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Cooperative Traits of Technology Adoption: Website Adoption in Irish Credit Unions

By *Donal McKillop and Barry Quinn*

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The purpose of this paper is to examine website adoption and its resultant effects on credit union performance in Ireland. Credit union specific factors influence adoption as does the socio-economic profile of the population from where the credit union draws its membership. Website adoption results in a reduction in the spread between the loan and dividend rate with this primarily driven by a fall in the loan rate. Given that the adoption of a website, albeit with limited functionality, translates into cost benefits this augurs well for the current restructuring process underway for Irish credit unions which has as one of its objectives the upgrade of credit union ICT sophistication.

Keywords: Credit unions, technology, probabilistic models

Cooperative traits of technology adoption: Website adoption in Irish Credit Unions.

Section 1: Introduction

Technological progress is often cited as the main, if not the most important, driver of change in the financial services industry. Worldwide, IT utilization has increasingly been linked with the advancement and success of financial intermediaries. For example, by enabling customers to access services through automated distribution channels without having to physically visit premises increases customer flexibility and reduces costs. Irish credit unions, which have higher population coverage (67%) than any other country in the world, have not similarly advanced in their use of IT for service and product delivery[1]. This can be traced to the failure in 2000 of an IT project that was supposed to create an integrated system to support the spread of ATM services, electronic fund transfer and ultimately a centralized banking system for all credit unions. The project was abandoned in 2001 as costs spiraled to €100 million.

Against this backdrop Irish credit unions have pursued their own IT development with various levels of sophistication and degrees of success. For example, only 50 credit unions offer ATM services (through a third party provider), less than 50 credit unions, through arrangements with one of two banks, offer electronic fund transfer (EFT) and almost no credit unions provide debit cards. Indeed 215 credit unions (53%) still do not even have a web presence. For those that do have a website it tends to be informational in form offering details on products and services, opening hours and links to social media sites with only limited evidence of transactional functionality[2].

[1] The World Council of Credit Unions estimated that in 2011 there were 51,013 credit unions in 100 countries, with 196.5 million members holding $1.56 trillion in assets. The first credit union in Ireland was established in 1958; by 2011 there were 403 credit unions with assets under management of €14.1 billion and 2.8 million members.

[2] The Irish Commission on Credit Unions (2012) classified the Irish credit union movement as being in a transitional development stage, well behind mature credit union movements such as those in the US, Canada and Australia. Classification as a transition movement rests in large part with the fact that credit unions have currently in place a technological infrastructure which has singularly failed to harness the benefits that can accrue from an integrated IT system for the delivery of products and services to their members.

The purpose of this paper is to examine the factors behind web presence adoption by credit unions and the costs and performance implications of such adoption. The analysis is undertaken for the period 2002 to 2010. It is based on financial statement and balance sheet data plus surveys of the web-based functionality of each credit union. Firstly, we formulate a probabilistic model to investigate web adoption, and assess the degree to which characteristics specific to the credit union and to its potential membership base influence the adoption decision. Our analysis suggests asset size, common bond type, trade association affiliation and a credit union's loan to asset ratio influence adoption as does the socio-economic profile of the population from where the credit union draws its membership including the proportion of the population in the age bracket 35 to 44, the proportion of the population that have access to broadband and the level of familiarity with a local ATM facility.

Secondly, we employ panel data techniques to capture the dynamic nature of website diffusion over the period 2002-2010. These models are used to investigate the effect of website adoption on the costs and performance of a `typical' Irish credit union over time. The dynamic model reveals that after controlling for factors that would affect differences across those credit unions that adopt a website and those that do not, there is a negative and significant effect on the spread between the loan and dividend rate plus a negative and significant effect on the loan rate itself. This effect although identified as small persists and is increasing over time.

This paper makes a number of distinct contributions. Firstly, it is timely as Irish credit unions are now entering a period of substantive structural change and the lessons from elsewhere in financial services is that IT is a catalyst for change. The Irish Commission on Credit Unions (2012) noted that since the onset of the financial and economic crisis credit unions have faced a decline in income and an increase in costs (the average cost-to-income ratio rose from 49.5% in 2006 to 88.7% in 2011). Consequently one of the conditions of the EU/IMF/ECB support package for Ireland is the restructuring of credit unions. A Credit Union Re-Structuring Board was established in 2012 to facilitate amalgamations and the creation of strong (anchor) credit unions capable of developing more sophisticated and more sustainable business models[3]. The Irish Government has set aside €250 million for this process some of which will be used to enable 'anchor' credit unions upgrade their ICT and other systems. This study which highlights that the adoption of a website, even with limited functionality, can provide cost reductions points to the potential of additional benefits accruing from more sophisticated levels of technological advance.

Secondly, this paper is the only one which has examined any facet of technology adoption for a credit union movement other than the US. Thirdly, the analysis offers insights into both adoption determination and the performance and cost implications of adoption. Prior US studies concentrated on a particular facet of the process, for example Ono and Stango (2005), and Borzekowski and Cohen (2005) examine decisions to outsource technology; Dow (2007) and Damar and Hunnicutt (2010) study the determinants of technology adoption; while Dandapani et al. (2008) and Pana et al. (2012) investigate changes in benefits to credit union members after adoption.

The rest of this paper is structured as follows. Section 2 reviews the literature on technology adoption by financial institutions and the cost and performance implications of such adoption. Section 3 details the methodology setting out the empirical models used to assess the determinants of adoption as well as the models used to assess performance differences before and after adoption. Section 4 describes the data set and presents the results of the empirical analyses while Section 5 summarizes and concludes.

[3] The Credit Union and Co-operation with Overseas Regulators Act 2012 was signed in to law in December 2012 and several of its key provisions are commencing immediately. The Act implements over 60 of the recommendations of the Irish Commission on Credit Unions (2012) across a range of areas, including: Prudential Regulation; Governance; Restructuring to be overseen by a Restructuring Board; and Stabilization.

Section 2: Literature Review

2.1 Factors important in determining internet banking adoption

Technological advances have had a dramatic impact on the structure, operations and economics of the financial services industry. Technological progress is often cited as the main, if not the most important, driver of change in the banking industry. Naturally, developments in information collection, storage, processing, transmission and distribution technologies have a major impact on many aspects of banking activity. IT developments affect financial services in two main ways. First, they contribute to reducing costs associated with the management of information (collection, storage, processing and transmission), mainly by substituting paper-based and labour-intensive procedures with automated processes. Second, they alter the ways in which customers have access to services and products, mainly through automated distribution channels such as internet, phone-based and other banking access channels. Engagement with IT has led in many cases to improvements in bank profitability primarily via increased revenues from service charges, or through lower processing costs (Hernando and Nieto, 2007; De Young et al., 2007).

