Do European Primarily Internet Banks Show Scale and Experience Efficiencies?

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Abstract

Empirical evidence shows that Internet banks worldwide have underperformed newly chartered traditional banks mainly because of their higher overhead costs. European banks have not been an exception in this regard. This paper analyses, for the first time in Europe, whether this is a temporary phenomenon and whether Internet banks may generate scale economies in excess of those available to traditional banks. Also do they (and their customers) accumulate experience with this new business model, allowing them to perform as well or even better than their peers, the traditional banks? To this end, we have generally followed the same analytical framework and methodology used by DeYoung (2001, 2002, 2005) for Internet banks in the USA although the limitations in the availability of data, as well as the existence of different regulatory frameworks and market conditions, particularly in the retail segment, in the 15 European Union countries have required some modifications to the methodology. The empirical analysis confirms that, as is the case for US banks, European Internet banks show technologically based scale economies, while no conclusive evidence exists of technology based learning economies. As Internet banks get larger, the profitability gap with traditional banks shrinks. To the extent that Internet banks are profitable, European authorities may encourage a larger number of consumers to use this delivery channel, by tackling consumers security concerns. This would allow Internet banks to capture more of the potential scale efficiencies implied in our estimations.

Keywords: internet banks, scale economies, experience economies, profitability, cost and income structure.

JEL classification: G21, O32, O33

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1. Introduction

The rapid incorporation of communication technologies, with Internet being one of the most important, is significantly changing the retail banking business. At the time of writing this article, banks worldwide have moved from the belief that their customers will shift all their banking operations from branches to their transactional web sites. The current conventional wisdom is that the multi channel (‘clicks and mortar’) banks will prevail, at least in the medium term and this, in turn, has incited Internet only banks to have some sort of physical presence, hence the term primarily Internet banks.

For the purpose of this paper, primarily Internet banks are those that rely heavily, although not exclusively (e.g. telephone, ATM), on Internet as a delivery channel. For this reason, some authors refer to Internet banks as being primarily Internet banks rather than Internet only. For the remainder of this article, the terms ‘Internet bank’ and ‘primarily Internet bank’ will be used interchangeably. To date, empirical evidence shows that Internet banks have been substantially less profitable than traditional banks both in the USA and the EU. This is mainly explained by the overhead costs, i.e., costs associated with web site development and marketing to gain name recognition, which are higher for Internet banks. However, this could be a temporary phenomenon and Internet banks may generate scale economies in excess of those available to traditional banks and/or they (and their customers) may accumulate experience with this new business model, which may allow them to perform as well or even better than their peers, the traditional banks.

We have generally followed the analytical framework and methodology used by DeYoung (2005) for US Internet banks. As in DeYoung’s paper, we have attempted to identify and estimate the magnitude of technology based scale and technology based learning effects of Internet banks that rely heavily on this new technology to develop their business model. These effects are considered additive to the general scale and experience effects that occur at new banks using the existing technology (i.e. branches, ATMs). Measuring managerial efficiency or so called X-efficiency is beyond the scope of this study.

We perform regression tests based on pooled annual data sets of Internet and newly chartered traditional banks in Europe using six financial ratios as endogenous variables. We apply the same two estimation techniques used by DeYoung (2005): ordinary least squares (OLS) and generalised least squares random effects (GLS-RE). The results of these tests are in general robust to the estimation technique. According to these results, and recognising the limitations of the methodology used, Internet banks show significant technology based scale economies arising from their ability to control operational expenses more efficiently than the new traditional banks. However, we do not find evidence that Internet banks access experience effects as a result of the heavy usage of Internet technology.

This article is divided into six parts in addition to this Introduction. The second part describes the Internet banking landscape in Europe as well as the analytical work on this matter. Special attention is paid to the differences and similarities in performance of Internet banks in the USA and Europe. Part three presents the financial literature on scale and experience economies on banking in the EU. Part four describes the objective of the paper and presents the analytical framework for analysing general and technology based scale and experience economies. Section five describes the data and the sources as well as a preliminary analysis of the performance of three samples of banks: small established
traditional banks, newly chartered traditional banks and Internet banks. Section six presents the regression framework and the results of the analysis. Finally, section seven summarises the article and presents the conclusions.

2. Internet Banks in Europe

The USA has led Europe in the speed and extent to which banks have adopted Internet banking as a delivery channel; nonetheless, the number of Internet banks in Europe (approximately 35) exceeded the number of those in the USA\(^1\) (20) by mid-2002. However, the market share in terms of deposits of European banks varies significantly by country.\(^2\) Most of the European Internet banks started to operate in the late 1990s but some institutions launched non-transactional websites before and/or were using the telephone as a delivery channel. Within Europe, the differences across countries in Internet banking penetration appear to be largely explained by the differences in the availability of access to the Internet. According to an OECD study (2001), France, Spain and Portugal followed by Italy, Germany and Belgium are the group of countries with the lowest rate of Internet penetration.\(^3\) Scandinavian countries have the highest penetration rates at over 50\%, comparable to that of the USA.

