Cass Business School
CITY UNIVERSITY LONDON

Centre for Banking Research
Cass Business School
City University London

WORKING PAPER SERIES

WP 04/10

Innovation and performance of European banks adopting Internet

Francesca Arnaboldi

(University of Milan and Cass Business School, City University London)

Peter Claeys

(University of Barcelona)

Innovation and performance of European banks adopting Internet*

Francesca Arnaboldi, Dipartimento di Economia, Diritto del lavoro e Diritto Tributario, Università di Milano[1]

Peter Claeys, Grup AQR IREA, Universitat de Barcelona[2]

Abstract

Virtual banks were believed to pose a credible challenge for traditional banks. In practice, although information technology had a strong impact on the banking sector, traditional banks have now taken the lead in online innovation; often complementing branch banking with simpler online facilities, like an internet portal. In other cases, traditional banks aquire, set up or manage an internet bank. We examine the determinants of banking groups' strategic choices with respect to the offer of on-line services. Based on a panel of the 60 largest EU banking groups over the period 1995-2005, our results suggest that banks with a heavy cost structure, a large market share in client deposits and high non-interest activities are more likely to introduce internet banking. Concentration in the banking market favours the adoption of internet banking; yet competitive pressure allows for the creation of small internet banks, at least initially. There is little evidence of economies of scope of information and communication techonologies. The performance of banking groups with an internet bank is poor. The initial investment in technology has proved higher that any consequent cost saving, especially on labour. Internet banks fail to create synergies with other banking activities.

JEL Classification: G21, G28, M11, O31, O32

Keywords: Banks, Internet, Innovation

---

* The authors wish to thank Luisa Anderloni, Elena Beccalli, Maurizio Bovi, Barbara Casu, Bob DeYoung, Raul Ramos, Bruno Rossignoli and the participants at MFA Chicago 2009, Cass Business School, Università di Milano, Universitat de Barcelona and the BAA 2010 Conference for their precious comments. Peter Claeys acknowledges support by a Marie Curie Intra-European Fellowship within the 6th European Community Framework Programme. All remaining errors are ours only.

[1] Francesca Arnaboldi, Dipartimento di Economia, Diritto del Lavoro e Diritto Tributario, Università di Milano, Via Festa del Perdono, 7 20122 Milan, Italy; e-mail: farnaboldi@unimi.it.

[2] Corresponding author's address: Peter Claeys, Grup AQR IREA, Facultat de Economia i Empresa, Universitat de Barcelona, Barcelona, Spain. E-mail: peter.claeys@ub.edu.

1. Introduction

The internet has revolutionised the business strategies of many services firms. In the banking sector, a few pioneering banks started to offer products via the internet in the mid nineties. These new entrants bypassed traditional banks through electronic channels, offering banking services without the support of a network of physical branches. The investment in 'clicks' instead of 'bricks' was seen as a means to reduce costs of the retail network, and offer lower fees and higher rates while improving customer convenience. However, the prospects of online banking to outcompete established 'brick and mortar' banks were vastly overstated. As the IT bubble burst, most of these *ex novo* internet banks were forced to quit the market. Traditional banks have been slower to incorporate the internet initially, yet nowadays offering online services is not considered a choice, but an integral part of companies' business models. As in other services sectors, online technologies are consolidated. Virtually all major banks combine 'clicks' and 'mortar', although they employ different strategies. A first strategy is to complement branch banking with basic online facilities through the bank's website, via an internet portal. We define this strategy as 'mixed banking'. A second strategy of traditional banks is to open an autonomous online bank, either via the acquisition of an internet bank or the creation of a new internet bank. Often, these internet subsidiaries are perceived by clients as an external bank. We call this second strategy 'internet banking' (IB henceforth).

Why do some banks create an additional online bank subsidiary instead of offering similar services via an online portal? At first sight, the online facilities offered by both types of banks are to a certain extent similar. All traditional banks also have an existing branch network to complement online services. So what are the reasons for setting up an internet bank? The choice of a particular online strategy is influenced by banks' comparative advantages in their cost structure and product mix. Banks may also prefer a particular model of internet banking if economic or market conditions are favourable. A better developed ICT infrastructure or competitive pressure from other banks is arguably an important condition for starting online services.

In this paper, we analyse the reasons for the adoption of these two online strategies in a panel of the 60 largest European banking groups in seven EU countries (Germany, France, Italy, Spain, the Netherlands, Sweden, and the UK) over the period 1995-2005. We test a probit model of a bank's strategic choice, and identify the bank and country-specific features that determine the adoption of internet banking.

Our first contribution to the literature is to compare banking groups that own an internet subsidiary to banking groups that decided to run only an internet portal. Our findings confirm similar determinants for adopting internet banks as in previous studies on online banking. Banks with a large market share, high labour costs, and specialised in deposits are more likely to introduce internet banking. The same banking groups also get a high income from non-core banking activities. In contrast, banks that cross-sell other products, such as loans, via traditional bank branches are typically the mixed banks that do not separate internet portals from other intermediation activities. This online strategy in the banking sector is not unlike the one seen in other services sectors.

Our second contribution is to examine the role of markets, by looking at several European countries. This study also sheds some light on the role of external factors in the adoption of new technologies. The ICT infrastructure, which fosters the demand for and supply of online banking services, is not a key driver of banks' strategic choice. The role of competition on the rate of innovation adoption varies over time: initially, a competitive market encourages the growth of of small *ex novo* internet banks. However, it is in more concentrated banking markets that this innovation gets sustainable over time.

Finally, we examine how online innovation has influenced the overall performance of the bank under each strategy. The growth pains of the first generation internet banks raise some doubt on the success of internet banking. We compare the performance of mixed vs internet banking groups in a panel random effects model. We find that since the introduction of the internet bank, banking groups have been able to cut down on costs, especially labour costs. However, it is unclear whether these productivity gains compensate the cost of the initial IT investment. There seem few synergies to be gotten from internet banking. Mixed banks seem better equipped to use the on-line channel to cross-sell other products. The "mixed bank" strategy - despite the relatively smaller cost savings - seems superior in terms of creating added value.

The paper is structured as follows. Section 2 is a review of the relevant literature; Section 3 presents the data and Section 4 discusses the methodological approach. The results are presented in Section 5 and Section 6 concludes

2. The consolidation of Internet banking

Internet banking aroused great expectations in the late nineties. At the peak of the technology wave, it seemed that online banks would replace traditional branch banks. Once IB has been set

up, economies of scale are potentially very large (Delgado *et al.*, 2007). However, IB needs to grow above a certain threshold to realise these potential economies of scale and become profitable. IB do grow faster than the average traditional banking start-up, but not fast enough to acquire a sufficient number of customers and to realise the expected reduction in overheads and pay for IT expenses (DeYoung, 2005). For these reasons, few Internet banks have been able to survive without the support of a network of physical branches.

The end of the IT boom has led to a consolidation of online technologies, also in the banking sector. Traditional banks have been facing up rather quickly to these pioneering internet banks. Virtually all major banks nowadays combine 'clicks' and 'mortar' (Gardner, 2009).
Our first contribution is to depart from previous studies like DeYoung *et al.* (2007) by comparing banking groups that own an internet subsidiary to banking groups that decided to run only an internet portal. The use of online technologies in the banking sector has matured so we focus on traditional banks, rather than the internet start-ups. There are no independent internet banks that have grown to a scale that is relevant for the banking market.[3] Virtual banking is not only feasible via an internet bank. Alternative models like an internet portal have become as important in traditional banks. Banks without any online presence at all are typically small niche or local banks, or are otherwise very distinct. Customer use of internet banking is nowadays predominantly concentrated among a few large banks, whether they are internet or mixed banks. We argue that these two models only superficially resemble each other, and that the bank's decision to adopt the internet or mixed bank is based on the existing business model. The driving factors behind the adoption of the internet bank model are similar to those for *ex novo* internet banks.