2.1 Banking Studies

Patterns of internet banking adoption by banks have received significant attention in the academic literature[4]. Furst et al. (2000) finds that US banks that incurred high fixed costs relative to net operating revenues, were members of a bank holding company, or were located in an urban area, were more likely adopters of internet banking. Courchane et al. (2002) notes that bank size, industry concentration and bank location were significant determinants of the probability of adoption. Nickerson and Sullivan (2003) suggest that US banks are more likely to adopt internet banking where uncertainty over the level of demand is low. Sullivan and Wang (2005) find that the adoption of internet banking was slower in US states where average income is low, where there is a scarcity of internet access, where financial institutions are

[4] Other IT adoption patterns examined in banking include: ATMs (Hannan and McDowell, 1984; 1986; Saloner and Shepard, 1995); Automated Clearinghouse Settlement Systems (Gowrisankaran and Stavins, 2004); Credit Scoring Technologies (Akhavein et al., 2005); Real Time Gross Settlement Systems (Bech and Hobijn, 2006); and Debit Cards and Electronic Giro Transactions (Bolt et al., 2008).

older, and where average bank size is smaller. Fuentes et al. (2006) show that although bank-specific characteristics are important determinants of banks' adoption decisions, competition also plays a prominent role[5]. Arnaboldi and Claeys (2010) find that EU banks with a heavy cost structure and a large market share in client deposits and non-interest activities are more likely to introduce internet banking.

Alongside this literature on the factors driving adoption is a literature which explores the impact on performance once adoption has occurred. DeYoung (2005) finds that the variable cost of producing a basic internet banking transaction is very low for US banks and that offering internet banking services can enhance the profitability of small banks. DeYoung, Lang, and Nolle (2007) compare community banks which adopted transactional banking websites in the late-1990s to branching-only community banks. The analysis found that internet adoption improved US community bank profitability with this achieved through increased revenues from deposit service charges. Hernando and Nieto (2007) find that for Spanish banks online banking was associated with lower overhead costs (particularly, staff, marketing and IT) and higher profitability which emerged about one and a half years after adoption[6]. Arnaboldi and Claeys (2010) find that for EU banks the initial investment in technology has proved higher than any consequent cost saving, and that internet banks fail to create synergies with other banking activities.

2.2 Credit Union Studies

The literature on technology adoption by credit unions is exclusively focused on the US credit union sector. Ono and Stango (2005) examine the factors that influence the decision to outsource information technology services. The decision to outsource is associated with asset size, and the diversity of the credit union’s product offerings. Borzekowski and Cohen (2005) find that the propensity to outsource is increasing in the number of other credit unions in the same geographic location that also elect to outsource. Dow (2007) examines the adoption of web and computer based banking

[5] The extent of competition is related to the geographical overlap of banks in different markets and their relative market share in terms of deposits. In particular, banks adopt earlier in markets where their competitors have already adopted.

[6] Hernando and Nieto (2007) also conclude that the internet was used as a complement to, rather than a substitute for, physical branches.

and find that larger credit unions are more likely to adopt new technologies earlier than their smaller counterparts. Callahan and Associates (2007) suggest that technology is still very much at the forefront of US credit unions attempts to retain and increase membership, enhance competitiveness, improve efficiency and improve member services. Dandapani et al. (2008) find that offering web access increases operating expenses but adopters still maintain the same average profitability as that of non-adopters. The authors also find some evidence of increased asset growth in credit unions that offered web accounts. Damar and Hunnicutt (2010) study the determinants of internet banking adoption within a consumer decision making framework. They conclude that organizational form as well as size may be critical in the adoption of new technology. Pana et al. (2012) investigate the changes in benefits to credit union members via the interest-rate spread around the adoptions of internet-based services and show that adopters offer a less favorable interest-rate spread to their members than non-adopters[7].

[7] Pana et al (2012) also find evidence that early adopters have a lower degree of market power in dealing with their members than late adopters and offer interest-rate spreads comparable to those of non-adopters over a three-year period following the adoption year.

Section 3: Methodology

In Section 3.1 we formulate a probabilistic model to enable an assessment of the degree to which characteristics specific to the credit union and to its potential membership base influence the web adoption decision. While in Section 3.2 we specify two models which will be used to investigate the effect of website adoption on the costs and performance of a `typical' Irish credit union.

3.1 Probability of adopting a web based presence

In economic terms we model the propensity of a credit union to adopt a web presence given a set of individual characteristics. Formally we define the model as:

$$Y_i = \begin{cases} 1 & if\ and\ only\ if\ y_i^* > 0 \\ & otherwise = 0 \end{cases} \quad Outcome\ Equation \tag{1}$$

Where

$$y_i^* = \propto + \beta X_i + \delta D_i + \varepsilon_i \qquad latent\ Adoption\ Index\ function \tag{2}$$

Equation (1) is what is actually observed while equation (2) is a latent regression and can be thought of as the unobserved propensity to adopt, where X_i is a vector of lagged continuous explanatory variables, D_i is a vector of lagged dummies variables and ε_i captures the unmeasured characteristics that affects the propensity to adopt for the ith credit union. Our observation mechanism is thus

$$Y_i = \begin{cases} 1 & if\ \varepsilon_i > -\propto - \beta X_i - \delta D_i \\ 0 & if\ \varepsilon_i < -\propto - \beta X_i - \delta D_i \end{cases} \tag{3}$$

In terms of a probability model

$$Prob(adopt) = Prob(Y_i = 1) = Prob(\varepsilon_i > -\propto - \beta X_i - \delta D_i)$$

$$Prob(not\ adopt) = Prob(Y_i = 0) = Prob(\varepsilon_i < -\propto - \beta X_i - \delta D_i) \tag{4}$$
$$= 1 - Prob(Y_i = 1)$$

As we are now dealing with a non-linear probability density function we use maximum likelihood estimation to produce estimators which are asymptotically efficient and consistent. Such estimation requires explicit specification of a functional form of individual probability of which the most popular are the normal and the logistic distributions. Both distributions are symmetric in nature, with the latter producing a probit model and the former producing a logit model. In a reasonable sample both models produce similar results.

The coefficients from the probit and logit models are difficult to interpret because they measure the change in the unobservable y* associated with a change in one of the explanatory variables. Measures that are more useful are the elasticities and the marginal effects. Elasticity gives the percentage change in the probability of a success in response to a one percent change in the explanatory variable and is obtained using partial derivatives. In this analysis we report a scale free measure of the proportionate effect on the probability of adoption due to a proportionate change in the regressor.

The marginal effect gives the percentage change in the probability of a success in response to a one unit change in the explanatory variable. Again we resort to the use of partial derivatives with estimates of the marginal effects calculated by rescaling the estimated coefficients. In that the marginal effects are different for different observations the problem of what to report arises. We have chosen to estimate the difference between the estimated prob (Y=1) before and after some typical change. We report the marginal effects in two forms, at the mean of the explanatory variables (this can be thought of as the marginal effect for a typical credit union) and with the individual marginal effects averaged across the sample (this can be thought of as the marginal effect for the full population).

3.2 Impact of technology adoption on performance

In assessing the impact of adopting a new technology on a credit union's performance it is important to consider the appropriate comparison of before and after performance variables to obtain accurate causal inferences. A credit union that chooses to adopt a new technology, such as a website, is likely to be characterised differently from those that do not adopt. These differences, if they influence a credit unions response to adoption, may invalidate casual comparisons, even after controlling for the differences that can be observed. The key issue for estimation is whether adoption is randomly assigned; that is can we assume the decision to adopt a new technology is independent of all other factors? This problem is one of confoundedness, endogeneity or self-selection.

