well as the overall IT strategy of the firm. The first is described by a discrete-time hazard function describing the probability of adopting during the period conditional on not having adopted to date and conditional on the IT strategy of the firm (outsourcing vs. in-house IT). The second equation is a logit, describing the choice to outsource in each period.

The model is estimated with varying assumptions regarding the correlation between the unobserved component of these decisions. In the simplest model, the errors in the outsourcing and adoption decisions are assumed to be independent. In the mixture model, firms are assumed to vary in their ability to utilize IT and each equation includes an unobserved 'IT type.' This captures heterogeneity between credit unions that is unobserved by the econometrician. The basic idea is that some firms may be more technologically savvy than others, in which case they may be more likely to adopt new technologies as well as to value keeping IT in house. This unobserved factor is modeled as having two discrete points of support. We can then estimate the proportion of the population that is of each type and the effect of outsourcing on Internet adoption conditional on

[1]See Brynjolfsson, Malone, Gurbaxani and Kambil (1994) for a discussion of related issues.

this heterogeneity.

In the Markov model, a credit union's type is allowed to vary in each time period. To generate persistence in this type, the temporal correlation is modeled as a Markov process over the sample, and the model estimates the transition probabilities in that process. With this set-up, the model closely resembles that in Cosslett and Lee (1985) and Hajivassiliou (1996), and the methods developed by those authors are used to overcome some of the computational issues that arise. While this version of the paper lays out that model, and its solution technique, estimates for the Markov model are not yet included.

2 Credit Unions and Technology

Credit unions are an increasingly important segment of the US financial system. As of mid 2003, credit union memberships totaled 84 million and assets at US credit unions exceeded $617 billion. This amounts to roughly 43% of the assets at FDIC insured savings institutions and 8% of the amount held at commercial banks. In terms of consumer savings and installment credit, credit unions accounted for 9.6% and 11.3% of these amounts respectively.(CUNA 2003)

As credit unions have grown and regulatory changes have been enacted, several policy issues have come to the fore. In particular, the policy of granting tax exempt status to these institutions has been challenged in recent years. The argument is made that their not-for-profit status confers an unfair advantage to credit unions relative to other small institutions. However, the degree to which these generally smaller institutions can compete in a world of ever larger financial entities may hinge more on their ability to harness the efficiencies of new information and communications technologies (IT).

IT spending by financial services firms, and banks in particular, exceeds that in other industries. According to one recent report, US banks spent roughly 6% of revenue on IT in 2002 compared with 4% for firms in other industries (Cournoyer 2003). Examining the impact of IT in banking, research at the most micro level indicates that these technologies may have profound effects on the skill-mix and nature of work inside the firm (Autor, Levy and Murnane 2001). Broader studies have linked IT at banks to increased cost efficiency (Casolaro and Gobbi n.d.) and increased economies of scale (Radecki, Weninger and Orlow 1997). Berger (2003) summarizes much of the work of IT in financial services.

Most recently, much of the technological innovation in financial services involves Internet banking.[2] The ability of customers to access their own accounts and perform their own transactions both increases the quality of a given bank's product and also offers labor savings for the institution itself. In a series of papers, Furst, Land and Nolle ((2000),(2002a), (2002b)) examine the early

[2] See roundtable discussion in the Brookings-Wharton Papers on Financial Services: 1999 for early thinking on the impact of the Internet in this industry.

adoption of Internet banking at national banks and find that adopters seem to be more profitable than non-adopters (although the causal direction is unknown) and were more likely to be in urban areas and parts of bank holding companies. They also find evidence of start up costs to initiate these technologies that may be substantial for smaller institutions.

One way however for such smaller institutions to lessen these costs, and to benefit from IT may be to outsource. As described later, approximately 25% of all credit unions outsource their core share and draft account systems to an outside provider. Interestingly, this percentage had been relatively stable since the late 1980's. Similarly, a recent survey of community banks finds that 38% outsource their key systems, a slightly higher percentage than credit unions.(ICBA 2003) The percentage at hospitals, another not-for-profit industry, is roughly 10% to 40% depending on the application.

The focus of this paper is to determine whether outsourcing IT systems lowers the cost of the related decision to offer Internet banking. As a generic model of technology adoption, this paper falls in a long line of research.[3] Within financial services, the literature is much smaller, however, authors have examined ATM adoption (Hannan and McDowell 1984) as well as the use of ACH (Gowrisankaran and Stavins 2002), in addition to the the Internet banking literature already mentioned. The empirical research on outsourcing is much smaller and often focuses on which activity will be outsourced rather than which firms will outsource a given business function.[4] A notable exception is the recent work by Ono (2003) regarding the importance of firm and supplier location to the outsourcing choice.

The current study examines both choices. It also tries to improve on the prior literature by more explicitly accounting for heterogeneity among firms in their ability to benefit from IT. This is done, not only to improve the current analysis but also to aid other research. For example, much of the prior literature on IT productivity has struggled with the possible endogeneity of IT, namely that adopters are simply the firms that benefit most and therefore that all gains from IT are overstated. Authors such as Brynjolfsson and Hitt (Forthcoming) and Borzekowski (2002) have used differencing and/or lagged instruments to address this question.

This paper strives to make additional progress in that area in two ways. First it attempts to find other exogenous shifters of adoption that could be used as instruments. If the outsourcing status of the firm, for example alters the ability to adopt Internet banking, it may be a valid instrument in assessing the cost or revenue impacts of that adoption. Second, it attempts to model IT adoption using a richer specification for unobserved firm attributes than the prior research.

[3]See Hall and Khan (2003) for a recent summary of many of the relevant issues.

[4]Much of this literature follows the Transaction Economics approach addressing issues such as asset specificity as well as contracting issues.

3 A Model of Technology Choice

To examine the relationship between outsourcing and Internet adoption, we posit a simple model of technology choice. The basic structure of the model is a two equation system evolving over time jointly specifying both the decision to adopt Internet banking as well as the overall IT strategy of the firm. The first is described by a discrete-time hazard function describing the probability of adopting during the period conditional on not having adopted to date. The second equation is a simple logit describing the choice of the firm outsourcing strategy in each period.