Costs are among the most important drivers for adoption of online technologies. Banks with a heavy cost structure can use the investment in an online bank to revise existing bank operations. They can start reducing a high wage bill and an expensive branch network by going online. For banking groups that sell basic products, cutting staff may be an important reason for investing in an IB. In contrast, banks that sell products with a high value added need to employ more specialised staff, which may require high wages. Productivity gains for this type of banks may be limited.
The product mix determines the overall competitive advantage of the mixed or internet bank (Berger and Mester, 2003). Banks with mainly deposit based products are better placed to go

[3] Only a few internet banks were able to survive by specialising in a particular service (consumer credit or financial advice); others have switched to alternative channels such as telephone banking.

online, as transactions can be easily automated. But internet banking is not just a process innovation that allows existing banks to centralise back office operations and increase their efficiency. The existence of virtual and branch offices has important effects on the interaction between clients and the bank. Banks that deliver more personalised products, like loans, would have a comparative advantage in providing services where the virtual office and the real desk are more closely integrated (Hernando and Nieto, 2007).[4] Some customers are willing to pay a premium for personal service, whereas others prefer handling rapidly some basic transactions but require personal assistance for others. A bank that offers both channels can differentiate to these two types of customers and raise profitability as a consequence. An internet bank would put these banks at a disadvantage. Customers themselves are often seen to be shifting deposits to other accounts, with the associated higher fee income for the bank (DeYoung *et al.*, 2007). Banks that are specialised in activities other than pure intermediation could benefit from integrating this non-interest activity based service with the internet bank.

Larger banking groups are better placed to go online with an internet bank. Although internet banks can pursue an aggressive strategy to position themselves on the market, and quickly attract new clients with high yielding deposits, this seems less important for traditional banks, which have already reached a stable position in the market. Instead, large banks can better reap the benefits of scale effects and obtain larger productivity gains via cost reductions in branches and personnel. They so receive a more stable flow of income and so obtain a strategic advantage over other banks (Nickerson and Sullivan, 2003).

Size makes it also easier to diversify business risk by starting up a variety of innovative projects (Corrocher, 2006). Larger banks can also more easily assume the business risk of running an IB. Online projects require a large initial investment and are subject to technological and managerial difficulties, with a high probability of failure (Furst *et al.,* 2002). Major banks usually have the skills to develop and solve operational problems arising from innovation adoption (Buzzacchi *et al.*, 1995). A large bank is also more likely to possess the specialized complementary assets necessary to the commercial success of innovations such as marketing and distributing IB services. Not only does size facilitate the start up of new projects, but risk aversion of managers to experiment with new technologies is known to be lower in large banks (Hannan and McDowell, 1984; Rose and Joskow, 1990).

[4] A few internet banks have also started cross-selling other products. In the US, standardised low risk loans are provided electronically already (Berger, 2003). In Italy trading online has also been offered by some internet banks. This has also been the case in the UK since early 2000.

The assimilation of innovation is not only driven by a bank's internal capacity to generate profits from new technology, but also depends on the interaction between bank characteristics and the features of the market it operates in. Our second contribution is to examine the role of country-specific factors, by looking at internet or mixed banks in several European countries. Some countries are endowed with economic and technological conditions fostering the development of online banking.

Increased use of ICT should have given a competitive edge to adopters of internet as it enhances the chance of contacting new clients and enlarging potential demand (Hester *et al.*, 2001). Some microeconomic studies find that higher PC ownership and usage is related to adoption of internet websites (Mantel, 2000; Bauer and Hein, 2006). Studies on the adoption of internet banking, considering the US regional markets, find that a more educated – and hence PC literate – labour force in more densely populated areas attracts internet banks (DeYoung *et al.*, 2007). From the supply side, higher R&D expenses and investment in ICT sectors would likely create economies of scope to the banking sector. Many OECD studies report the positive spillover effect of technological development on labour productivity, although it seems the services sector has been lagging behind in the use of ICT (O'Mahoney and Van Ark, 2003).

One cause of the slow adoption of new technologies may be the structure of the banking system. A very competitive financial sector does not always boost innovation, as strong competition skims any monopoly rents. A few oligopolists instead can exploit economies of scale and scope and use their market power to accrue the rents of investment in risky projects (Martins *et al.*, 1996; Nicoletti *et al.*, 2000). Mixed banks are therefore a more likely outcome in a less competitive financial sector (De Young *et al.*, 2007).[5]

Market structure determines bank decisions over time. The presence of *ex novo* internet banks, which may initially have been launched to quickly attract new clients with high yielding deposits, may have changed the decision of traditional banks to invest in online technology. In our sample of EU banks, some traditional banks started as a branch bank, and then moved to an online model. A quicker option was to take over a loss-making stand-alone internet bank or alternatively set up separate internet subsidiaries with their own brand.[6] Some banks may choose to open internet banks only in response to the opening of a new online bank. The reasons for IB adoption by the followers might be different than for the strategic 'first movers'. Empirical studies that control for the number of rival banks that adopt internet banking, find this strategic move to be as important as overall market concentration (Fuentes *et al.*, 2006). Strategic

[5] Differences in market structure also differentiate the transmission of monetary policy. The effects of changing interest margins on deposits, and loan rates, are stronger in more competitive markets.

considerations and market structure change the behaviour of banks over time. Our third contribution is to look at the dynamic effects of introducing internet banks over a sample period (1995-2005) that covers the transition of traditional branch banking to the set up of mixed and/or internet banks. The year 1995 can be considered as the start of the IT revolution in the banking sector (Gardner, 2009); the year 2005 closes the sample period, before the turbulences of the financial crisis and since nearly all large banks had moved to mixed and/or internet bank by then.

3. Data

For the purpose of this analysis we distiguish two strategies: (i) internet *banking* (IB) when a banking group opens of an autonomous online bank, either via the aquistition of an existing internet bank or the creation of a new internet bank and (ii) *mixed banking* when a banking group choses to complement branch banking with basic online facilities through the bank's website. We examine the adoption of internet in the 60 largest commercial banks that together account for more than three quarters of all banking activities in Europe in terms of capitalization over the period 1995-2005.[7]

Table 1 lists the banks in our sample, indicating the name of the subsidiary, and the year of introduction of the internet bank. As mixed banks do not report specific data on internet portals, we analyse consolidated data at the level of the banking group. An autonomous division to exclusively deliver web services exists in 23 of these banks. While online portals have been quite common since 1995, only in a few cases did banks have internet divisions that early. Most have been acquired or set up around the year 2000. There are relatively more bank groups that have created separate online banks in smaller EU countries and Italy. In Italy, most internet banks have been bought up by larger banks; while in other EU countries, it is more common for banks to create internet banks 'in house'.

Table 2 compares internet and mixed banks by cost structure, size and product mix.[8] Firstly, we analyse the effect of bank size in different ways: absolute size, relative size and growth rate. Absolute size, measured by total assets, indicates that banks just need to reach a threshold size, behyond which scale effects start to play a role. The bigger the bank, the higher the chance to have IB because a bank is better equipped to bear the risk (Nickerson and Sullivan, 2003). Alternatively, only banks that can expect to attract a reasonable share of the domestic market can

[6] A few of these banks, like Unicredit, have switched from an internet bank to a mixed model.
[7] All banks in the sample combine clicks and mortar, but some rely more on the online channel than do others. Instead of using a binary measure, another possibility is to measure the intensity of the use of internet as a delivery channel by the number of physical branches. The correlation between our dummy variable and this measure is not significant.
[8] All data are taken from Bankscope, a Bureau Van Dijk database, which provides balance sheet information on banks at comparable standards.

realise sufficient cost savings to justify the initial set up costs. We measure relative size by considering a bank market share and we expect to find a positive relationship with the probability of adopting IB. Third, we consider the annual growth rate of total assets. This could be considered an indicator of the need of a bank to invest in IB. If banks are growing fast, they could require investments in IB to manage complexity. Finally, customer deposits can also be considered a good proxy for bank size and we expect a positive relationship between deposits and IB adoption.

The next set of variables relates to cost structure, product mix and risk. We use the ratio of personnel expenses to total assets as an indicator of the total labour costs necessary for maintaining a certain level of activity. The higher the labour costs, the higher the probability to open an IB, to transfer staff to the newly created bank and thus reducing costs in the holding company. However this may depend on the type of bank and its specific business mixt. The sign of the relationship thus is uncertain. To capture the relevance of overhead costs, we measure the difference between a bank cost income ratio and the average ratio in the domestic banking sector. The higher the cost to income ratio, the higher the probability to open a pure IB, since this strategy may help reducing overall costs (Nickerson and Sullivan, 2003). We proxy non-interest income by the ratio of other operating income to total assets. The sign of the relationship is uncertain. Bank originally focussing on non-interest activities may decide to expand the deposit base via IB. Alternatively, a large share of non interest income may provide incentives to stick to the current business model and not engage in IB. Finally, we measure overall risk by the standard deviation of the return on equity. We expect riskier banks to have a higher probability to establish an IB to diversify their risk.