In our panel dataset, which has repeated observations on individual credit unions over time a `two-way effects' estimation can be derived from a counterfactual framework where unconfoundedness holds conditional on unobserved heterogeneity and the history of a set of covariates thought to influence the outcome variable. In the context of an Irish credit union, after controlling for those operational and structural characteristics that are thought to influence cost and performance, the unobserved heterogeneity that is like to remain would relate to technological ability, that is the ability of credit union staff and management to learn, adapt, and effectively utilise the new website to derive cost and performance benefits.

The baseline panel model employed in the investigation has the following form:

$$Outcome_{it} = \beta_0 + \beta_T D_{i,t-1}^T + Controls_{i,t-1} + DI_{it} + \alpha_i + \theta_t + \varepsilon_{it} \tag{5}$$

The outcomes refer to a selection of cost and performance variables. The specification includes an indicator variable for each panel which controls for unobservable individual credit union effects, α_i, (that do not vary over time) and a set of time dummies, θ_t, to control for group level time effects[8]. The control matrix includes variables that are thought to affect the outcome. Lagged values are used to help mitigate a possible endogeneity issue of contemporaneous feedback relationships with the performance and cost outcomes variables.

$D_{i,t-1}^T$, is a lagged dummy variable taking the value 1 if the credit union had a live website in that year, and zero otherwise. A lagged variable is used as the decision to adopt may not be strictly exogenous with for example funding to enable adoption

[8] The $Corr(\alpha_i, X_{it})$ and rho values reported in Tables 3 and 4 provide some credence to the use of a two-way effects estimator. The rho values suggest that the majority of the error variance is due to cross credit union variation, while there does appear to be correlation between the fixed effect and the covariate matrix in all models.

dependent on the past performance of the credit union.[9] As an alternative an `in-sample' adoption dummy is also used to test the robustness of our results on the basis of the Rubin Causal model framework. It takes the value of one for those credit unions which have adopted a website after 2002. This effectively re-categorises those credit unions which had adopted a website in 2002 to be in the control group and thus allows a more robust assessment of the causal impact of adoption to be estimated.

Although time-constant variables, such as the dummy variables for common bond type and credit union location, cannot be included by themselves in a fixed effects model, they can be interacted with variables that change over time and, in particular, with year dummy variables. This controls for how the effect of the common bond and location impacts on performance and cost changes over time. The term, DI_{it}, is a vector of interaction terms of the dummy variables with the time dummies.

One limitation of a fixed effect estimator is that any unobserved time-varying confounding variable, such as past outcomes, cannot be subsumed in the time-invariant omitted variable α_i. Specifically it may be reasonable to assume that the distinct history of the outcome variable will have an influence on how adoption impacts upon the current outcome. This motivates the following specification:

$$Outcome_{it} = \beta_0 + Outcome_{it-h} + \beta_T D_{i,t-1}^T + Controls_{i,t-1} + DI_{it} + \alpha_i + \theta_t + \varepsilon_{it} \quad (6)$$

where $Outcome_{it-h}$ is a vector of lagged values for multiple periods.[10]

[9] In using a lagged value we are assuming that the decision to adopt is weakly exogenous or pre-determined. That is $D_{i,t}^T$ is independent of all subsequent structural disturbances, $\varepsilon_{it+s}, s \geq 0$. Variables that are predetermined in a model can be treated, at least asymptotically, as if they were exogenous in the sense that consistent estimators can be derived when they appear as regressors (Greene, 2008).

[10] One immediate issue in applying least squares to this empirical model is that lagged values of the outcome are likely to be correlated with unobserved individual effect, which would result in `dynamic panel bias' (Nickell, 1981), which cannot be eliminated through any form of differencing.

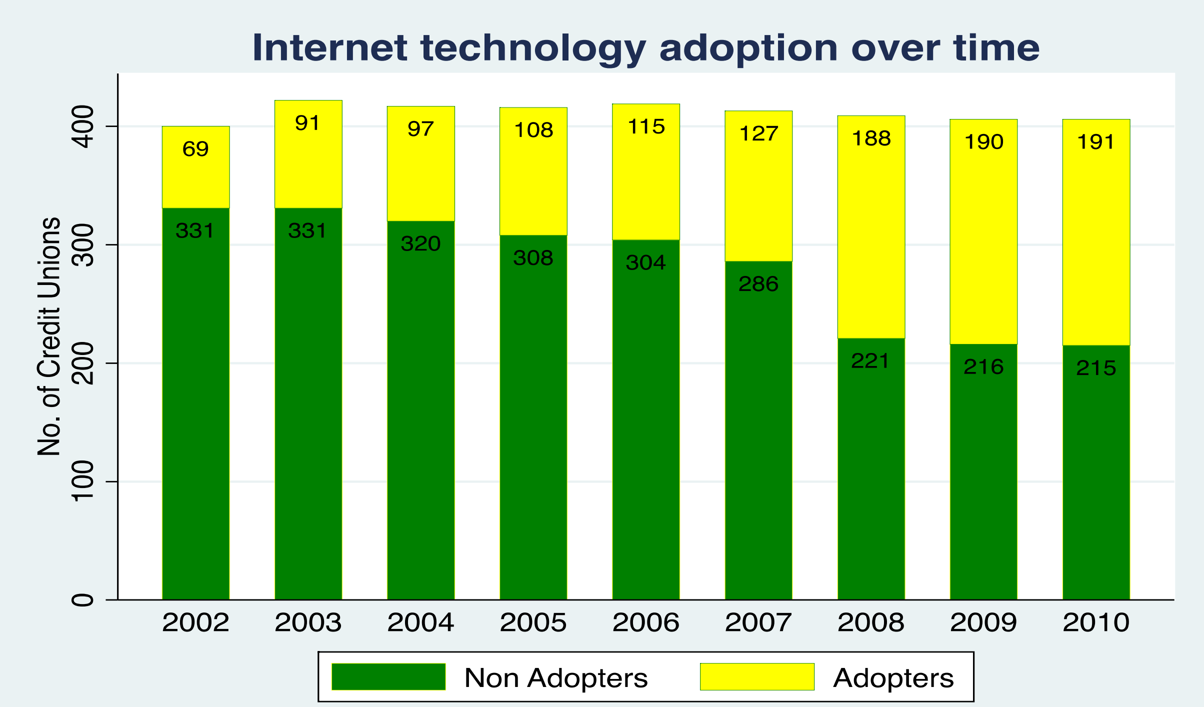
Section 4: Data and Results

In Section 4.1 information is presented on trends in web adoption over the period 2002 to 2010. In section 4.2 the variables potentially important in explaining the adoption of a website are discussed with these variables dictated by the literature review, the financial and operational characteristics of credit unions and the economic fundamentals of the area from which the credit union draws its members. Section 4.3 profiles the performance and cost metrics assessed before and after website adoption and the control variables employed in the panel models. Section 4.4 presents adoption determinant estimation results while in Section 4.5 estimates of the performance and costs effects of website adoption are detailed.

4.1 Credit unions with a web-based presence 2002 to 2010

To empirically investigate adoption over time, data on the history of a credit union's website was acquired using the Internet Archive online facility and data from the IE domain registry. Figure 1 shows the trend in website adoption within the Irish credit union movement over the period for which we have financial data, 2002-2010.