As described below, the model is estimated with varying assumptions regarding the correlation between these two equations. To accomplish this, each credit union is assumed to be of a given 'IT type.' This heterogeneity among credit unions is unobserved by the econometrician and captures the basic idea is that some firms may be more tech savvy than others. Firms that are more adept at using technology may be more willing to keep IT in house and more willing to adopt the newer Internet technologies. This would generate a negative correlation between outsourcing and Internet adoption.

However the opposite may also be true: firms with greater sophistication may be more able to capture the returns from outsourcing and from offering Internet banking leading to a positive correlation between these decisions. While the exact direction of the correlation is not obvious a priori, it is reasonable to assume that these decisions are related and the model strives to capture that effect.

3.1 Internet Adoption

The first component of the model is the credit union's decision to adopt Internet technology in each period. The precise definition of what technologies must be in place to qualify as 'adoption' is delayed until the next section, where the available data is described. In all cases however, Internet adoption is treated as an absorbing state: once a credit union has adopted, it is assumed that it keeps the technology.[5]

To begin the model, we specify the net benefits of adopting Internet technologies in a given period conditional on not having adopted in the prior period as:

$$h_t^* = X_t\beta + S_t\delta + I_t\theta + \epsilon_t^1 \tag{1}$$

Above, X_t includes variables altering the net benefits of Internet adoption, including but not limited to demographic data about the credit union's market, while S_t is a dummy variable for the IT status of the credit union. This will take the value of one when the credit union outsources. The

[5] If one believes that firms may adopt and then relinquish the technology, then the model can be viewed as measuring time to first adoption.

remaining two terms are unobserved by the econometrician: I_t is an unobserved dummy variable for the 'higher-tech firms' while ϵ_t^1 is an iid error term.

The econometrician is unable to see h_t^*, but rather sees:

$$h_t = \begin{cases} 1 & \text{if} \quad h_t^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

Therefore, if $p(x)$ is defined as the probability of observing x, then the probability of adopting Internet banking at time t for any firm that has not yet adopted is:

$$\begin{aligned} p(h_t = 1 | X_t, S_t, I_t) &= p(h_t^* > 0 | X_t, S_t, I_t) \\ &= p(X_t\beta + S_t\delta + I_t\theta + \epsilon_t^1 > 0) \\ &= p(\epsilon_t^1 > -X_t\beta - S_t\delta - I_t\theta) \\ &= F(X_t\beta + S_t\delta + I_t\theta) \end{aligned} \tag{3}$$

where F is the cumulative distribution function for ϵ_t^1.

3.2 Outsourcing

In each period, the firm must also decide whether to outsource their IT operations or to keep them in-house. While such a switch entails considerable fixed costs, the current model does not explicitly account for these.[6] Parallel to the equations for Internet adoption, we can then define the net benefits of outsourcing, S_t^*, as :

$$S_t^* = Z_t\gamma + I_t\mu + \epsilon_t^2 \tag{4}$$

$Z_t\gamma$ captures the net benefits from outsourcing while μ_t which captures additional benefits (possibly reduced relative costs) of outsourcing that the 'tech savvy firms' enjoy but which is unobserved by the econometrician. The iid error term is denoted ϵ_t^2.

Again, the econometrician is unable to see S_t^*, but rather sees:

$$S_t = \begin{cases} 1 & \text{if} \quad S_t^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

[6] See Ito (1996) and Bresnahan and Greenstein (1996) for evidence regarding the adjustment costs related to IT.

$$
\begin{aligned}
p(S_t = 1|Z_t, I_t) &= p(S_t^* > 0|Z_t, I_t) \\
&= p(Z_t\gamma + I_t\mu_t + \epsilon_t^2 > 0) \\
&= p(\epsilon_t^2 > -Z_t\gamma - I_t\mu_) \\
&= F(Z_t\gamma + I_t\mu)
\end{aligned} \tag{6}
$$

It is important to note that the decision to outsource is not modeled as being dependent on the firm's choice of whether to offer Internet banking. While it is possible that a firm would change its core strategy in order to be able to adopt Internet banking more easily, the adjustment costs of that change are assumed to be too high to make it profitable to do so. Firms switching their core strategy are assumed to do so for reasons outside of Internet banking. In contrast, the ability to offer Internet banking to your customers is assumed to directly depend on the type of share and draft systems at the firm.

3.3 Unobserved Heterogeneity

The model is estimated allowing three different specifications of the correlation between these decisions within a given firm. As described above, each of these results from various assumptions about the unobserved type. In the base model, the type is assumed to be irrelevant, i.e. each decision is independent. In the mixture model, each firm is assumed to be a high type with a fixed probability over the entire sample and in the Markov model, the probability of being a given type in each period is allowed to vary.

To specify the likelihood functions for this model, we first specify the most general case and then offer then specifics. Let $\mathbf{h}$ and $\mathbf{S}$ represent the entire time path of h and S, respectively i.e. $\mathbf{h} \equiv (h_1, h_2, \cdots h_T)$ and $\mathbf{S} \equiv (S_1, S_2, \cdots S_T)$. Similarly, let $\mathbf{X}, \mathbf{Z}, \mathbf{I}$ represent the entire time path of these variables. If $P(\mathbf{X})$ is defined as the joint probability of $\mathbf{X}$, then likelihood function is simply:

$$
L \equiv P(\mathbf{h}, \mathbf{S}|\mathbf{X}, \mathbf{Z}) \tag{7}
$$

which can be expressed as:

$$
L = \sum_{\mathbf{I}} P(\mathbf{h}, \mathbf{S}, \mathbf{I}|\mathbf{X}, \mathbf{Z}) \tag{8}
$$

This last expression simply expresses the likelihood as the joint probability of the observables $\mathbf{h}$, and $\mathbf{S}$ and the unobserved type vector $\mathbf{I}$ summed over all possible paths for $\mathbf{I}$.

$$L = \sum_{\mathbf{I}} [P(\mathbf{h}, \mathbf{S}|\mathbf{X}, \mathbf{Z}, \mathbf{I})P(\mathbf{I})] \tag{9}$$

With some algebra:

$$L = \sum_{\mathbf{I}} [P(\mathbf{h}|\mathbf{X}, \mathbf{S}, \mathbf{I})P(\mathbf{S}|\mathbf{Z}, \mathbf{I})P(\mathbf{I})] \tag{10}$$