We then test the mean difference between both types of banks (with a t-test). We observe that mixed bank are slightly larger, but do not experience slower growth in their assets than internet banks. The market share of mixed banks is not significantly different from that of internet banks. Although IBs are similar in size to mixed banks, their overall risk is higher. We observe strong differences in the structure of activities of internet and mixed banks. The former are more specialised in deposit and non-interest based activities: deposit accounts are about 20% more important than in mixed banks. In contrast, loan activities are only about half as important. This translates in much lower net interest income for internet banks. In contrast, IBs report a higher amount of off balance sheet activity and other operating profits: non-interest income is about the double for internet banks. Both types of banks are also noticeably different in costs. Average

costs are significantly higher for internet than for mixed banks: personnel costs are about double as high.

These sample statistics hide some differences on the various European banking markets between internet and mixed banks. On all markets, internet banks retain more deposits, and have fewer loans. They all display higher personnel costs too. But French internet banks have lower overall costs. IBs in France, Germany and Spain are slightly larger than mixed banks, but in no country do IBs grow faster than mixed banks. The market share of IBs on their respective markets shows important differences between countries with large IBs (Germany, France, and Spain) and small IBs (Italy and Sweden).

Parts of these differences across markets could be due to country-specific factors. Table 3 lists summary information on the economic structure of each country. First, we look at the role of financial market structure. We measure concentration by the Herfindahl index and the C-5 ratio (data are from the ECB). The five largest EU countries have less concentrated markets than the smaller economies. The largest banks hold just a third of the entire market in Germany, Italy or the UK. Different countries start from different levels of concentration. We can measure the speed of concentration by M&A activity. We measure this by the ratio of mergers and acquisitions on the total number of banks. We expect that the majority of the concentration effect on innovation to be captured by concentration indexes. The three big euro-countries – Italy, France and Germany – have seen much more M&A activity than other EU countries. Despite this consolidation, in the period under scrutiny the Italian or German banking markets are relatively less concentrated than other markets considered in this study.

Secondly, not all EU countries are as innovation friendly. We take a set of variables from the European Innovation Scoreboard and Eurostat, to look at the importance of aggregate spending on innovation. We expect that these variables have a positive impact on the probability of adopting IB, since they can be considered as good measures of country innovation attitude. These are aggregate technological indicators, such as employment in R&D sectors, or communication and IT expenses. The smaller EU economies, together with the UK, are clearly ahead of the large eurozone countries. The same is true if we look at R&D investment in human resources in the financial sector. We observe a similar pattern if we include variables related to some micro-characteristics related to the demand and supply for IT services. We consider the effect of the general level of education of the population, penetration of broadband lines, and the price of telecommunication. An increased use at lower costs of online technologies should improve the performance of online banking. ICT costs are much lower in the Netherlands and

Sweden, while the broadband network is much better spread. Higher education levels probably make clients more receptive to the idea of IT and online banking. At the same time, it boosts the education level of the labour force, so raising productivity and wages. Education levels are similar across Europe; although lower on the continent.

Finally, aggregate macroeconomic changes impact all banks in a similar way. We control for some macroeconomic variables that may have an impact on bank performance. Higher aggregate labour productivity growth or GDP per capita proxies aggregate economic growth. The interest spread determines the intermediation margin for banks. Economic conditions have become more rather similar for EMU countries, the central banks of Sweden and the UK still decide on domestic monetary policy.

4. The adoption of different internet bank models

4.1.A panel probit model

We attempt to explain the different strategies of European banking groups by means of a panel probit model. We identify the determinants of internet adoption by bank *i* in market *j* at some point in time ($d_{i,t}$) by some bank-specific characteristics $X_{i,t}$ and country-specific factors $Z_{j,t}$. This gives the following specification:

$$d_{i,t} = \alpha_i + \beta X_{i,t} + \gamma Z_{j,t} + \mu_{i,t}. \qquad (1)$$

The dependent variable takes a value of one if a bank started an internet bank in a specific year and is zero otherwise.[9] We estimate (1) by random effects, as we do not consider the full sample of banks, but have selected a representative set of banks for each group. The bank specific features we include in (1) are described in Table 2. We also include a dummy variable for the acquisition of internet banks by traditional banks. The probit model also includes market-specific characteristics, detailed in Table 3. We report the percentage effect of the different variables (at their mean) on the probability of adopting an internet bank. A standard measure of fit of a probit model is given by the MacFadden R^2. An alternative indicator is the number of correctly predicted dummy variables. Given that we have a binary and a continuous measure – both on the [0,1] interval – we measure the correlation by the point biserial correlation. This baseline model has been modified and tested to include three further specifications listed in the following sections.

[9] All banks in the sample combine clicks and mortar, but some rely more on the online channel than do others. Instead of using a binary measure, another possibility is to measure the intensity of the use of internet as a delivery channel by the number of physical branches. The correlation between our dummy variable and this measure is not significant.

4.2.Main results

The results of the probit model in Table 4 (column 1 – baseline model) confirm some insights from the descriptive evidence.[10] A first main finding is that banking groups that adopt an IB do so because of a particular product mix. Banking groups that are more specialised in intermediation of deposit accounts have more chances of opening an autonomous IB. The effect is not particularly strong: a 1% increase in deposits increases the chances of opening an IB by just 0.19%. We also find that banks that generate large amounts of non-interest income are more likely to create an IB. For every additional unit of non-interest income, the probability to have an IB raises by 0.53%. If in addition a bank reduces its loan activities by 1%, it has a 0.71% higher chance of having an IB. Hence, the probability to open an IB strongly depends on the existing business model. These probabilities are in the same range as those reported in DeYoung *et al.* (2007). Macroeconomic policy does also affect the decision to adopt an IB, and this depends importantly on the interaction with the product mix. The higher the interest spread on deposit based accounts – and hence the intermediation margin – the more profitable to set up an IB. This favours banks with mainly deposit based activities. A 1% higher yield spread makes it 1% more probable that a bank will invest in IB.

Our results also confirm that investment in IB is driven by concerns about costs. Banks with above average costs are more likely to invest in IB. The specialisation of IBs in deposits or non-interest income show that banks start the initial investment in IT as they hope to achieve larger reductions in costs over time. Evidence on labour costs show that reductions in wage expenses are a major motivation. A 1% increase in staff expenses raises the probability of investing in online banks by about 2%. Given that traditional banks can be either specialised in deposit based activities or in servicing a market of high-yielding products, it is not immediately obvious whether high labour costs are due to overstaffing or to higher wages for better skilled staff. Banking groups do not provide detailed data on IT, branches and labour costs, but we can obtain data on total staff employed in some banks. We estimate a probit model on a reduced sample of banks which report these personnel data and we find that banks that invest in IB have more personnel. [11] This is not the case for banks that offer higher average wages. This result suggests that overstaffed banks are likely to adopt internet to reduce the branch network and lay off staff. It confirms evidence on other innovations in the banking sector. Escuer *et al.* (1991) and Ingham and Thompson (1993) find that labour intensive banks adopt ATM earlier than capital intensive banks. Banks want to cut back on the costs of a large volume of labour intensive but low-yielding deposit accounts (Furst *et al.*, 2002). Online banking is mainly a process innovation.

[10] The fit of this model is close: the point biserial correlation in the baseline model is 0.72; the MacFadden R^2 is 0.55.
[11] Results not reported.

Given that deposits are an important driver behind IB adoption, the scale of bank operations probably matters in the decision to open a new IB. But unlike small internet banks, which attract large amount deposits to support a fast initial growth, deposit expansion is less important for large banking groups. We indeed find that the percentage growth rate of total assets is not significant. Moreover, the size of the bank is not a requirement *per se* to start an internet bank. There is no absolute threshold above which banks start considering IB as a worthy investment. However, as in DeYoung *et al.* (2007) and Fuentes *et al.* (2006), we find that banks need a sufficiently large market share to start moving activities online. Each per cent increase in market share raises the probability of starting an IB by 0.25%. This confirms the theoretical prediction of Nickerson and Sullivan (2003) that only banks with a large market share will invest in innovation. The percentage estimate is in the middle of the range they find for US banks.