Figure 1



Source: *Internet Archive (www.archive.org), IE Domain registry (www.domainregistry.ie)*

There has been a steady increase in web adoption over the period although in 2010 53% of credit unions still do not have a web-based facility. Credit unions in Ireland can be distinguished in terms of their common bond as either occupational or community credit unions. In 2010 there were 45 occupational credit unions with the remainder (358) community based. In 2002, 20% of occupational credit unions had a web presence with this rising to 50% in 2010 (comparable figures for community credit unions were 16% and 47%). Credit unions are also designated as rural or urban with an equal number of credit unions in each category. In 2002, 23% of urban credit unions had a web presence by 2010 this had risen to 57% (comparable figures for rural credit unions were 7% and 40%).

It is usual to differentiate web functionality into three categories. At the first (lowest) level, an *informational* website displays general information on interest rates, and contact details. At the second (intermediate) level, an *interactive* website allows members to request information on share and loan balances, to request statements and also accepts applications for membership, loans or share accounts. Finally, at the third (highest) level, a *transactional* website also allows members to complete transactions such as paying bills, make loan payments or deposits, and transfer funds between accounts.

To gauge web functionality the researchers accessed all websites in 2010/2011. All websites could be classified, at a minimum, as informational sites offering details on products and services, opening hours and links to social media sites. Thereafter differences in web functionality appeared relatively modest with even the very largest credit unions offering relatively minor transaction functionality. For such sites there was some evidence of internal transactions such as account transfers, loan applications and withdrawal requests as well as external transactions, although less so, such as recurring bill payments and transfers to third party accounts.

The relatively unsophisticated nature of web-based provision relates to two factors. The first is that Irish credit unions have been unable to create a sophisticated integrated technology solution across credit unions and secondly credit unions are constrained by legislation and the regulatory authorities in the range of services that they provide. Irish credit unions for the most part are relatively simple savings and loans institutions. For example our audit of credit union service provision suggest that financial technologies such as phone banking and ATMs have adoption rates of considerably less than 10% while very few credit unions offer debit cards[11].

Therefore in the ensuing empirical analysis we do not differentiate in terms of website functionality rather we simply divide credit unions into two categories those with a website and those without.

4.2 Adoption determinants

Credit union specific variables which may be important in explaining the adoption of a web base facility include *asset size* (larger credit unions more likely to be adopters of new technologies); *expenditure on labour* (initially an increase in labour expenses may coincide with adoption and preparation for adoption)[12]; *the proportion of income from non-interest sources* (adopting a new technology may have a positive impact on non-interest income); loans as a proportion of total assets (a high loan to asset ratio is indicative of a financially healthy credit union with high earnings potential and consequently available funds for investment in new technologies); *ILCU affiliation*, a dummy variable is used to distinguish between credit unions affiliated to the Irish League of Credit Unions (ILCU) and those that are not (the ILCU is promoting an integrated technology solution); *organizational structure*, a dummy variable is used to distinguish between credit unions structured around an occupational common bond and those based on a community bond (occupational credit unions are more like to adopt a website as there members tend to be mostly in employment, on average better educated and potentially technologically literate); *location,* a dummy variable is

[11] Debit cards are not listed under Exemptions from Additional Services Requirements and consequently require prior approval by the Central Bank of Ireland on a credit union by credit union basis. Approvals are hard to come by and where they are achieved they are subject to significant delay (between four and eight months).

[12] See (DeYoung, Lang, & Nolle, 2007) for empirical evidence of increases in labour expenses due to the adoption of Internet technologies.

used to distinguish between urban and rural credit unions (urban credit unions are more likely to adopt due to superior connectivity in urban areas)[13].

Variables which profile the population from where the credit union draws its members are created from electoral district data published by the Irish Central Statistics Office. The variables include *employment status*, the proportion of potential membership of the credit union that is employed (the more affluent the member the more likely they will have a computer and the more likely the credit union will adopt web technology)[14]; *age,* the proportion of the potential credit union membership that is between the ages of 35-44 (those 35-44, generation X are perceived not to be as technologically savvy as generation Y (19-34 year old) cohorts);[15] *female,* the proportion of the potential credit union membership which is female *(*perhaps the gender breakdown of potential credit union membership influences adoption probability*); computer literate,* the proportion of third level educated people who have a computer-based qualification (the greater the perceived familiarity of members with internet technology the greater the probability the credit union will adopt a web-based presence); *accessibility*, the proportion that have access to broadband internet (an increase in broadband accessibility in an area can be expected to have a positive impact on the likelihood of internet technology adoption); *familiarity*, a dummy variable is used to distinguish between credit unions with a local ATM facility and those without (familiarity with similar but older technologies improve the chance that members will adopt technology based services encouraging the credit union to adopt a web-based presence);[16]

[13] Operational and financial data on credit unions affiliated to the Irish League of credit Unions (ILCU) was provided by that trade association, for other credit unions the information was obtained from paper-based copies of their annual returns supplied by credit unions on a case-by-case basis.

[14] Bauer and Hein (2006) argue "*the more one earns, the more likely that a computer has been purchased, reducing the marginal cost of internet banking*". Lee et al. (2008) argue that the less affluent may be less likely to be user of e-banking technologies.

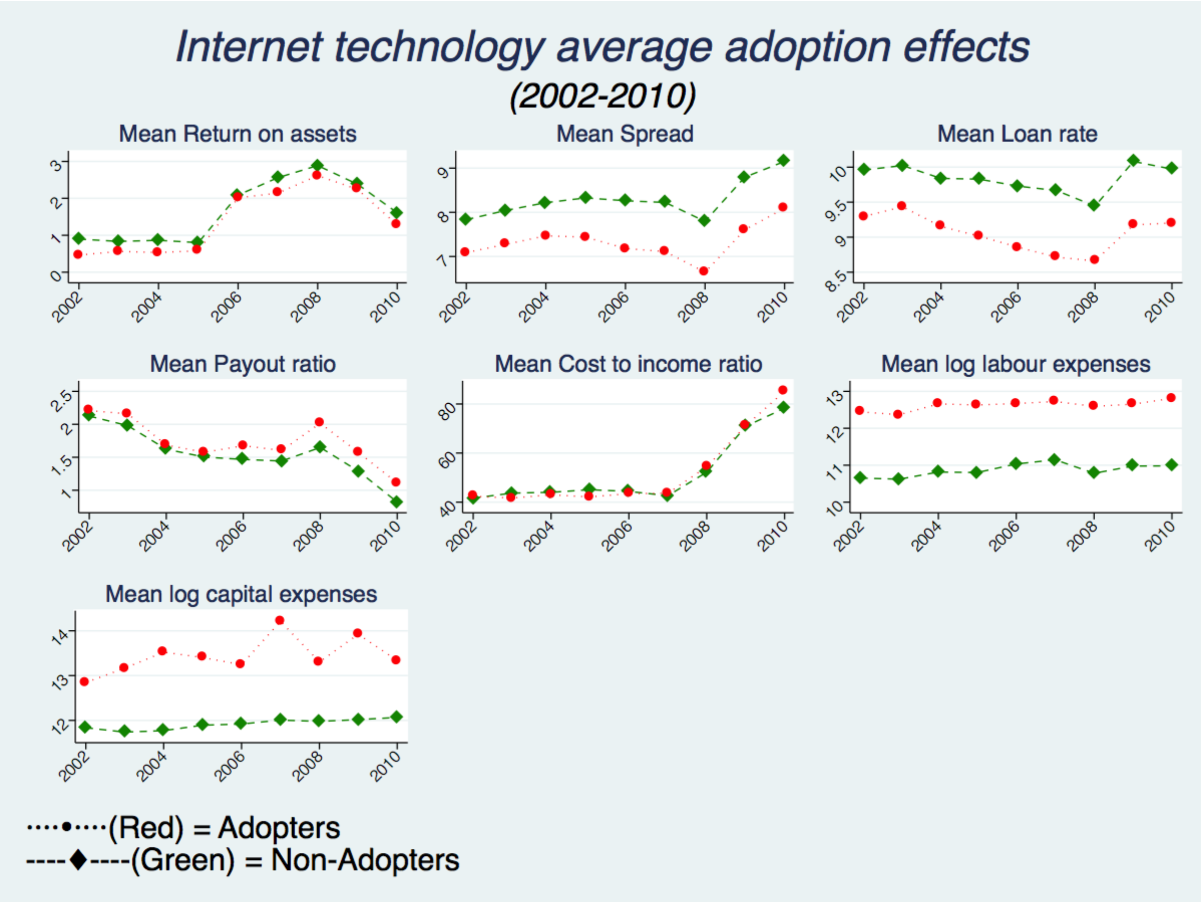
[15] Kennickell and Kwast (1997) note that those under the age of 35 are more likely to use PC banking and ATMs than older cohorts.