3.3.1 Minimal Model

In the base or 'minimal' model, the decisions for a given firm are assumed to be independent. In the specification above, this means that the decisions are independent of the firms type and the last term in equation 10 are dropped. The likelihood function simply becomes:

$$L = \prod_{s=1}^{T} p(h_s|X_s, S_s) \prod_{s=1}^{T} p(S_s|Z_s) \tag{11}$$

3.3.2 Mixture Model

In the mixture model, credit unions are assumed to be either high or low types over the entire sample period. Under this assumption, the last term in Equation 10 has only two values: the probability that the firm is a high type or that it is a low type. Let λ_0 be the probability that a credit union is the low type. Then the likelihood function becomes:

$$L = \lambda_0 (\prod_{s=1}^{T} p(h_s|X_s, S_s, I = 0))(\prod_{s=1}^{T} p(S_s|Z_s, I = 0)) + (1 - \lambda_0)(\prod_{s=1}^{T} p(h_s|X_s, S_s, I = 1))(\prod_{s=1}^{T} p(S_s|Z_s, I = 1)) \tag{12}$$

3.3.3 Markov Model

The central feature of the Markov model is that credit unions are assumed to switch type with fixed transition probabilities. To model this, we specify that I evolve as a Markov process with the following transition probabilities:

	$I_t = 1$	$I_t = 0$
$I_{t-1} = 1$	τ_{11}	$1 - \tau_{11}$
$I_{t-1} = 0$	$1 - \tau_{00}$	τ_{00}

The unobserved type generates the correlation between the Internet adoption and the outsourcing decision. Persistence is this unobserved type is attained through the Markov process.

$$L = \sum_{\mathbf{I}} [(\prod_{s=1}^{T} p(h_s|X_s, S_s, I_s))(\prod_{s=1}^{T} p(S_s|Z_s, I_s))(\prod_{s=1}^{T} p(I_s|I_{s-1})p(I_0))] \tag{13}$$

where:

$$p(h_s|X_s, S_s, I_s)) = F(X_t\beta + S_t\delta + I_t\theta)^{h_s}(1 - F(X_t\beta + S_t\delta + I_t\theta))^{1-h_s} \tag{14}$$

$$p(S_s|Z_s, I_s)) = F(Z_t\gamma + I_t\mu)^{S_s}(1 - F(Z_t\gamma + I_t\mu))^{1-S_s} \tag{15}$$

To estimate the minimal and Markov models, an iterative technique is used that alternates between first estimating the β, γ, μ and θ parameters conditional on τ or λ_0 and then estimating these latter variables conditional on the former. The Markov model, although not estimated in this version of the paper, uses a particular algorithm to estimate the likelihood which is discussed in the appendix.

The last issue is that censoring is an issue in this panel in two places. First, June 1998 is the first time that the Internet questions are asked. As a result, precise adoption times are not included in the data for the firms that had adopted by then. All of these firms are simply assumed to have adopted in the first period. The second issue is that credit unions do leave the sample, most often as a result of a merger. The likelihood for these firms includes the terms for adoption and outsourcing up to the time the firm exits, effectively treating them as right censored.

4 Data

4.1 Sample

The credit union data for this study comes from the NCUA Form 5300 Reporting forms. All federally insured credit unions are required to file these forms detailing their financial condition and other firm information semi-annually in June and September. Some state chartered, privately insured credit unions also file with the NCUA although under state regulations.[7]

As detailed in Table 1, 11,397 credit unions filed at least one report between December 1997

[7]The result is that these filings capture nearly the universe of credit unions in the US. As of June 2003, approximately 100 credit unions primarily in Ohio are not included in the filings.

and June 2003. To avoid issues of left censoring, only those credit unions present as of December 1997 are kept in the sample. Since new credit union formations are rare (in fact, the industry is rapidly consolidating), this drops only 62 observations. Since the outsourcing and Internet banking decisions are only relevant for those firms that are automated, the sample is further restricted to those using computers in December 1997 and June 1998. As a result, another 692 are dropped. Finally, a handful of observations with gaps in their reporting along with any firms that have 'bad' data on outsourcing are omitted from the dataset. The final sample consists of 10,390 credit unions, roughly 91% of all credit unions in the US over this period.

Table 1: Derivation of Credit Union Sample

Desc	**Credit Unions**
US Credit Unions 12/97 - 6/03	11,397
Present at 12/97	11,333
Automated at 12/97 and 6/98	10,641
No gaps in reporting	10,630
Usable data re: outsourcing	10,390

Source:

4.2 Outsourcing and Internet Data

The variables relating to outsourcing and Internet use are also derived from the NCUA data. Beginning in 1992, credit unions were asked about their overall IT strategy with one question:[8]

> Indicate in the box at the right the number of the statement below which best describes the system the credit union uses to maintain its loan and share records[9]:
>
> 1=Manual System (No Automation)
>
> 2=Vendor Supplied In-House System
>
> 3=Vendor On-Line Service Bureau
>
> 4=CU Developed In-House System
>
> 5=Other

As described above, only credit unions that had automated by December 1997 are included in this study, limiting the data to options 2-5. To be conservative, firms are defined as outsourcing

[8]To be more precise, the question was asked once before in the June 1987 filings, but was not regularly included until 1992.

[9]While the wording of this question has not changed, slight changes to the answer choices have been made.

only if they indicate choice 3 above: all others are grouped as having in-house systems.[10]

Table 2 details the number of credit unions that outsource in each period in the dataset, along with how many credit unions change status. Out of the 10,390 credit unions present in December 1997, 2,629 or about a quarter outsourced their main IT system for share and draft accounts. Interestingly, that fractions stays reasonably constant over the sample. Although only 8,921 credit unions remain in June 2003, still about 25% are outsourcing.

The two columns labeled Stop Outsource and Start Outsource contain the number of firms that have switched in each period from outsourcing to in-house software and from in-house software to outsourcing respectively. While only about 1% of the sample will switch in any given period, nearly 12% switch at least once over the sample period.