We also find that riskier banks are more likely to introduce IB. This is a surprising finding given that we use data at the level of the banking group. One explanation is that large and riskier banks look for diversification of their business. Given that internet banks require a high set up cost and carry an elevated business risk, diversification into internet banking does not seem advisable. However, given that it is large banks that invest in IB, this additional risk can perhaps more easily be absorbed. An alternative explanation is that managers at large banks are more risk loving (Rose and Joskow, 1990). We cannot test the attitude towards risk aversion, but we can interact the risk variable with the market share of the bank to test whether such effect matters. Column 3 (interaction with risk) in Table 4 shows that there is no such effect.

4.3. Getting the most out of ICT

The results of the baseline probit model in Table 4 do not show important effects of demand or supply-side factors in ICT, in contrast to studies that look at the adoption of IB by retail consumers (Bauer and Hein, 2006), or use data on regional markets in the US (DeYoung *et al.*, 2007; Corrocher, 2006). Access to cheaply available online technologies or IT literacy is not really important for the creation of IBs. Nor do we see any significant effect of low IT costs. The level of tertiary education only has a marginally positive effect on IB adoption. Unsurprisingly, banks in countries where the financial sector employs more staff in R&D activities are more likely to start an IB.[12] However, the growth of labour productivity does not specifically spur investment in new technologies in the financial sector. These results confirm evidence on the

[12] But overall expenditure on IT or R&D as a share of GDP does not give incentives to create an IB.

small effects of IT usage or human capital on productivity growth in the services sectors in Europe (Inklaar *et al.*, 2008). For this reason, in the remainder of the analysis we do not include these insignificant variables in the model specification (Table 4, column 2, reduced baseline model).

Market structure plays a key role in reaping the productivity gains from IT investment. We find that in less concentrated banking systems, the adoption of internet banks has greater chances to happen. We would expect such a result for *ex novo* internet banks, which can easily enter the market and may follow aggressive strategies to expand their client base (DeYoung *et al.,* 2007; Fuentes *et al.* 2006), but not for banks with a large market share. We might expect that in financial markets with a relatively high concentration, banks with a high market share can more easily reap the benefits of opening an IB thanks to the scale effect in bank operations. An oligopolistic market structure favours internal innovation of incumbent banks over the competition of newcomers. New technologies usually spread faster in markets with intermediate levels of concentration (Escuer *et al.*, 1991). We may better understand the effect of concentration by analysing the development of internet banking over time.

4.4.Acquiring or setting up an internet bank

Some banks have chosen not to set up an IB internally, but to acquire an already existing *ex novo* internet bank. Many French and Italian banks have been very active in taking over small IBs and consequently tried to incorporate these banks (Table 1). Acquiring or setting up an internet bank really are two different routes to IB.

We have included a dummy variable to capture these acquisitions.[13] A panel probit model without this 'acquisition' dummy obviously performs considerably worse in fitting the initial classification of banks (Table 4, column 4, no acquisition dummy). If we compare the dummy for the IB to the predicted probability, the point biserial correlation is substantially lower. This lower fit is due to some outliers, and these are precisely those banks that aquired the IBs. We also observe that the findings of the baseline model continue to hold, except for the effect of concentration. We now see that banks set up an IB internally when market concentration is higher, which supports the hypothesis that oligopolistic markets more easily adopt innovation.[14]

[13] In contrast to studies like Furst *et al.* (2002) or DeYoung *et al.* (2007) we analyse the consolidated balances of banks, hence we cannot include a dummy for belonging to a bank holding, which they argue to be an important reason to adopt IB.

[14] One could argue that our finding on the French and Italian banking markets are due to the particularly strong consolidation that took place in recent years, following a wave of mergers. Other EU countries too have seen a consolidation wave in the banking sector. We therefore constructed an index of M&A activity in different countries, proxied by the ratio of the number of mergers

We can consider the acquisition of an IB as an alternative strategy to setting up an IB internally. Banking groups that acquired an existing IB usually have a lower return and a higher cost to income ratio compared to mixed banks or of banking groups that created an IB (Table 7). We test an ordered probit model in which acquired or set up IBs belong to different categories. The explanatory variables in the baseline model remain invariant. The results in Table 5 indicate that either strategy reacts very much in the same way to the external factors. The acquisition of an internet bank is not so much driven by the product mix. In contrast to IBs that are set up within the banking group, acquired IBs focus more on loans than on fee income. The cost incentive is similar in both types of IBs, but personnel costs are higher in set up IBs. This illustrates two important reasons for having an IB. First, traditional banks acquired IBs to get into different areas of the banking business. After adoption of the IB, they become more similar to the other IBs. Second, banks set up an IB to cut personnel costs. Some other traditional banks do not have this need to reduce costs, and the easiest option is to acquire an existing bank. A final result is that concentration in the banking market does not influence the buying decision, but has a negative impact on the establishment of a new IB.

4.5.Some robustness checks

Our main results are robust to some more modifications of the baseline specification. In order to control for country-specific features that remain fixed over time, we add 6 country dummies to the baseline model (Table 4, column 1). We take the UK as the benchmark. The estimates are close to the ones obtained in the baseline specification without dummies (Table 6, column 1, country dummy). With the exception of Germany, none of the country dummies is significant. We attribute this difference to the fact that German banks embraced online banking earlier than other countries. It should not come as a surprise that the fitted probability of this model is much higher, since it captures much of the remaining unexplained country variation. The point biserial correlation is 0.79. Nonetheless, the explanatory power of this model is actually lower than that of the baseline model, which shows that our variables Z_{jt} capture relevant changes across markets.

Internet started to diffuse gradually since 1995, so banks accumulated experience and learned how to introduce new technologies (Gardner, 2009). Clients have grown more familiar with

over total the number of banks in the country. When we include this variable, together with the acquisition dummy, we do not see a significant effect (Table 4, column 5, baseline model with M&As).

Internet, and with online transactions. Despite the exuberant expectations during the internet boom of the late nineties, and the collapse of many IT activities in the aftermath of the burst of the bubble in 2001, the expansion of online businesses has continued. We look at the common effects of IT development and possibly any other change for the banking sector, by adding a time dummy for each year (Table 6, column 2, country and time dummy). None of these year dummies are significant, and nor are the country dummies. The fit of this is model is obviously closer than without time- and country fixed effects (point biserial correlation is 0.80).[15] However, our baseline model is capturing most of the time variation, as the explanatory power of the augmented model is not higher than before. A time dummy is a shortcut to analyse all the changes in banking over a decade. In fact, not many banks provided internet services as from 1995. Some have made a gradual transition from offering no online transactions at all to an informational site, and then went on to provide more content over time. As the boundary between informational website and internet portal is not very clear, we could not modify the classification of the banks to test with an ordered probit model the difference between banks with no online presence, and the categories of mixed and internet banks.

5. Performance of different internet bank strategies

Internet banking seems an adequate strategy for banks with a large market share so that they can spread labour costs on a big volume of deposit accounts. However, banking group serve different market segments and may use IB to integrate intermediation activities with other earning products. Moreover, the experience with internet banking can be transferred to other divisions. On the other hand, mixed banks may achieve higher benefits from the joint provision of virtual and real services. This less sophisticated – and less costly – form of online banking is not necessarily inferior to the internet bank.

We examine how online innovation has changed overall bank performance under each strategy. We look at how each type of innovation has been integrated in bank activities, and how it has contributed to aggregate value added of the banking group. This implies we do not look at the performance of the IB subsidiary as such, but how it is being integrated in the banking group. This provides a fairer benchmark for the performance of mixed banks; whose use of online technologies cannot be separated in the accounts of the banking group. Hence, we compare consolidated data at the level of the banking group.

[15] Corrocher (2006) or Fuentes *et al.* (2006) use a duration model to test these changes over time.

5.1.Bank performance

We measure bank performance by four different indicators. A first measure of profitability is the ROA, which shows the ability of a bank to generate profits from its assets. The return on equity (ROE) alternatively measures the return to owners' investment. It is however a less adequate measure of net return, since it depends on the mix between equity or debt capital. On the cost side, we use as a gross measure the ratio of total overhead expenses to assets. These are the overall costs a bank generates for a given size of operations. The cost income ratio (ratio of overheads to operating income) reflects the operational costs generated for realising a unit of income. The lower this ratio, the more cost-efficient a bank is in its operations.

Table 8 displays the mean performance of banking groups with internet or mixed banks. Overall, the differences between groups are not large, but they are statistically significant. We observe also important differences between bought or set up IBs. internet banks have a higher return on assets. This is entirely due to the good performance of newly set up IBs, as acquired IBs perform worse than mixed banks. At the same time, the return on equity is higher for mixed banks, yet for IBs that have been set up, this difference is not significant. Overhead costs are twice as high in IBs as in mixed banks. As a consequence, they are about 20% less cost efficient than mixed banks. Acquired IBs have typically lower overhead costs than set up IBs, but lower income compared to operational costs.