[16] See for example, Bauer and Hein (2006) and Kim et al. (2006) who found such a phenomena with regard to internet banking.

4.3 Performance after adoption

A number of performance and cost metrics are considered. The performance metrics include *return on assets; the interest rate spread* (the difference between the cost to members of borrowing and the dividend rate members are paid on their savings); *the loan rate* and *dividend pay-out ratio* are also investigated separately to decompose any overall effect. While the cost metrics include a *cost to Income ratio*; with any cost further assessed using *labour expenditure* and *capital expenditure*. Figure 2 presents a dynamic visualization of the performance and cost metrics grouped by whether the credit union adopts a website or not.

Figure 2

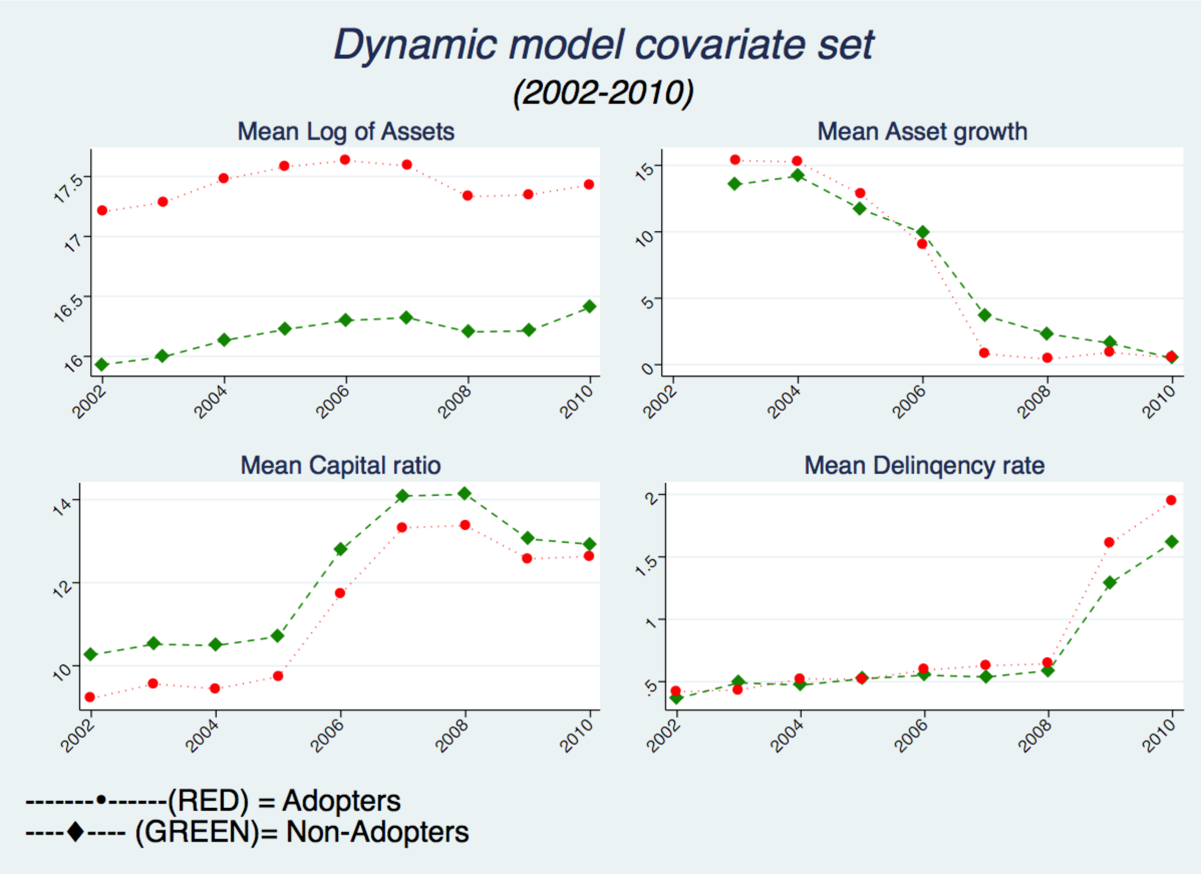


The graphical overview reveals some distinct difference in these groupings, with adopters experiencing lower spreads on average (likely driven by lower average loans rates) and higher average labour and capital expenses. The latter finding is consistent with the initial encroachment on costs of the adoption of a new technology. The former finding suggests that credit unions are passing any benefit accrued from this new technology to their membership; a practice in keeping with their cooperative ethos. That said, care must be taken when drawing any casual inference on the effect of adoption from these graphs as to do so infers that the non-adopters and adopters have no other differences other than treatment (adoption of a website).

A number of credit union characteristics are used in a conditioning covariate set to control for observable differences in the performance and cost metrics between website adopters and non-adopters. It is important to include factors that are thought to distinguish how a credit union will engage with Internet technology. Risk metrics are included namely a *capital ratio* and a *delinquency ratio;* the size of the credit union and its growth performance are included through incorporating *asset size* and *asset growth;* the adoption rate is likely to be increasing in the number of prior adopters, with adopters who are geographically close probably particularly important, to capture this a *penetration rate per county over time* is included[17]; as in the analysis of the factors driving web adoption dummy variables are included to distinguish between *occupational and community based common bonds* and between *rural and urban* credit unions. Figure 3 presents a dynamic visualization of selected operational characteristics grouped by whether the credit union adopts a website or not. The graphical analysis shows that credit unions that adopt a website are typically bigger in size, and have lower capital ratios with perhaps surprisingly the suggestion that since 2008 delinquency rates are higher for those credit unions that have adopted a web-based presence.