The questions regarding the Internet were first asked in the June 1998 filing. While current forms have several questions about firms' electronic capabilities, the only question available for the entire period read as the following until 1999:

> If the credit union has a world wide web site, is the web site interactive (Does the web site allow users to download statements, transfer money, pay bills, etc?)

and more recently reads as:

> If you have a World Wide Website, please indicate the type (select only one)
> 1 = Informational
> 2 = Interactive
> 3 = Transactional

More specific definitions of these terms appear in the NCUA instructions. Since, the focus of this study is the link between outsourcing and the decision to offer Internet banking services, adoption is defined as saying yes to the first question and indicating option 3 on the second. Having a transactional website implies that the firm must have linked there website to the back office loan and share account systems which are the possible subjects of outsourcing. This same connection is not necessary, for example, for a website that only offers brochure-like information to current or prospective customers.[11]

In Table 2, the last column shows the number of credit unions that have adopted the Internet in each period. By June 1998, only 277 firms had transactional web sites tied to their core systems. By June of 2000, just over 10% of these firms had that capacity and by June 2003, nearly 35% of

[10] The data for some credit unions indicates obvious noise and these observations have been 'cleaned.' For example, the raw data may indicate that a credit union has kept its IT in-house over the entire sample with exception of one period of outsourcing. Given that outsourcing is a longer term decision with substantial switching costs, the data for this one period is assumed to be in error and is corrected. A complete description of the algorithm used is clean the data is available from the author.

[11] Other, less stringent, constructions of the Internet adoption variable are also consistent with this link between the technologies. For example, one could count credit unions with Interactive sites as having forged that link. Using these definitions does not appear to alter the results substantially.

Table 2: Summary of Outsourcing and Internet Adoption

Date	Credit Unions	Outsource	Stop Outsource	Start Outsource	Offer Int Banking
Dec 1997	10,390	2,629	0	0	0
June 1998	10,390	2,607	101	79	277
Dec 1998	10,278	2,578	55	49	402
June 1999	10,117	2,545	47	41	547
Dec 1999	9,939	2,514	23	21	783
June 2000	9,796	2,471	32	16	1,083
Dec 2000	9,638	2,439	69	69	1,428
June 2001	9,490	2,404	40	31	1,859
Dec 2001	9,337	2,366	45	42	2,150
June 2002	9,185	2,330	43	31	2,512
Dec 2002	9,068	2,295	64	49	2,830
June 2003	8,921	2,249	81	62	3,145

Source:

the sample had adopted. Note that this number does overstate Internet adoption somewhat since credit unions operating without automation are dropped from the denominator.

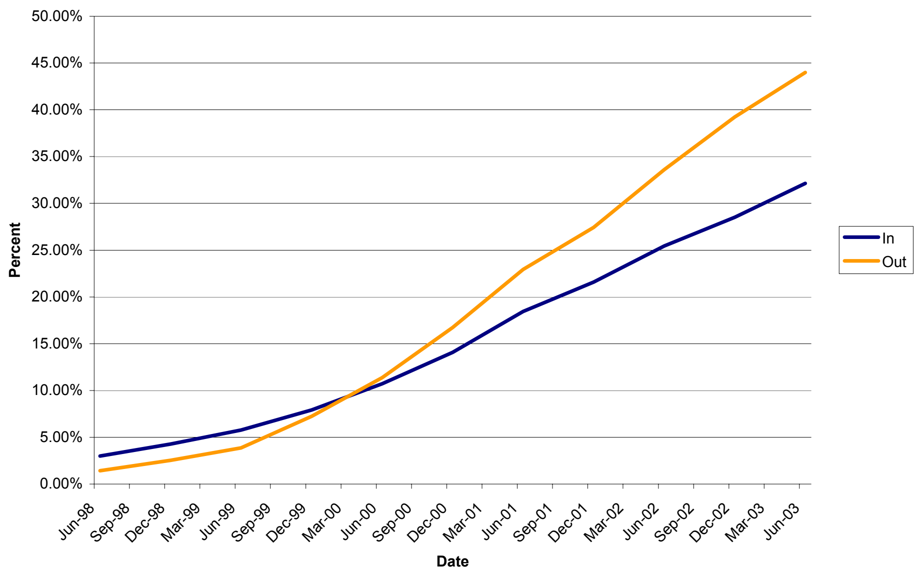
The relationship between outsourcing and Internet adoption is displayed in Figure 1. The graph decomposes the cumulative adoption of Internet banking into the rates for credit unions that outsource and for those with in-house systems. Until early in 2000, Internet adoption at credit unions that outsourced appears to lag behind that at other credit unions. From then on, their adoption rate is higher so that by June 2003, nearly 45% of outsourcing credit unions utilize Internet banking compared to only 32% of those with their core systems in-house.

On the surface this seems to indicate that the early adopters were those credit unions with in-house systems, perhaps those that recognize and can capture the strategic value of IT. Later on however, once the outsourcing suppliers had offered an Internet banking product, other firm were more able to adopt this technology. As a result, adoption at the outsourcing firms becomes dominant. This analysis however, does not control for the relevant characteristics of credit unions that may impact these decisions. This is done in the next section.

4.3 Other Variables

The control variables used in the analysis that follows fall into three categories: firm size, firm characteristics and market level variables. Firm size is measured by log of assets in order to capture the large skew in this distribution. As shown in Table 3, the mean credit union in 2003

Figure 1: Empirical Adoption of Internet Technology by Outsourcing Status



had \$66 million in assets, however the variance was over \$300 million. In fact, the smallest firm in the sample has fewer than \$1 million in assets while the largest is just over \$19 billion.

The model is estimated including both linear and quadratic size terms. This is a critical specification issue since size is the dominant factor in many technology decisions, and since the relationship between firm size and these two decisions is quite different. To show this point, two probit regressions were estimated as of June 2003: in the first, the binary variable is whether the firm has adopted Internet banking by that date while the second looks at the outsourcing decision. Both include log assets and log assets squared. The predicted probabilities of outsourcing and adopting the Internet are shown in Figure 2.[12]

As is the case with many technologies, the likelihood that a credit union will offer Internet banking is strictly increasing in the size of the firm. In contrast, the probability of outsourcing is not monotonic. Small firms are extremely unlikely to outsource their IT. Likewise very large firms are less likely to outsource, leaving the bulk of outsourcing in the middle. It appears that the establishment of these relationships involves at least some fixed costs which leaves the smallest firms with in-house systems. Slightly larger firms can bear this cost and benefit from these services, while the largest firms are able to capture some of the returns to scale and other benefits of in-house IT.