There are important differences across countries in the performance of both types of banks. Spanish IBs perform slightly better than Spanish mixed banks: while both measures of return are higher for the former, cost efficiency is lower for the latter. French IBs are very good at containing operational costs, and this also results in a higher return on assets than mixed banks. But cost efficiency does not translate into excellent performance: the ROA for French banks is rather low, and IBs only do slightly better. internet banks in the small EU economies (Netherlands, Sweden) are very cost-inefficient. As a consequence, both ROA and ROE for IBs in these countries are dismal. This is also the case for Germany and Italy, but the differences are less marked.. In these countries, mixed bank gain significantly higher profits at lower costs than IBs. UK banks are much more successful in generating operating revenue from setting up IBs. UK banks alone are responsible for the superior ROA and ROE of internet banking among EU banks. However, the same UK banks have very high costs, far above the levels we observe in other EU countries.

5.2.The random effects panel model

Studies that look at the profitability of mixed banks, typically compare some proxy of bank performance $c_{i,t}$ by including a shift dummy $d_{i,t}$ for the internet banks in a regression that explains performance by some bank-specific features $Y_{i,t}$, like in (2):

$$c_{i,t} = \lambda_i + \phi Y_{i,t} + \theta d_{i,t} + \omega d_{i,t} Y_{i,t} + \delta_C d_i + \delta_T d_t + \mu_{i,t} \qquad (2)$$

We estimate (2) by random effects, but the coefficient θ is a biased estimate of the effect of internet on bank performance as the choice to adopt IB may be endogenous to past performance. Banks that performed dismally could see IB as an opportunity to reduce costs and increase profit margins. Similarly, well-run banks may consider IB as a way to maintain their headway. In either case, the IB dummy is correlated with the performance measure. We therefore instrument this dummy variable with the exogenous choice variables we used to explain the decision to adopt internet banking. Specifically, we substitute the predicted probability of internet banks $\hat{d}_{it}$ from (1) for d_{it} in equation (2).

Our hypothesis is that the shift effect of IB adoption on costs is positive due to set up costs that are far larger for an IB than for a bank that simply sets up an internet portal. The net effect of IB adoption on performance is unclear. Mixed banks may be better at integrating activities online with personalised – and higher yielding – services. But we know from Section 4 that banks that generate large amounts of non-interest income are more likely to create an IB, and this may therefore generate superior income.

Further, we include in the model (2) a number of bank-specific features that are proxies for differences in cost structure composition of bank assets and e product mix. We include the total number of deposits and loans as a measure of intermediation activities. We expect a negative relationship between deposits and revenues since deposits represent liabilities for banks. Secondly, the higher the amount of loans the more profitable the bank should be. However, the larger the loan portfolio, the bigger the chance of non-performing loans. Non-performing loans typically generate losses for the bank with negative impact on revenues. Futhermore, loan-generation is subject to due diligence process which is costly. Overall the net effect of loans on performance is ambiguous.

We then include off balance sheet items and other operating income to capture the non-interest related activities. The increasing use of financial instruments which do not involve the acquisition by banks of conventional on-balance-sheet assets raises some difficult questions. Banks generally are becoming more deeply involved in an array of novel instruments and

techniques. Some of these are technically very complicated and are probably only fully understood by a small number of traders and market experts; many pose complex problems in relation to risk measurement and management control systems; and the implications for the overall level of risk carried by banks is not easily assessed. Thus, off balance sheet activities could be considered as a proxy for bank risk (BIS, 1986). Higher levels of risk are usually associated to poorer performance. Other operating income is expected to have a positive impact on revenues. We control for the level of risk of bank operations by including tier 1 capital: a higher level of tier 1 capital is usually associated to bank soundness.

Finally, the net interest income and expenses capture the net flows from intermediation activities with respectively an expected positive and negative effect on returns. All variables are expressed as a ratio to total assets. Some of these features are different for internet and mixed banks. In particular, IB adoption may impact particularly on personnel expenses or on intermediation costs, or on fee income. In addition to the shift dummy, we interact the dummy with each explanatory variable ($d_{it}Y_{it}$) to test the intensity of the change in the online strategy. Given that EU markets are quite different, and there have been gradual changes in online technologies over time, we include in (2) also a country (d_i) and time dummy (d_t).

5.3.Main results

Table 9 displays the random effects estimates for the entire panel of banks for the different measures of performance.[16] Column (a) of each panel reports the coefficients for mixed banks, while column (b) shows the dummy responses for the IBs. Overall, there are no significant differences between types of banks in the average return on assets or in average overheads. In contrast, IBs report a significantly lower average return on equity, and incur much higher costs compared to a mixed banks. These differences are large and significant. The average ROA of an internet bank is about a quarter lower than that of a mixed bank, while the cost income ratio is about 10% higher. The main reason for this downward shift in cost-efficiency is the heavy cost burden due to the sunk cost of IT.

[16] The time dummy does not show important common effects on the performance of banks over time. The country dummy confirms some of the differences between EU markets. Italian banks incorporate competitive *ex novo internet* banks in a large banking group, and we find that their overhead costs are much lower than for other European banks. However, as they earn a dismal return, their return is much lower too. Spanish and Swedish internet banks do manage to be much more cost efficient, and get about an additional 0.30% return on assets from investing in internet banking. The finding on the success of internet banking in the Spanish market may explain the especially positive scale and experience effects Hernando and Nieto (2007) detect. We alternatively include country specific variables in (2). The main results of the panel are robust to the inclusion of these characteristics. The results show that market characteristics like R&D and ICT levels, education or web access have positive effects on return, but change costs by little. Market structure is neutral.

Much of the differences in performance between IBs and mixed banks are a consequence of the different product mix. IBs are much less cost efficient in the lending business. In contrast, mixed and internet banks alike get a positive return from fee income. IBs however earn a 50% higher ROA than mixed banks, while incurring only a third of the costs to generate a similar level of other operating income. The reason for this cost effectiveness lies mainly with personnel costs. In fact, the results indicate that investment in an online bank strongly reduces personnel expenses. It thus seems that the investment in IB – which according to our results is driven by high costs –pays off. It seems that IBs have managed to reduce costs despite hiring highly qualified labour to staff the IT service. The decrease in personnel costs has also raised the ROA, but although the effect is large, it is not significant. In contrast to previous empirical studies of innovation in the banking sector, IBs do seem to have large effects on labour costs thus indicating that the IBs are a process innovation.

It is less clear that IBs have been able to reap benefits from providing different products. IBs do get a particularly large return from fee income but this is offset by the fact that interest income is not as high as in mixed banks. The net effect of product diversification on the profitability of internet banks is negative. This evidence is consistent with Bonaccorsi di Patti *et al* (2006), who found that IBs do not earn higher returns from the joint provision of e-banking and traditional services.[17] In summary, our results indicate that IBs have not outperformed banks that choose to use an internet portal, therefore suggesting there may be alternative ways to a profitable adoption of Internet.[18] Mixed banks are able to create more synergies between deposit intermediation and loan activities. They can link the simple access on routine transactions with the more personalised service on higher yielding products.

5.4.Scale and learning effects in online innovation

In section 4, we found that market share is an important driver behind IB adoption. These scale effects should also be important for performance. Larger banks should benefit more from the economies of scale of setting up an IB, as they can spread the initial start-up costs related to IT, marketing, and new products over more clients. An insufficient scale of banking operations has made *ex novo internet* banks unprofitable initially, but performance improved as the scale of operations grew (Hernando and Nieto, 2007). We therefore include bank size (measured by total assets) as an additional variable in equation (2) to test for general scale effects. If a scale effect

[17] They find that in Italian IBs, the revenues per customer fall as new e-clients do not always request additional services.

[18] Our findings do not imply that IBs are doing worse than the banks that did not adopt any online technology. Possibly, IBs have outperformed traditional banks, as shown in other studies on specific EU markets (Ciciretti *et al.*, 2008).

exists, it is likely to be stronger for IBs than for mixed banks. We therefore interact bank size with the IB dummy to test for technology specific scale effects.