[17] Networks effects literature suggests that demand for a product can be related to the number of adopters of compatible products (Gowrisankaran and Stavins, 2004).

Figure 3



4.4 Empirical Findings: Adoption determinants

Table 1 presents the estimation results and some diagnostics tests for the probit and logit models. In the estimation we use a robust variance-covariance estimator so that we can adjust for the potential dependence between observations due to some unobserved firm specific variable, eg technological ability. In accordance with theory each model produces different coefficient results but in general the coefficients tell a qualitatively similar story about the influence of each regressor on the probability of adoption.

Comparison of the models using the R^2 measures shows a pronounced improvement in the explanatory power of the logit model relative to the probit model using the McKevley-Zoviano R^2 (0.85518 compared to 0.7449) but a more minor improvement when the McFaddens R^2 is used (0.345 compared to 0.344). It is also the case that the fit diagnostics present quite different predictive power profiles, the

McKevley-Zoviano R^2 indicates that predictive power is extremely good (86% and 75%) but the McFaddens R^2 predictive power at 34% is at best average. Also reported is the likelihood ratio test which indicates that the null hypothesis that all coefficients are zero can be rejected for both models.

In Table 1 we have highlighted at the 1%, 5% and 10% levels those explanatory variables which prove significant influences on whether a credit union adopts a web presence. In terms of the credit union specific characteristics the variables which prove important are asset size (LNTA), organisational structure (OCCUP BOND = 1 if occupational credit union), being a member of the trade body the Irish League of Credit Unions (ILCU =1), and the proportion of a credit union's asset base held in the form of loans (LTA). In each instance the coefficient is positive which implies that larger credit unions, occupational credit unions, those affiliated to the ILCU and those with a greater loan to asset ratio are more likely to adopt a web presence. A number of the variables utilised to profile the population from where the credit union draws its members also prove significant. These include the percentage of the population that is employed (EMP), the proportion of the population in the age bracket 35 to 44 (GENX), the proportion of the population that have access to broadband (BBAND), and familiarity, with a local ATM facility (ATM LOCATION =1 if local facility). With the exception of GENX all coefficients are positive. Our results imply that credit unions which draw members from a population with a greater percentage in employment, with more access to broadband, have familiarity with a local ATM and with fewer in the age bracket 35 to 44 are more likely to adopt a web presence.

As detailed in the methodology section a full interpretation of the coefficient estimates of the explanatory variables can only be revealed through computation of their marginal effects and/or elasticities. In Table 2 we provide the estimated results for both. Consider first the marginal effects. These give the percentage change in the probability of a success in response to a one unit change in the explanatory variable. They are reported in two forms, firstly at the mean of the explanatory variables (marginal effect for the typical credit union) and secondly with the individual marginal effects averaged across the sample (marginal effect for the full population).

Furthermore, it should be noted that when explanatory variables take the form of a dummy variable the marginal effects are interpreted as the change in the probability of adoption for a discrete change in the dummy variable from zero to one.

In Table 2 the calculation of marginal effects at the mean of the explanatory variables consistently estimates the magnitude of such effects to be somewhat greater compared to the intuitively more appealing observation specific marginal effects averaged across the sample. As in Table 1 the magnitude of the effects are broadly similar for both the probit and logit models. Concentrating on the marginal effects averaged across the sample we note that a 1% change in asset size (LNTA) increases the probability of adoption by 19% while an increase of 1% in the loans to asset ratio (LTA) increases the probability of adoption by only 0.04%. Occupational credit unions (OCCUP) have a 17% or 18% increased probability of web adoption relative to community credit unions while being affiliated to the ILCU increases the probability of adoption by 18% or 19%.

For the variables utilised to profile the population we can see that a 1% increase in the proportion of the population that is employed (EMP) increases the probability of web adoption by 1%. The probability of adoption increases by 0.06% with a 1% increase in the population with broad band access (BBAND) but falls by 2% with an increase in the proportion of the population which falls into the age bracket 35 to 44 (GENX). Those credit unions with ATM facilities (ATM LOC), even though they are provided through a third party, have a 61% increased probability of web adoption. This latter result is perhaps of no surprise in that ATM introduction is in itself a sizeable technological investment and is indicative of a credit union which is embracing the capabilities of technology.

Elasticity estimates are also reported in Table 2. These measure the percentage change in the probability of success in response to a 1% change in the explanatory variable.[18] It is not appropriate to calculate elasticities when the explanatory variable is dummy in form. Again, the magnitude of the elasticities is broadly similar for both

[18] Note that in the case of the variable LNTA we have expressed it as the natural log of total assets hence the elasticity figures for LNTA are in fact semi-elasticity calculations.

the probit and logit models. The profile detailed in Table 2 broadly maps onto our previous discussion of marginal effects. Of the six elasticities identified as significant we note that the probability of adopting web technology is most sensitive to changes in the number of those employed in the credit union's catchment area.

4.5 Empirical Findings: Performance after adoption

Table 3 presents the estimation results for the baseline panel model defined in equation (5). From Table 3 it can be seen that after controlling for a number of credit union characteristics, the adoption effect is statistically significant at the 1% level in both the spread and loan rate models. It is not significant in the equations where return on assets (ROA), cost to income ratio (CI), labour expenditure (LAB) and capital expenditure (CAP) are the dependent variables. The coefficient estimates on the web adoption effect in the spread and loan rate models are negative. The implication of the negative findings is that the benefits from new technology adoption is being passed to members in the form of a reduced spread between the dividend paid to members and the loan rate charge to members with the reduction in spread being essentially due to a loan rate reduction. That credit unions are passing benefits to members in the form of a reduced rate on loans probably relates to the fact that a majority of Irish credit unions have been significantly under lent in recent years, see Report of the Irish Commission on Credit Unions (2012).

An alternative `in-sample' adoption dummy is used to test the robustness of these findings. This effectively re-categorises those credit unions which had adopted a website in 2002 to be in the control group and thus allows a more robust assessment of the causal impact of adoption to be estimated. Table 4 highlights that when the web adoption effect is restricted to an in-sample indicator this new website indicator is again negative and statistically significant at the 1% level in both the loan rate and spread equation and insignificant for specifications where ROA, CI, LAB and CAP are the dependent variables. As with the previous results this indicates a negative effect of website adoption on these outcomes, suggesting that any benefits from the new technology are being passed on to credit union members in the form primarily of a loan rate reduction. This stricter definition of website adoption is used in the remainder of the analysis as it is more in keeping with the specification in equation 5.

To assess whether the effects of adoption persists over a longer period the opportunity was taken to re-caste the outcome variables in the form of moving averages for two and three years windows. In Table 5 we have chosen to only report coefficient estimates for the lagged adoption indicator, although the complete specification is used in the analysis of each moving average outcome. An encouraging result is the persistence of the adoption effect on both loan rates and spreads over the two and three year window. In fact there appears to be a slight increase in the estimated coefficient as the time period extends. The increase in average effect over time may be indicative of some form of learning economies when adopting a new technology, see for example, DeYoung (2005); Delgado, Hernando, and Nieto (2007). In Table 5 there also appears to be some evidence of an effect on the cost to income ratio (significant at the 10% level) when calculated on a three-year moving average basis.