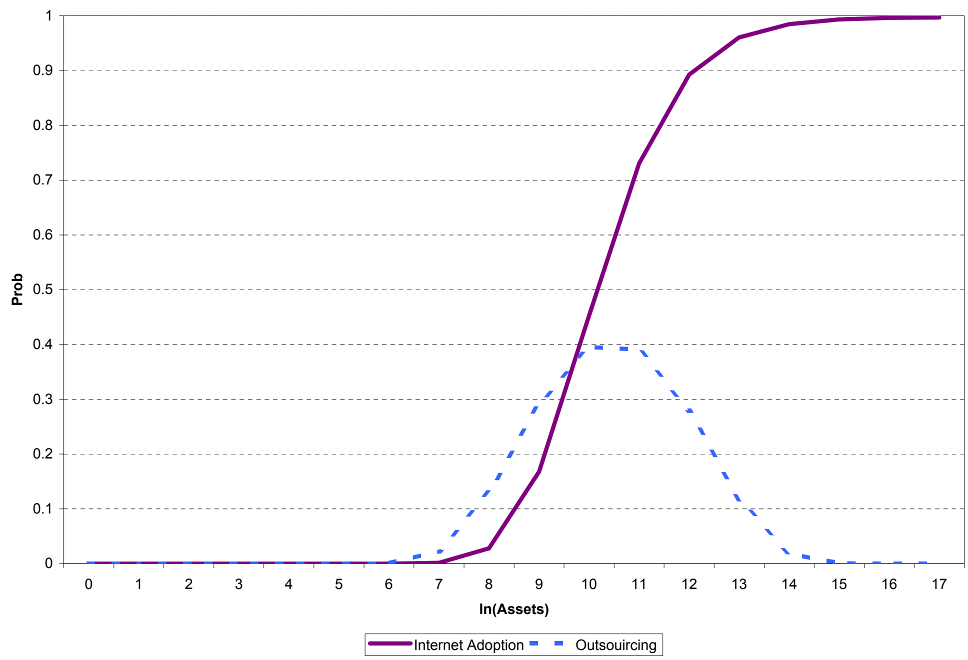
The other firm characteristics are included to capture possible variation among credit unions in the costs and benefits of outsourcing and Internet adoption. By law, every credit union must specify a common bond or field of membership, i.e. a closed group that it is founded to serve. These groups are most often defined by a given community, association, educational institution, military group or government entity and dummies are included for each of these types of membership. The omitted category includes commercial credit unions that serve the employees of a given company and those that have multiple common bonds. Variation in the technology decisions among different fields of membership likely reflect either variation in costs resulting from different conditions in the sponsoring entity or differences in the benefits of that technology to the credit union's population.

A dummy is also included for state chartered credit unions (as opposed to federally chartered firms) that may capture regulatory differences that effect these decisions. The last firm characteristic is a dummy variable for whether the credit union has a special designation indicating that it serves a limited income population.

One bank specific variable, the log of potential members, is included solely in the Internet equation. Given the common bond that a given credit union's members must share, the potential number of customers is limited. As a result, the benefits from using Internet banking to attract customers depends on the maximum number that would join. The other benefits of adopting, namely labor or quality improvements are related to the current number of customers which is

[12] Another way to look at this, which will be done in the next version, is to non-parametrically estimate the relationship between size and these tech decisions.

Figure 2: Predicted Probability of Outsourcing and Internet Adoption



highly correlated with the asset variable already discussed. The costs and benefits of outsourcing are also more likely tied to actual customers which is why the potential member variable is excluded from the outsourcing equation.

For each credit union, the market is defined as the Metropolitan Statistical Area (MSA) or rural county in which the firm is located. This follows the standard definition in banking research. In each equation, a dummy is included for credit unions in rural counties. In general, these credit unions are likely to be farther away from service providers and therefore less likely to outsource. This distance is also likely to increase the cost of adopting Internet banking: however, the benefits of Internet banking to rural customers who often have a greater distance to travel to their credit union may offset the increased costs and leave the predicted effect ambiguous.

In the outsourcing equation we also include the log of population to reflect variation in the opportunities available to the firm. Credit unions in more populous areas are likely to have access to more business services and in particular, may have access to staff and resources to maintain their own in-house systems.

Table 3: Summary Statistics

	June 1998		June 2001		June 2003	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Assets	35.373	159.54	49.753	226.272	66.775	317.757
Log Potential Members	1.552	1.657	1.795	1.805	2.011	1.971
Limited Income	0.037	0.194	0.061	0.239	0.089	0.285
State Chartered	0.386	0.487	0.394	0.489	0.394	0.489
FOM-Community	0.072	0.258	0.096	0.295	0.096	0.294
FOM-Association	0.071	0.257	0.07	0.256	0.046	0.209
FOM-Educational	0.101	0.301	0.104	0.305	0.074	0.261
FOM-Military	0.018	0.132	0.017	0.130	0.012	0.111
FOM-Government	0.155	0.362	0.158	0.365	0.096	0.295
Rural	0.201	0.401	0.204	0.403	0.205	0.404
Log Population	6.328	1.781	6.347	1.797	6.358	1.803
Pop 18-24 Yrs Old	0.095	0.024	0.099	0.029	0.101	0.039
Pop w/ Higher Educ	0.191	0.049	0.200	0.051	0.206	0.053
Internet Use	0.258	0.044	0.502	0.058	0.665	0.089
Teller Wage	9.506	0.580	10.005	0.603	10.01	0.640
Rural	0.201	0.401	0.204	0.403	0.205	0.404
Int Banking Prevalence	0.025	0.041	0.177	0.139	0.316	0.192
Outsourcing Prevalence	0.225	0.181	0.226	0.18	0.222	0.181

In the Internet banking equation, we include several variables reflecting the likelihood that the credit union's customers would value this service. These include the population in the state that uses the Internet (drawn from the Current Population Survey), the percentage of the population that has some form of post-high school education (drawn from the Census), and the percentage of the population aged 18-24 (drawn from the Census). Each of these are expected to positively impact the rate of adoption.[13]

As discussed above, Internet banking has the capacity to lower a firm's costs to the extent that it is labor saving. To measure this effect, the annual wage of bank teller's in the credit union's MSA or in the non-MSA part of the credit union's state is used as a control. This data is provided annually on the Occupational Employment Survey. Precise details on the construction of this variable are available from the author.