In addition to scale effects, the learing process can have an additional impact on operational costs. It takes time before an investment gets incorporated in business practices. Overhead expenses fall gradually as employees learn by doing.[19] We follow Hernando and Nieto (2007) and interact a time trend with the IB dummy in (2) to capture these experience effects with online technologies. There are a sufficient number of years in our sample to capture the existence of these 'learning by doing' effects.[20] We estimate specification (2) with these additional variables, but do not interact the dummy variable with the explanatory variables, except for total labour expenses. Table 10 reports the panel random effects estimates.

It is apparent from the results summarised in Table 10 is that scale effects are important. Larger banks are overall more cost efficient. But internet banks have access to scale effects. Their cost efficiency rises on average by an additional 20%. IBs are particularly good at reducing the level of overhead expenses. These reductions come in addition to lower labour expenses. Internet banks incur only a third of the cost of mixed banks in terms of additional labour. This enormous rise in labour productivity, and improved cost efficiency allows large internet banks to get an extra positive return on each additional unit of total assets. We know that IBs are actually slightly smaller than mixed banks (Table 2). This should give more scope to IBs to grow, and earn positive marginal returns. We find that the scale effects dominate the learning effects. We find no evidence that an online bank becomes more cost efficient, the longer it has been part into the banking group.

6. Conclusions

The IT revolution of the nineties fuelled the belief that new online competitors would overhaul the way of doing business of entire industries, including the banking sector. Even though these predictions proved unrealistic, internet did change the outlook of the banking industry. All major banks have integrated online technologies in their business models. Some banks have opened an internet portal to allow their clients at least some basic transactions. Other incumbents opted for a more radical innovation, and have integrated internet banks into their group, either by acquiring one of the online competitors or by creating a separate internet entity with its own brand. These developments in the use of online technologies in the banking sector is not unlike the consolidation seen in other services sectors like e-commerce or transport.

[19] Evidence that new technology pays off over time can be found in Corrocher (2006) or Fuentes *et al.* (2006).
[20] We drop the time dummy in (2).

Our analysis of internet usage in a panel of the largest 60 European banking groups over the period 1995-2005 shows that the choice of one online model is determined by cost concerns and product mix. Overstaffed banks see the investment in an internet bank mainly as an opportunity to reduce labour costs. Banks with a large market share in the deposit market are particularly well placed to automate routine transactions. A bank instead chooses to set up an online portal if it is more specialised in services which require more personalised interactions. Can the incorporation of online technologies be turned into a profit-making business? Internet banks manage to cut labour costs but it is unclear whether these productivity gains outweigh the cost of the initial IT investment. Moreover, IBs have not been able to integrate well the internet division with their other banking activities. In contrast, mixed banks seem able to keep a much closer eye on clients' needs and rapidly adapt to them, thanks to the closer links between deposit intermediation, loans and other non-interest related activities. European banks have benefited from the universal banking system to link both types of activities. The strategy of mixed banks, despite the relatively smaller cost cuts, is superior in creating added value.

Bank management, when deciding on the role of ICT in their business strategy, should carefully consider market developments. Creating an IB is not automatically pushing the bank at the vanguard of technology. In order to be successful, IBs should not just reduce costs, but create synergies between the online bank and the other activities of the banking group. The latter strategy would mean a convergence to the model other traditional banks have followed, by offering a range of products from costless access to deposit activities, to a more personalised service on higher yielding intermediation activities at bank branches.

Innovation in financial markets is known to spur economic growth. As in other sector studies (Inklaar *et al.*, 2008), we fail to find a catalysing effect of technology policies that boost R&D or IT infrastructure. Policymakers may instead influence market conditions to harness the assimilation of innovation. The structure of the banking market plays a key role in driving innovation. Reform of financial legislation and more generally policy initiatives to open up financial services could boost productivity (Conway *et al.*, 2006). But we find that liberalisation of a highly regulated industry fosters the creation of new banks only at the initial stage. Some degree of concentration is necessary to maintain innovation over time. Competition policy should aim to strike the right balance between effective competition and bank scale.

REFERENCES

BIS (1986) “The management of banks’ off-balance-sheet exposures: a supervisory perspective”, Comments by Basel Committee on Banking Supervision, March.

Bauer, K., Hein S. (2006) “The Effect of Heterogeneous Risk on the Early Adoption of internet Banking Technologies”, *Journal of Banking and Finance* 30(6), p. 1713-25.

Berger, A., (2003) “The Economic Effects of Technological Progress: Evidence from the Banking Industry”, *Journal of Money, Credit, and Banking* 35(2), p. 141-76, April.

Berger, A., and Mester, L. (2003) "Explaining the dramatic changes in performance of US banks: technological change, deregulation, and dynamic changes in competition", Journal of Financial Intermediation 12(1), p. 57-95.

Bonaccorsi di Patti, E., Gobbi, G., Mistrulli P. (2004) “Testing for Complementarity between Stores and E-Commerce: The Case of the Banking Industry” *Banca d’Italia*, unpublished manuscript.

Buzzacchi, L., Colombo, M., Mariotti S. (1995) “Technological regimes and innovation in services: the case of the Italian banking industry”, *Research Policy* 24, p. 151–168.

Ciciretti, R,. Hasan, I., Zazzara C. (2008) “Do internet Activities Add Value? Evidence from the traditional banks”, *Journal of Financial Services Research*, 22, p. 95-118.

Conway, P., de Rosa, D., Nicoletti, G., Steiner F. (2006), “Regulation, competition and productivity convergence”, *OECD Economics Department* working paper 509.

Corrocher, N. (2006) “Internet adoption in Italian banks: an empirical investigation”, *Research Policy* 35, p. 533-544.

Delgado, J., Hernando, I., Nieto M. (2007) “Do European Primarily internet Banks Show Scale and Experience Efficiencies?” *European Financial Management* 13(4), p. 643-71.

DeYoung , R. (2005) “The performance of Internet-based business models: evidence from the banking industry”, *Journal of Business*, 78(3), p. 893-947.

DeYoung, R., Lang ,W., Nolle D. (2007) “How the internet affects output and performance at community banks”, *Journal of Banking and Finance* 31, p. 1033-1060.

ECB (2005) “EU Banking Structures”, October.

Escuer, M., Redondo ,Y. , Fumas V. (1991) “Market Structure and the Adoption of Innovationsr”, *Economics of Innovation and New Technology* 1(4), p. 295-307.

Fuentes, R., Hernandez-Murillo, R., Llobet G. (2006), *Federal Reserve Bank of St. Louis*, Working Papers: 2006-058.

Furst, K., Lang ,W., Nolle D. (2002) “Internet banking: developments and prospects”, *Center for Information Policy Research*, Harvard University.

Gardner, J. (2009) “Innovation and the Future Proof Bank: A Practical Guide to Doing Different Business-as-Usual”, *John Wiley & Sons*.

Gondat-Larralde, C., Nier E. (2004) “The economics of retail banking-an empirical analysis of the UK market for personal current accounts”, *Bank of England Quarterly Bulletin*, p. 153-159.

Hannan, T., McDowell J. (1984) "The Determinants of Technology Adoption: The Case of the Banking Firm," *RAND Journal of Economics*, The RAND Corporation, 15(3), p. 328-335.

Hernando, I., Nieto M. (2007) “Is the internet delivery channel changing banks’ performance? The case of Spanish banks”, *Journal of Banking and Finance*, 31(4), p. 1083-1099.

Hester, D., Calcagnini, G., De Bonis R. (2001) “Competition through innovation: ATMs in Italian Banks”, *Rivista Italiana degli Economisti*, VI, p. 359–381.

Ingham, H., Thompson S. (1993) “The adoption of new technology in financial services: the case of building societies”, *Economics of Innovation and New Technology* 2, p. 263–274.

Inklaar, R., Timmer, M. , van Ark B. (2008) “Market services productivity across Europe and the US”, *Economic Policy*, p. 139–194.

King ,R., Levine R. (1993) “Finance, entrepreneurship and growth: theory and evidence”, *Journal of Monetary Economics*, 32, p. 513-542.

Mantel, B. (2000) “Why don’t consumers use electronic banking: Towards a theory of obstacles, incentives, and opportunities”, *Federal Reserve Bank of Chicago*, occasional paper series.

Martins, J. , Scarpetta, S. , Pilat D. (1996) “Mark-up ratios in manufacturing industries: Estimates for 14 OECD countries”, *OECD Economics Department* Working Papers, n. 162.

Nickerson, D., Sullivan R. (2003) “Financial Innovation, Strategic Real Options and Endogenous Competition: Theory and an Application to internet Banking”, *Federal Reserve Bank of Kansas City*, Payments System Research Working Paper: PSR WP 03-01.