In Section 3 it was argued that it may be reasonable to assume that the history of the outcome variable has an influence on how adoption impacts upon the current outcome, motivating specification 6. Consequently a dynamic model of both a credit union's loan rate and the dividend rate loan rate spread is used to investigate if the statistical impact of website adoption persists in the presence of the history of these outcomes. A three-lag model was found to best capture the dynamic nature of both loan rates and spreads. The results are presented in Table 6. The Arellano and Bond (1991) panel data test for autocorrelation in the residual is reported and highlights the absence of any autocorrelation in the error matrix .Once the dynamic nature of the outcome variable is considered there is no longer any significant relationship found for website adoption in the spread model. However, the specification with loan rate as the outcome continues to exhibit a negative significant adoption effect at the 5% level, although the effect is somewhat reduced.

Overall the various estimations suggest that the web adoption effect on the loan rate ranges from -0.107 (see Table 6) to -0.325 (see Table 4). For the average credit union loan of €3,025 this suggests an annual interest cost reduction of between €3.24 and €9.83. While this is not a sizeable saving it does emphasise that the adoption of a website albeit with limited functionality does translate into cost benefits for credit union members.

Section 5: Summary and Conclusions

In this analysis we detail the diffusion of web adoption by credit unions over the period 2002 to 2010 and highlight that even at the end of this period 53% of credit unions do not have a web presence. Websites where they exist are primarily informational offering details on products and services, opening hours and links to social media sites. Thereafter differences in web functionality appear relatively modest with even the very largest credit unions offering relatively minor transaction functionality.

Our analysis suggests that asset size, organisational structure, being a member of the ILCU and the loan to asset ratio are important credit union specific drivers of web adoption. Characteristics of the area from where the credit union captures its members are also important. Factors such as the percentage of the population that is employed, the proportion of the population in the age bracket 35 to 44, the proportion of the population that have access to broadband and the level of familiarity with a local ATM facility are all identified as influencing the probability of the web adoption decision.

These results suggest that the decision by a credit union to adopt a web presence is an interactive process driven by some factors under a degree of control by the credit union, for example asset size, but also others outside its control, notably members with access to broadband. Going forward outside factors such as access to broadband will not be a problem due to IT infrastructure investment by Government. Rather, the constraints will be internal most notably around asset size. Over 55 percent of credit unions have an asset base less than €20 million. Operating at such a scale suggests significant investment in technology is not feasible. The alternative is for credit unions to either enter into shared technology relationships or amalgamate. The latter will reduce credit union numbers but the larger entities that emerge will be better placed to invest in technology, perhaps aided by funding from the Restructuring Board, and better placed, through their larger membership base, to gain cost advantages from this investment.

In the second part of the analysis panel data techniques were used to identify the dynamic effect of website adoption on a credit union's cost and performance. The most prominent result emerging from this analysis was that the adoption of a web presence resulted in a reduction in the loan rate dividend rate spread with this driven by a loan rate reduction. It was also noted that the spread and loan rate adoption effects persists over a two and three-year period. For the average loan the annual interest cost reduction was at its best under €10. While this is not a sizeable saving it does emphasise that the adoption of a website, albeit with limited functionality, translates into cost benefits for credit union members.

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Table 1: Probit and Logit results

PARAMETERS	Probit		Logit	
CONSTANT	-18.87791***	(0.00000)	-33.23699***	(0.00000)
LNTA	0.77345***	(0.00000)	1.33291***	(0.00000)
OCCUP BOND	0.64449**	(0.04639)	1.23376**	(0.03065)
URBAN LOCATION	-0.15627	(0.42608)	-0.23274	(0.48241)
ILCU	0.85752	(0.11032)	1.57528*	(0.06767)
LABOUR EXPEND	-0.00093	(0.90798)	0.00051	(0.97132)
NON INTEREST INCOME	-0.00078	(0.93301)	-0.00009	(0.99580)
LTA	0.01652*	(0.06070)	0.02959*	(0.05205)
EMP	0.03807**	(0.01818)	0.06717**	(0.01419)
GENX	-0.08092**	(0.04760)	-0.13223*	(0.05897)
BBAND	0.02514***	(0.00868)	0.04217***	(0.00884)
ATM LOCATION	5.21570***	(0.00000)	16.84178***	(0.00000)
FEMALE	0.04876	(0.25383)	0.08965	(0.25221)
COMPUTER LITERATE	0.01076	(0.74361)	0.01361	(0.80679)
N	415		415	
McFaddens R^2	0.344		0.345	
McKevley-Zaviona R^2	0.74490		0.85518	
Wald $\chi^2_{(\beta 1=\beta 2...\beta k=0)}$	1187.75748		1923.77124	
P-value	0.00000		0.00000	
Log Likelihood	-183.78440		-183.36548	

P-values in parenthesis (* p<0.10, ** p<0.05, *** p<0.01) Adjusted for latent firm heterogeneity

Table 2: Marginal effects and elasticities

	Marginal Effects at the Mean		Average Marginal Effects		Elasticities	
PARAMETERS	Probit	Logit	Probit	Logit	Probit	Logit
LNTA	0.30543***	0.33221***	0.19362***	0.19346***	0.68912***	0.62955***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
OCCUP BOND	0.25123**	0.27596***	0.16587**	0.18357**		
	(0.03389)	(0.00923)	(0.04093)	(0.02375)		
URBAN LOC.	-0.06165	-0.05794	-0.03843	-0.03326		
	(0.42528)	(0.48130)	(0.41884)	(0.47704)		
ILCU	0.28684**	0.34243**	0.18441**	0.19201**		
	(0.03131)	(0.01112)	(0.04531)	(0.01679)		
LABOUR EXP	-0.00037	0.00013	-0.00023	0.00007	-0.01974	0.00575
	(0.90799)	(0.97132)	(0.90802)	(0.97132)	(0.90794)	(0.97133)
NON-INT INC	-0.00031	-0.00002	-0.00019	-0.00001	-0.02023	-0.00119
	(0.93301)	(0.99580)	(0.93301)	(0.99580)	(0.93299)	(0.99580)
LTA	0.00652*	0.00738*	0.00414*	0.00430**	0.71982*	0.68354*
	(0.06009)	(0.05267)	(0.05691)	(0.04712)	(0.06558)	(0.06008)
EMP	0.01504**	0.01674**	0.00953**	0.00975**	1.90049**	1.77731**
	(0.01806)	(0.01436)	(0.01505)	(0.01088)	(0.02002)	(0.01735)
GENX	-0.03196**	-0.03296*	-0.02026**	-0.01919*	-1.01760**	-0.88146*
	(0.04753)	(0.05904)	(0.04578)	(0.05674)	(0.04963)	(0.06177)
BBAND	0.00993***	0.01051***	0.00629***	0.00612***	0.42320**	0.37637**
	(0.00853)	(0.00901)	(0.00786)	(0.00776)	(0.01039)	(0.01175)
ATM LOC	0.65327***	0.66836***	0.60555***	0.60900***		
	(0.00000)	(0.00000)	(0.00000)	(0.00000)		
FEMALE	0.01926	0.02234	0.01221	0.01301	2.16423	2.10937
	(0.25358)	(0.25268)	(0.25071)	(0.24822)	(0.25631)	(0.25810)
COMP LIT	0.00425	0.00339	0.00269	0.00197	0.06548	0.04391
	(0.74365)	(0.80679)	(0.74392)	(0.80690)	(0.74347)	(0.80679)