The last two variables included in the estimation are 'prevalence' variables. The percentage of other credit unions in a given market that outsource is included in the outsourcing equation and likewise the percentage of other credit unions that have adopted Internet banking is included in that equation. These variables have two possible explanations: they either capture unobserved characteristics of the market that make the relevant technology choice more likely or else measure spillover or network effects in these decisions.[14]. One needs to be careful, since in the latter case, the variable will be correlated with the error term. However, for now this is not viewed as a major issue and these controls are included in the estimation.

5 Results

The first step in the analysis of outsourcing and Internet adoption is to examine each of these decisions separately. Tables 4 and 5 show the results of descriptive regressions for outsourcing and Internet banking respectively. To examine the determinants of outsourcing, probit models are estimated for both 1998 and 2003. To examine Internet banking, a parametric hazard function was estimated using assuming a Weibull distribution and an earliest possible adoption in 1996.

Table 4 shows the results of the outsourcing probits. Rather than detailing the actual coefficients, the table details the probability derivatives estimated for a commercial credit union of median size in an urban market. The first three columns contain results for June 1998 and the last three for June 2003. For each date, the first column includes only a linear term for assets. A quadratic term is added in the second column and the prevalence variables are added in the third.

The coefficients on the size variables are the most significant, both statistically and in magnitude. As described above, the response to size is an inverted U with medium sized credit unions the most likely to outsource.

The firm characteristics show some more variety: depending on the year and specification, educational, military and government credit unions show some evidence that they are less likely to outsource IT. The probability of outsourcing is 7% to 8% lower at educational credit unions

[13]All figures from Census and the CPS are only released annually. Simple linear interpolation is performed to generate the semiannual figures used in the estimation.

[14]This latter issue is the focus of Borzekowski and Cohen (2004)

(relative to commercial credit unions), possibly as a result of the availability of local expertise and ability that allows them to keep IT in-house. In 2003, government and military credit unions may have that same advantage or may face higher bureaucratic or administrative hurdles to outsourcing.

Besides the market prevalence of outsourcing, most of the other variables show little effect on the firms' choices. The prevalence of other firms outsourcing does positively correlate with the probability that the given firm will do so. As discussed above, this may reflect network effects or some other local market conditions. In this case, the change in the coefficients for the rural dummy variable and the population variable indicate that the prevalence term is capturing some local market conditions. In fact, once one conditions on that variable, rural credit unions are more likely to outsource, ceteras paribus.

Table 4: Descriptive Results for Outsourcing

	1998a	1998b	1998c	2003a	2003b	2003c
	(1)	(2)	(3)	(4)	(5)	(6)
Log Assets	.058***	1.044***	0.993***	.046***	1.139***	1.100***
	(.003)	(.044)	(.045)	(.003)	(.052)	(.053)
Log Assets Squared		-.052***	-.049***		-.055***	-.053***
		(.002)	(.002)		(.003)	(.003)
Limited Income	.006	.045	.023	-.019	.007	-.015
	(.024)	(.030)	(.030)	(.018)	(.024)	(.024)
State Chartered	.022**	.030***	.012	.005	.018	-.008
	(.009)	(.011)	(.011)	(.012)	(.014)	(.014)
FOM-Community	.033*	.029	.005	.028	.011	-.007
	(.017)	(.020)	(.019)	(.019)	(.022)	(.021)
FOM-Association	-.097***	-.073***	-.063***	-.107***	-.033	-.032
	(.016)	(.023)	(.022)	(.023)	(.037)	(.036)
FOM-Educational	-.066***	-.080***	-.063***	-.072***	-.088***	-.072***
	(.013)	(.016)	(.016)	(.018)	(.022)	(.022)
FOM-Military	-.104***	-.023	-.034	-.136***	-.087*	-.106**
	(.024)	(.038)	(.036)	(.029)	(.049)	(.045)
FOM-Government	-.009	-.023	-.019	-.040**	-.061***	-.056***
	(.012)	(.014)	(.014)	(.017)	(.020)	(.020)
Rural	-.031*	-.021	.046**	-.029*	-.014	.050**
	(.015)	(.019)	(.020)	(.017)	(.021)	(.022)
Log Population	-.007*	.001	-.001	-.009**	-.001	-.005
	(.003)	(.004)	(.004)	(.004)	(.005)	(.005)
Outsourcing Prevalence			0.737***			0.724***
			(.028)			(.032)
Obs.	10390	10390	10390	8921	8921	8921

Source:

Table 5 shows the results of parametric hazard estimations where the dependent variable is

Table 5: Descriptive Results for Internet Adoption

	(1)	(2)	(3)	(4)
Log Assets	1.890***	48.418***	48.112***	52.762***
	(.035)	(8.919)	(8.864)	(9.902)
Log Assets Squared		.862***	.862***	.858***
		(.007)	(.007)	(.007)
Outsource Dummy				.900***
				(.035)
Log Potential Members	1.242***	1.227***	1.226***	1.221***
	(.022)	(.021)	(.021)	(.021)
Limited Income	.796**	.880	.882	.883
	(.079)	(.087)	(.087)	(.088)
State Chartered	.959	.969	.966	.970
	(.037)	(.037)	(.037)	(.037)
FOM-Community	1.055	.946	.950	.953
	(.061)	(.055)	(.055)	(.055)
FOM-Association	.520***	.605***	.609***	.600***
	(.068)	(.079)	(.080)	(.079)
FOM-Educational	1.312***	1.249***	1.253***	1.244***
	(.080)	(.076)	(.076)	(.076)
FOM-Military	1.067	1.253**	1.253**	1.241**
	(.108)	(.126)	(.126)	(.125)
FOM-Government	1.105*	1.085	1.086	1.084
	(.059)	(.058)	(.058)	(.058)
Pop 18-24 Yrs Old	3.883**	3.483**	3.383**	3.325**
	(2.200)	(1.973)	(1.919)	(1.888)
Pop w/ Higher Educ	19.974***	37.528***	31.087***	31.719***
	(8.422)	(15.675)	(13.439)	(13.712)
Internet Use	.015***	.012***	.011***	0.011***
	(.004)	(.003)	(.003)	(.003)
Teller Wage	.945*	.954	.952	.953
	(.031)	(.031)	(.031)	(.031)
Rural	.978	.986	1.005	1.002
	(.056)	(.056)	(.058)	(.058)
Int Banking Prevalence			1.268*	1.261*
			(.176)	(.175)
p	5.291	5.314	5.266	5.269