Nicoletti, G., Scarpetta S. (2003) “Regulation, Productivity and Growth: OECD Evidence”, *Economic Policy* 36, p. 9–72.

Nicoletti, G., Scarpetta, S., Boylaud O. (2000) “Summary indicators of product market regulation with an extension to employment protection legislation”, *OECD Economics Department* Working Paper 226.

O’Mahony, M., van Ark B. (eds.) (2003) “EU Productivity and Competitiveness: An Industry Perspective Can Europe Resume the Catching-up Process?” Luxembourg: EC.

Rose, N., Joskow P. (1990) “The diffusion of new technologies: evidence from the electric utility industry”, *RAND Journal of Economics* 21, p. 354–373.

Scarpetta, S., Hemmings, P., Tressel, T., Woo J. (2002) “The role of policy and institutions for productivity and firm dynamics”, *OECD* working paper 329.

TABLES

Table 1. Online banking in EU countries

	Internet bank	name of subsidiary	year	mixed banks
Germany	Deutsche Bank	Bank24	1994	Bayerische Hypo-und Vereinsbank Deutsche Zentral-Genossenschaftsbank KfW Bankengruppe IKB Deutsche Industriebank
	Commerzbank	.comdirect	1995	
	Dresdner Bank	Advance 24	1997	
France	Banque Fédérative du Crédit Mutuel	Crefidis	2003 (A)	Calyon Natixis Société Générale Groupe Caisse d'Epargne Caisse Nationale des Caisses d'Epargne et de Prévoyance – CNCE
	BNP Paribas	Cofidis	1997	
Italy	Unicredito	Xelion	2002 (A)	Intesa Antonveneta Banca Nazionale del Lavoro (BNL) Banca Popolare dell'Emilia Romagna Banco Popolare di Verona e Novara
	Capitalia	Fineco	2002 (A)	
	Gruppo Monte dei Paschi Siena	Banca 121	2001 (A)	
	Banche Popolari Unite	IWBank	2003 (A)	
	Banca Popolare di Milano	Web@nk	1999	
	BancaSella	WebSella.it	1997	
	SanPaolo	@ImiWeb	1999 (A)	
Spain	Banco Popular	Banco Popular-e	2000	La Caixa Caixa d'Estalvis de Catalunya Caja de Ahorros del Mediterraneo CAM Caja Madrid Bancaja Bankinter Caixa Galicia
	Banco de Sabadell	Activo Bank SA	1998	
	BBVA	Uno e-bank	2000	
	Banco Santander	Open Bank	2000 (A)	
Netherlands	ING Groep	Ing Direct	1997	ABN Amro Holding Rabobank Fortis Bank SNS Bank
	Delta Lloyd	Ohra	1999 (A)	
Sweden	Skandia	Skandiabanken	2000	Nordea Bank Swedbank Skandinaviska Enskilda Banken Svenska Handelsbanken
UK	Arbuthnot banking group	Secure Trust Bank Plc (BankNet)	2002 (JV)	Barclays Bank Bradford and Bingley Bank of Scotland HBOS HSBC Lloyd TSB National Westminster Bank Ulster Bank Clydesdale Bank Royal Bank of Scotland Standard Chartered
	Abbey National Bank	Cahoot	2000 (A)	

Notes: (JV) indicates joint venture, (A) means an existing internet bank was taken over.

Table 2. Bank-specific factors, differences between internet and mixed banks

variable	legend	expected sign		all countries	Germany	France	Italy	Spain	Netherlands	Sweden	UK
bank size	size (total assets)	+	mixed	18.34**	18.91	19.08	17.96	17.28	18.56	20.16***	18.23***
			IB	18.04	19.96***	20.05***	17.71	18.31***	18.07	15.12	14.35
growth total assets	growth rate of total assets (in %)	+	mixed	13.57	5.82	17.39	8.46	13.05	19.66	13.3	15.53*
			IB	11.42	9.63	16.78	6.49	16.19	14.44	26.30	6.45
bank market share	market share	+	mixed	12.16	12.06	13.72	10.42**	6.90	18.22	27.01**	9.32**
			IB	13.98*	21.93**	27.26**	7.38	15.55**	18.05	11.00	2.70
deposits	customer deposits on total deposits	+	mixed	39.70	28.00	32.21	40.40	42.97	43.80	39.00	42.50
			IB	44.69***	37.23***	31.95	47.67 ***	43.83	61.31 ***	49.70***	46.10***
cost ratio	deviation of average cost income ratio	+	mixed	62.60	49.90	75.20***	68.60	56.43	73.90	59.70	57.40
			IB	70.75 ***	77.34 ***	67.10	71.38 ***	55.14	80.11 ***	85.64 ***	69.48 ***
personnel cost	personnel expenses/total asset	+/-	mixed	11.30	4.30	8.08	15.13	12.61	10.20	2.28	14.80
			IB	20.12 ***	9.50***	7.99	15.38	13.21	12.27 ***	18.36 ***	75.39 ***
loans	total loans/total deposits	+/-	mixed	0.99***	0.90 ***	0.49	0.61	0.42	0.47	6.22 ***	0.36 ***
			IB	0.48	0.40	0.39	0.61	0.50***	0.62 **	0.40	0.27
non-interest activity	other operating income/ total asset	+/-	mixed	10.10	4.39	11.15	10.21	6.22	9.47	9.33***	15.00
			IB	22.84***	12.95***	13.11	17.45***	4.90	10.93	1.54	102.67***
standard dev. ROE	standard deviation of ROE	+	mixed	6.90	7.30	5.67 **	7.30***	6.60	4.62	5.94	8.80
			IB	8.69 ***	9.69 ***	4.78	4.98	10.30 ***	5.14	5.34	18.96 ***

Notes: average per country, * / ** / *** indicates that the coefficient is significantly for the mixed for the internet bank, at 10%/5%/1% significance level.

Table 3. Country-specific factors

	Expected sign	Germany	France	Italy	Spain	Netherlands	Sweden	U K
Banking market								
HHI Herfindahl index	+	177.1	398.8	244.4	462.4	1430.65	696.58	2 9 1
C5-ratio (market share of the five largest banks)	+	20.14	32.71	23.86	36.70	68.08	46.58	2 8
M&A activity (number of M&A on total number of banks)	0	0.49	0.14	0.59	0.43	0.35	0.42	0 . 1
R&D								
prices of telecommunication, national calls	+	1.42	1.14	1.47	1.65	0.52	0.35	0 . 6
web access (broadband penetration rate)	+	6.48	7.52	4.87	5.57	14	11.20	6 . 0
IT expenditure as % of GDP	+	2.90	3.00	1.80	1.40	3.30	3.80	3 . 5
communications expenditure (% GDP)	+	2.90	2.40	3.10	3.30	3.10	3.60	3 . 1
R&D personnel (fraction of employed in the financial intermediation sector)	+	45.46	52.63	54.20	64.08	64.12	70.91	4 5
R&D personnel (% of total employment)	+	1.63	1.55	1.05	1.33	1.39	2.50	n a
education (tertiary education levels)	+	0.38	0.88	0.45	0.68	0.54	0.51	0 . 6
Economy (control)								
GDP per capita (real, USD 2000)		30198	28530	27268	25622	34111	32008	3 2 2
productivity (growth of labour productivity)		1.02	1.2	0.53	1.18	1.17	2.4	1 . 6
yield spread		1.16	1.49	1.21	0.21	1.73	1.66	0 . 2

Notes: data are averages over the sample period; *Source*: ECB (2005), Eurostat, and European Innovation Scoreboard.