P-values in parenthesis (* p<0.10, ** p<0.05, *** p<0.01)

Table 3: Two way individual effects model						
Regressors	ROA	SPREAD	LOAN RATE	COST-TO-INCOME	LAB. EXPEND	CAP. EXPEND
$Website_{t-1}$	-0.009	-0.333***	-0.275***	0.218	0.004	0.112
	(0.115)	(0.116)	(0.094)	(1.866)	(0.039)	(0.155)
Asset growth	0.001	-0.001	-0.007	-1.039***	0.004	0.014
	(0.007)	(0.006)	(0.005)	(0.117)	(0.003)	(0.016)
Log of Assets $_{t-1}$	-0.047	-0.063	0.257	-27.591***	0.628**	-0.144
	(0.424)	(0.356)	(0.343)	(5.766)	(0.275)	(0.900)
Capital ratio $_{t-1}$	0.146***	-0.016	0.024*	0.333	0.011	-0.058
	(0.029)	(0.018)	(0.013)	(0.262)	(0.008)	(0.062)
Delinquency rate $_{t-1}$	0.063*	0.143***	0.145***	-1.324**	-0.043	0.041
	(0.038)	(0.029)	(0.028)	(0.568)	(0.057)	(0.046)
Loans to assets $_{t-1}$	0.007	-0.005	0.009*	0.525***	0.002	-0.002
	(0.006)	(0.006)	(0.005)	(0.091)	(0.003)	(0.008)
Cost to income $_{t-1}$	-0.014***	0.007***	-0.004***		0.000	-0.007
	(0.003)	(0.002)	(0.002)		(0.002)	(0.008)
County penetration rate	0.928*	0.340	0.375	2.899	0.134	-0.008
	(0.474)	(0.284)	(0.236)	(5.230)	(0.174)	(0.176)
Observations	3,044	3,044	3,044	3,044	3,044	3,044
Wald	899.8	751.8	532.3	1237	1270	678.2
Rho	0.649	0.751	0.837	0.840	0.908	0.583
$Corr(\alpha_i, X_{it})$	0.0892	0.133	-0.375	-0.868	0.501	-0.101

Table 4: Two way individual effects model (In sample adoption indicator)						
Regressors	ROA	SPREAD	LOAN RATE	COST-TO-INCOME	LAB. EXPEND	CAP. EXPEND
$Website_{t-1}$	-0.069	-0.338***	-0.325***	0.946	0.001	0.114
	(0.134)	(0.123)	(0.092)	(1.973)	(0.034)	(0.170)
Asset growth	0.000	-0.001	-0.007	-1.036***	0.004	0.014
	(0.007)	(0.006)	(0.005)	(0.114)	(0.004)	(0.017)
Log of Assets $_{t-1}$	-0.060	-0.058	0.251	-27.433***	0.627**	-0.146
	(0.397)	(0.375)	(0.324)	(5.525)	(0.271)	(0.973)
Capital ratio $_{t-1}$	0.145***	-0.015	0.025**	0.335	0.011	-0.058
	(0.030)	(0.017)	(0.012)	(0.241)	(0.008)	(0.067)
Delinquency rate $_{t-1}$	0.064*	0.143***	0.145***	-1.328**	-0.043	0.041
	(0.038)	(0.030)	(0.027)	(0.563)	(0.059)	(0.044)
Loans to assets $_{t-1}$	0.007	-0.005	0.009*	0.525***	0.002	-0.002
	(0.006)	(0.006)	(0.005)	(0.094)	(0.003)	(0.007)
Cost to income $_{t-1}$	-0.014***	0.007***	-0.004***		0.000	-0.007
	(0.003)	(0.002)	(0.002)		(0.002)	(0.008)
County penetration rate	0.962**	0.332	0.394*	2.493	0.136	-0.005
	(0.453)	(0.296)	(0.219)	(4.945)	(0.173)	(0.176)
Observations	3,044	3,044	3,044	3,044	3,044	3,044
Wald	993.1	827.1	665.4	1458	1201	637.4
Rho	0.648	0.757	0.842	0.839	0.908	0.584
$Corr(\alpha_i, X_{it})$	0.0902	0.0891	-0.416	-0.867	0.502	-0.110

Rho estimates the variation in the model, which can be attributed to the unobserved individual effect.

Table 5: Persistence of adoption effects

	1 year	2 year moving average	3 year moving average
ROA	-0.069	-0.073	-0.245*
	(0.131)	(0.121)	(0.139)
Spread	-0.338***	-0.373***	-0.393***
	(0.114)	(0.102)	(0.106)
Loan Rate	-0.325***	-0.316***	-0.394***
	(0.091)	(0.083)	(0.097)
LAB. EXPEND	0.001	0.002	-0.012
	(0.034)	(0.028)	(0.022)
CAP. EXPEND	0.114	0.040	0.097
	(0.145)	(0.084)	(0.128)
COST-TO-INCOME	0.913	0.456	1.830*
	(1.986)	(0.929)	(1.065)

Bootstrapped standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1. This table only reports the coefficients of the lagged adoption indicator, although the complete specification is used in the analysis of each moving average outcome.

Table 6: Dynamic models				
	Spread		Loan Rate	
Y_{t-1}	0.589***	(0.024)	0.759***	(0.031)
Y_{t-2}	0.200***	(0.035)	0.109***	(0.036)
Y_{t-3}	0.081***	(0.030)	0.060**	(0.031)
Website_{t-1}	-0.088	(0.059)	-0.107**	(0.042)
Asset Growth	-0.012**	(0.005)	-0.009**	(0.004)
OCCUP	-0.328*	(0.185)	-0.274**	(0.128)
URBAN	0.062	(0.116)	-0.001	(0.072)
Log of Assets $_{t-1}$	-0.175***	(0.024)	-0.087***	(0.016)
Capital ratio $_{t-1}$	-0.002	(0.007)	0.002	(0.005)
Delinquency rate $_{t-1}$	0.041	(0.029)	-0.013	(0.028)
Loans to assets $_{t-1}$	0.002	(0.002)	0.006***	(0.001)
Cost to income $_{t-1}$	0.006***	(0.002)	0.000	(0.001)
County penetration rate	-0.204*	(0.114)	0.024	(0.087)
Observations	2,185		2,185	
AB1	0.399		0.118	
p-value	0.690		0.906	
AB2	-2.212		-1.607	
p-value	0.0270		0.108	
AB3	-2.712		-1.422	
p-value	0.00669		0.155	

AB# is the (Arellano & Bond, 1991) panel data test for autocorrelation in the residual for # lags. The constant term and year dummies are suppressed from each output. Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.01

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