Source:

the time to adoption of Internet banking. The table details hazard ratios, so that any entry can be interpreted as the relative increase (decrease) in the probability of adopting in a given period. Again, the first column contains only the linear term, the second adds the quadratic term, the third column includes the prevalence term and the fourth includes the primary variable of interest, namely a dummy for outsourcing. As with outsourcing, size is a big determinant of the Internet technology choice. The other firm specific variables indicate that association credit unions are substantially less likely to adopt as are limited income credit unions. Each of these most likely reflect the characteristics of the credit union's customers.

Credit unions with more potential members are more likely to adopt, supporting the idea that one benefit of these technologies may be to attract customers. Credit unions in markets with better educated individuals as well as those in markets with more young adults are also more likely to adopt. This supports the ideas that potential customer usage was driving early adoption. Surprisingly, the Internet use variable is highly significant and of the opposite sign than expected. Regardless of the specification, credit unions in markets with higher Internet use are less likely to adopt. This variable is most likely capturing other features of the market, warranting some further examination. Lastly, the addition of the prevalence variable again seems to alter the other market level variables indicating that at least in part, it is capturing some market level heterogeneity.

The critical result in this table is in column (4). Counter to the pattern in Figure 1, the results in the last column of Table 5 show that adoption of Internet banking is negatively correlated with the outsourcing status of the firm. Controlling for observable factors, firms that outsource are less likely to adopt the Internet. This indicates that either a) fixed costs or other frictions do not allow the outsourcers to pass on the apparent cost savings from their economies of scale or b) that unobserved differences in the value of Internet banking is driving these results.

To address these issues, the joint models described earlier are estimated. As a robustness check and to account for the fact that credit unions of different sizes may be behaving differently, the minimal model and the mixture model are estimated on two different samples. The first two columns of Table 6 show estimates based on the full sample. The latter two show estimates on a sample of credit unions with assets between \$10 million and \$100 million dollars as of June 1998. This corresponds to the group that are most likely to outsource as shown above.

Table 6: Coefficient Results of Minimal and Mixture Models

	(Full-Minimal)	(Full-Mixture)	(Limited-Minimal)	(Limited-Mixture)
		Internet Adoption Equation		
C	-26.990***	-27.000***	-27.000***	-31.424***
	(1.083)	(1.080)	(6.330)	(6.379)
Log Assets	3.721***	3.720***	3.720***	4.484***
	(0.191)	(0.191)	(1.190)	(1.200)
Log Assets Sq	-0.141***	-0.141***	-0.141***	-0.176***
	(0.009)	(0.009)	(0.056)	(0.057)
Log Potential Members	0.231***	0.231***	0.231***	0.224***
	(0.019)	(0.019)	(0.023)	(0.023)
Pop 18-24 Yrs Old	1.759***	1.760***	1.760***	1.768***
	(0.611)	(0.611)	(0.782)	(0.789)
Pop w/ Higher Education	3.186***	3.190***	3.190***	3.013***
	(0.438)	(0.438)	(0.552)	(0.551)
Internet Use	3.168***	3.170***	3.170***	3.479***
	(0.189)	(0.189)	(0.239)	(0.238)
Teller Wage	-0.221***	-0.220***	-0.221***	-0.207***
	(0.033)	(0.033)	(0.044)	(0.043)
Rural	0.169***	0.169***	0.169***	0.180***
	(0.062)	(0.062)	(0.075)	(0.075)
Int Banking Prevalence	1.580***	1.580***	1.580***	1.553***
	(0.140)	(0.140)	(0.174)	(0.173)
Outsourcing Dummy	-0.105***	-0.046	-0.105***	-0.005
	(0.042)	(0.103)	(0.051)	(0.129)
Type		-0.063		-0.061
		(0.102)		(0.130)
		Outsourcing Equation		
C	-32.904	-25.900	-32.900	-5.556
	(0.129)	(0.317)	(1.190)	(5.627)
Log Assets	6.223***	4.250***	6.220***	0.259***
	(0.027)	(0.069)	(0.230)	(1.091)
Log Assets Sq	-0.304***	-0.207***	-0.304***	-0.011***
	(0.001)	(0.004)	(0.011)	(0.053)
Rural	0.182***	-0.056***	0.182***	-0.146
	(0.011)	(0.056)	(0.015)	(0.087)
Log Population	-0.024***	-0.087***	-0.024***	-0.060***
	(0.002)	(0.012)	(0.004)	(0.020)
Outsourcing Prevalence	3.667***	2.940***	3.670***	1.931***
	(0.016)	(0.080)	(0.024)	(0.123)
Type		7.320***		7.215***
		(0.032)		(0.047)
Lambda0		0.741***		0.565***
		(0.023)		(0.034)
N	10,390	10,390	3,523	3,523
LogL	51,880	23,917	25,682	12,459

Both models are specified with the linear and quadratic terms in assets and including all the variables from the prior results. For simplicity the tables omit the results for the FOM, Limited Income and State Chartered variables. The top panel of Table 6 shows the coefficients from the Internet adoption equation while the outsourcing equation results are in the bottom panel.

The signs in these results are mostly the same as those in the prior estimation so that Internet banking adoption is more likely for larger credit unions with more potential members and those in markets with a more educated population and younger population. The coefficients for Internet use now have the expected positive sign, indicating that credit unions in states with high Internet use overall adopt Internet banking faster. Surprisingly, a higher teller wage is now associated with a lower likelihood of adoption. Firms in rural markets are more likely to adopt this technology while firms serving a limited income population are less likely to adopt. The results still show that outsourcing of IT systems follows the inverted U pattern in shown in Figure 2. The other outsourcing results also continue, namely that outsourcing is less likely in more populous markets, and more likely if other credit unions in the market outsource.