Table 4. Random-effects probit model

	(1) Baseline model	(2) Reduced baseline model	(3) Interaction with risk	(4) No acquisition dummy	(5) With M&As
personnel cost	0.03	0.02	0.02	0.00	0.03
cost ratio	0.05	0.07	0.07	0.14***	0.05
deposits	0.19**	0.19**	0.19**	0.22***	0.19**
loans	-0.71*	-0.70*	-0.78**	-0.52**	-0.71*
non-interest activity	0.53*	0.53*	0.60*	0.40	0.53*
bank market share	0.25*	0.20**	0.32*	0.12**	0.25*
bank size	-1.43*	-1.14	-1.21	-0.50	-1.43*
growth total assets	0.02	0.02	0.02	0.01	0.02
standard dev. ROE	0.30*	0.30*	0.46*	0.31**	0.30*
acquisition	0.75***	0.74***	0.76***		0.75***
yield spread	1.01*	1.22**	1.23**	0.81**	1.01*
HHI index	-0.00**	0.00**	-0.00**	-0.00**	-0.00**
education	-1.97	-0.76	-1.29	-0.03	-1.97
R&D personnel	0.14*	0.18**	0.19**	-0.47**	0.14*
productivity	-0.49	-0.54	-0.56	0.19***	-0.49
GDP per capita	0.00				
web access	-0.41				
M&A activity					-0.31
interact scale and risk			-0.02		
number of obs (banks)	382 (60)	382 (60)	382 (60)	382 (60)	382 (60)
error variance	2.71	2.75	2.75	2.81	2.71
ρ	0.88***	0.88***	0.88***	0.89***	0.88***
Wald chi^2	27.94*	27.78**	27.79**	47.75***	27.94*
Mac Fadden R^2	0.47	0.46	0.45	0.49	0.47
Point biserial correlation	0.72	0.77	0.77	0.68	0.72

Notes: coefficients indicate marginal probability (in %); * / ** / *** indicate significance at 10/5/1% level.

Table 5. Buying up or setting up: the ordered probit model

	set up internet bank	bought up internet bank
personnel cost	0.02***	-0.10***
cost ratio	0.03*	0.20***
deposits	0.11***	-0.15***
loans	-0.15*	1.25***
non-interest activity	0.30***	-12.58**
bank market share	0.10***	0.14***
bank size	-0.66***	-1.45***
growth total assets	0.01	-0.01
standard dev. ROE	0.07**	0.13
yield spread	0.28**	0.38
HHI index	-0.00***	-0.00
education	0.01	-0.04
R&D personnel	0.04**	0.21***
productivity	-0.32***	-0.13
number of obs (banks)	382 (60)	
Point biserial correlation	0.70	0.50

Notes: coefficients indicate marginal probability (in %); * / ** / *** indicate significance at 10/5/1% level.

Table 6. Probit model, with country and time dummy

	(1) Country dummy	(2) Country and time dummy
personnel cost	0.04	0.04
cost ratio	0.02	-0.03
deposits	0.25**	0.36***
loans	-7.68*	-14.37**
non-interest activity	0.40	0.98**
bank market share	0.36***	0.46***
bank size	-2.91**	-3.91***
growth total assets	0.04*	0.05*
standard dev. ROE	0.20	0.36
acquisition	9.50***	12.26***
yield spread	1.09*	4.44***
HHI index	0.00	0.00
education	-4.82	-9.97
R&D personnel	0.40***	0.13
productivity	-0.49	-1.18
Italy	-3.30	-5.71
Spain	-6.17	-1.40
Germany	-6.14	-0.76
France	0.17	-0.16
Netherlands	-10.66	-11.71
Sweden	-16.62	-15.20
D 1998		-0.67
D 1999		-4.45
D 2000		1.11
D 2001		-0.60
D 2002		-4.33**
D 2003		-2.96
number of obs (banks)	382 (60)	382 (60)
error variance	2.74	2.85
ρ	0.88***	0.89***
Wald chi^2	25.64	22.69
R^2	0.45	0.49
Point biserial correlation	0.81	0.83

Notes: coefficients indicate marginal probability (in %); * / ** / *** indicate significance at 10/5/1% level.

Table 7. Bank-specific factors, differences between internet banks

	bought IB	set up IB	first mover IB	follower IB
customer deposits on total deposits	46.83	44.09	38.00	45.02**
total loans/total deposits	.56	.46	.38	.85
other operating income/ total asset	10.26	26.72**	15.77	19.91
deviation of average cost income ratio	70.73	70.15	74.33**	65.94
personnel expenses/total asset	12.21	22.43**	11.18	18.11**
market share	12.66	14.48	20.34**	13.90
size (total assets)	18.43	17.94	19.10	18.03
growth rate of total assets (in %)	5.67	13.09**	12.12	13.29
standard deviation of ROE	7.59	8.79	6.88	7.87

Notes: averages over sample, * / ** / *** indicates that the coefficient is significantly different, at 10%/5%/1% significance level.

Table 8. Average performance of banks

	return on assets		return on equity		cost income ratio		overheads to assets ratio	
	mixed banks	Internet banks	mixed banks	Internet banks	mixed banks	Internet banks	mixed banks	Internet banks
all countries	0.63	0.76**	12.39***	10.51	62.57	71.56***	0.02	0.04***
		*[0.41 / 0.88**]*		*[7.40 / 11.60**]*		*[73.37 / 70.93]*		*[0.02 / 0.05***]*
Germany	0.19	0.17	6.00	4.90	49.60	77.90***	0.01	0.02***
France	0.26	0.45***	7.90	13.11***	75.60***	65.00	0.02	0.01
UK	0.96	2.66***	18.70	21.29	57.37	73.67***	0.03	0.15***
Italy	0.37	0.45	6.32	8.22	69.73	72.19*	0.02	0.03*
Spain	0.90	1.16***	14.10*	15.20	56.90*	54.90	0.02	0.02*
Netherlands	0.51***	0.29	11.55***	7.45	72.75	80.80***	0.02	0.03***
Sweden	0.67***	0.28	15.83***	6.25	57.17	88.48***	0.00	0.04***

Notes: in straight brackets, difference between bought and set up IBs; */**/*** indicates significance of the t-test at 10/5/1% level.

Table 9. Panel random effects model

	return on assets		return on equity		cost income ratio		overheads to assets ratio	
	(a) mixed	(b) IB	(a) mixed	(b) IB	(a) mixed	(b) IB	(a) mixed	(b) IB
deposits	-0.42**	-0.55	-8.30*	-9.38	25.19***	7.36	0.42**	-0.03
loans	-0.33	-0.83**	-5.85	-6.55	-3.16	-3.20	0.32*	0.72**
off balance sheet items	-0.02**	-0.01	-0.46***	-0.54	0.29	-0.44	-0.00	0.04
net interest income	0.02***	-0.00	0.36***	-0.06	-0.92***	0.02	0.01	0.00
net interest expense	-0.02***	-0.00	-0.29**	-0.07	0.67***	0.01	-0.01	0.00
other operating income	0.03***	0.01	0.60***	0.33**	-0.76***	-0.54***	0.01	-0.00
personnel expenses	-0.01*	-0.00	-0.37**	0.29	1.51***	-1.27***	0.14***	-0.02**
tier1 capital	0.06***	0.01	-0.73	1.41	0.03	-3.26**	0.01	0.02
dummy internet bank		-0.09		-2.88**		6.48***		0.00
number of obs (banks)	281 (50)		281 (50)		281 (50)		263 (46)	
R^2 within	0.34		0.41		0.41		0.88	
R^2 between	0.85		0.69		0.75		0.85	
R^2 overall	0.67		0.53		0.63		0.84	
ρ	0.21		0.31		0.46		0.89	
Hausmann test	75.55***		59.71***		11.35		52.23**	

Notes: */**/*** indicates significance at 10/5/1% level; column (a) reports the coefficients Φ, column (b) ω and θ; country and time dummies not reported.

Table 10. Panel random-effects model

	return on asset	return on equity	cost income ratio	overheads to assets ratio
deposits	-0.16	-2.37	7.79	-0.01
loans	-0.25	-4.78	-0.59	0.15
off balance sheet items	-0.02**	-0.43**	0.19	0.00
net interest income	0.02***	0.42***	-1.20***	0.00
net interest expense	-0.02***	-0.36**	1.03***	-0.00
other operating income	0.03***	0.54***	-0.79***	0.00
personnel expenses	-0.02	-0.52*	2.56***	0.16***
dummy personnel expenses	0.01	0.52*	-1.78***	-0.04***
tier1 capital	0.06***	-0.63	-0.44	0.00
dummy internet bank	-1.96**	-40.48**	88.94***	3.64***
scale effect	0.01	0.32	-3.70***	-0.01**
scale technology effect	0.10**	1.79*	-4.45***	-0.15***
experience effect	0.13***	3.13***	1.28**	-0.04
experience technology effect	-0.02	-0.33	0.00	-0.00
Number of obs (banks)	281 (50)	281 (50)	281 (50)	263 (46)
R^2 within	0.32	0.40	0.41	0.89
R^2 between	0.87	0.72	0.75	0.86
R^2 overall	0.69	0.55	0.63	0.86
ρ	0.12	0.18	0.46	0.90

Notes: */**/*** indicates significance at 10/5/1% level; country dummies not reported.