In both estimates of the minimal model (for the full sample and the limited sample), the coefficient on outsourcing is negative and statistically significant. Again, controlling for observable features of the credit unions, outsourcing seems to lower the probability of Internet banking adoption. This effect is true even for the mid-sized firms in the limited sample.

By explicitly accounting for a restrictive form of correlation between the equations (through the type variable), the mixture model is designed to ascertain whether this is the result of market frictions or some unobserved composition effect. The interesting result is that firm type greatly predicts outsourcing and yet has no discernible effect on Internet adoption. The results indicate that on average 26% (1-λ_0) of credit unions in the full sample are high types and the large positive coefficients on type in the outsourcing equation indicate that high type firms almost exclusively outsource their systems. However, high type firms are no more likely to offer Internet banking. Further, conditional on type, outsourcing no longer alters the relative costs and/or benefits of Internet adoption. While the data clearly indicate that type drives the outsourcing decision, the current specification does not distinguish its effect on Internet adoption separately from the outsourcing itself.

6 Conclusion

The basic results indicate that, at least among these firms, the more rapid adoption of Internet banking (seen in the raw data) by outsourcing firms is the result of who they are rather than the outsourcing itself. Once the model controls for observable characteristics, the apparent relationship reverses and outsourcing firms are slower to adopt the new technology.

In the current specification, controlling for the unobserved firm type eliminates this result, showing no difference between outsourcers and others in adoption rates. Neither the firm's type, nor its technology decision are indicative of Internet adoption behavior, instead leaving a credit union's choice to adopt the Internet to be primarily driven by the demographics of its customers. Credit unions serving a poorer population are slower adopters, while those in areas with better educated, Internet using populations are faster to offer this service. The results regarding the teller wage and the fact that rural credit unions are more rapid adopters are both provocative and warrant further investigation.

For the outsourcing decision, many of the observable characteristics such as the credit union's field of membership seem to impact their choice. However, the unobserved type is a primary driver of outsourcing. The limited switching from in-house software to outsourced systems that exists in the data leads the model to predict that there are two types of credit unions - those that outsource and those that do not. Combined with the fact that the percentage of other credit unions that outsource in a given market also strongly predicts outsourcing behavior, this fact suggests that yet undiscovered firm and market level variables are driving this decision.

Lastly, the findings regarding the differential effect of firm size on the probabilities of Internet adoption and outsourcing are intriguing. The smallest firms neither outsource nor offer Internet banking, quite plausibly due to the relatively large fixed costs associated with either choice. Firms at the middle of the distribution are able to benefit enough to cover those fixed costs and therefore are more likely to adopt and to offer Internet banking. For the largest firms, the patterns diverge: these firms are the most likely to benefit from Internet banking however they are large enough to manage their IT systems in-house.

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A Estimation Algorithm

As written in equation 13, the likelihood function involves the summation of 2^T terms. To see this, note that the function is summed over all possible time paths for the firms unobserved type. This may be tractable in this application, since T is limited to only 11 periods. However, were we to extend the estimation period or to extend the model to include a richer specification for the unobserved effects, this equation could become unmanageable. For this reason, we utilize the recursive algorithm described in Cosslett and Lee (1985) and Hajivassiliou (1996) modified for this application. This algorithm is described here.

To begin, we define terms. Let $\mathbf{C_t}$ be the set of all observations on h and, S up to and including time t. Then define $Q_t(I_t) \equiv P[\mathbf{C_t}, I_t|\mathbf{X_t}, \mathbf{Z_t}]$ i.e. the probability of seeing the data that has occurred to time t jointly with the firm being of type I_t at time t. The likelihood function described earlier can then be written as

$$L = \sum_{I_T=0}^{1} Q_T(I_T) \tag{16}$$

However, as these authors have discovered, a recursive relationship exists for Q_t. In particular,

$$\begin{aligned}
Q_t(I_t) &= p[\mathbf{C_{t-1}}, h_t, S_t, I_t|\mathbf{X_t}, \mathbf{Z_t}] && (17)\\
&= \sum_{I_t=0}^{1} p[\mathbf{C_{t-1}}, I_{t-1}, h_t, S_t, I_t|\mathbf{X_t}, \mathbf{Z_t}] && (18)\\
&= \sum_{I_t=0}^{1} p[h_t, S_t, I_t|\mathbf{X_t}, \mathbf{Z_t}, \mathbf{C_{t-1}}, I_{t-1}]p[\mathbf{C_{t-1}}, I_{t-1}] && (19)\\
&= \sum_{I_t=0}^{1} p[h_t, S_t, I_t|X_t, Z_t, I_{t-1}]Q_{t-1}(I_{t-1}) && (20)\\
& && (21)
\end{aligned}$$

As a result, the likelihood function can be recursively estimated from the equation above. We first calculate $Q_0(0)$ and $Q_0(1)$ and then note that:

$$\mathbf{Q_t} = \mathbf{M_t} \cdot \mathbf{Q_{t-1}} \tag{22}$$

where

$$M_t \equiv \begin{pmatrix} p[h_t, S_t, I_t = 0 | I_{t-1} = 0] & p[h_t, S_t, I_t = 0 | I_{t-1} = 1] \\ p[h_t, S_t, I_t = 1 | I_{t-1} = 0] & p[h_t, S_t, I_t = 1 | I_{t-1} = 1] \end{pmatrix} \tag{23}$$

The first derivatives of the likelihood function can also be calculated recursively by noting that,

$$\partial \mathbf{Q_t} / \partial \Theta_t = \mathbf{M_t} (\partial \mathbf{Q_{t-1}} / \partial \Theta_{t-1}) + (\partial \mathbf{M_t} / \partial \Theta_t) \mathbf{Q_{t-1}} \tag{24}$$

A.1 Initial Conditions

Assuming that the Markov process described above is in the steady state than the initial conditions, i.e. the probability that a given firm is high or low type, is determined by the transition probabilities. Let λ_0 be the probability that a credit union is low type. Then:

$$\lambda_0 = \frac{1 - \tau_{11}}{2 - \tau_{00} - \tau_{11}} \tag{25}$$

and $Q_0(0) = \lambda_0$, $Q_0(1) = (1 - \lambda_0)$.