In Spain and Portugal, despite the low Internet penetration rate, the take-up of Internet banking is at levels above those in countries such as France, Germany, Italy, or even the USA. Scandinavian countries show the highest levels of Internet banking use. The situation in Spain and Portugal compared to that of other countries appears to be somewhat atypical as it shows a level of utilisation of this distribution channel above that which would be expected from the level of Internet penetration. Somewhat in contrast, the USA has a relatively low level of utilisation of this distribution channel for banking despite a high Internet penetration rate. Technical and financial safety is seen as a crucial factor for the take-up of Internet banking in Europe. As a matter of fact, the above mentioned penetration rates of Internet banking may overestimate actual utilisation rates since some account contracts may have remained idle, as customers have been sceptical about safety features of Internet banking (ECB, 2001). As a result, many Internet banks have found it necessary to have some form of physical presence and/or maintain other channels such as the telephone, hence the term primarily Internet bank.

In the USA, a considerable number of Internet banks were established as independent start-ups, while in Europe, no meaningful Internet bank has been launched that is independent from an existing financial institution. This fact is relevant when analysing the financial performance and business activities of Internet banks in the USA and Europe. In Europe, the long term viability of Internet banks has to be contemplated in the context of the financial group often assuming the specialisation of the Internet bank in some market segments (e.g. mutual funds). The asset size range of the European

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\(^1\) Sources: ECB and Office of the Comptroller of the Currency. Note, the ECB data also includes dedicated branches (i.e. ING Direct), hence data are not fully comparable.

\(^2\) The Internet banks’ deposit share was approximately 0.02\% of the French banking market, while it was 1.4\% of the Spanish market.

\(^3\) The variable representing Internet penetration has been calculated as a percentage of the total population using the Internet in each country. The penetration of Internet banking is the number of customers expressed as a percentage of the total population.
Internet banks\textsuperscript{4} (US$ 77.8 million to 21.8 billion) is larger than that of the US Internet banks\textsuperscript{5} (US$ 79 million to 1.4 billion) for a similar period.

Brokerage is one of the main drivers used for these banks for acquiring new customers. This is one key difference in Internet bank adoption rates in the USA and the EU. The take-up of online brokerage in the USA was very rapid (Furst \textit{et al.}, 2000) but this did not flow through to banks, because they were restricted in the degree to which they could engage in securities activities (see Barth \textit{et al.}, 2003, for comparisons of the permissible range of banking activities across countries). Another important reason for the difference in adoption rates is the continued reliance of US households on paper cheques rather than electronic payments. Paper cheques are less compatible with Internet banking, and require physical bank offices for the collection and clearing of cheques. Moreover, EU banks’ familiarity with other kinds of electronic banking (i.e. electronic funds transfers, EFTs; electronic data interchange, EDI; electronic benefits transfers, EBTs; and electronic trade confirmations, ETCs) does help banks to move current customers on line.

The profitability (return on assets, ROA) of European Internet banks was negative on average over the period 1994–2002, although about half of those institutions included in this study were showing profits as of end 2001. This finding is consistent with the fact that no matter what technology a new bank relies on, it is likely to perform worse than a mature bank for a number of years. A common element arises when analysing the non-interest expenses of Internet banks both in the USA (Sullivan, 2000) and Europe (ECB, 2001): costs associated with web site development (i.e. software research and development expenses, amortisation of purchased software, data processing) and promotion (i.e. marketing) to gain name recognition are higher in the case of primarily Internet banks, due to the fact that they have been recently created, and to the nature of the distribution channel itself (see Delgado and Nieto (2004) for evidence in Spain). Moreover, the oldest Internet banks that have already been in operation for over three years, show a better performance both in terms of ROA and cost savings\textsuperscript{6} than the rest of the Internet banks, although their performance still lags that of the average traditional mature bank.

As well as offering advantages, Internet banking potentially increases and modifies traditional banking risks and influences their risk profile (BIS, 1998, 2000; Ciciretti \textit{et al.}, 2004). A major source of risk for banks is credit risk. However, as described in Section 5.2, net lending over total assets is lower for Internet banks when compared with mature traditional banks (see Delgado and Nieto (2004) for evidence in Spain). Generally speaking market risk and liquidity risk are greater when customers can transfer their deposits from one institution to another rapidly to take advantage of higher interest rates as is sometimes the case in Internet banking in Europe (see Delgado and Nieto (2004) for evidence in Spain). At the same time, strategic and operational risks, (which include legal and security risks), as well as reputational risks are potentially greater and differ somewhat from those faced by traditional banks.

The changes in financial institutions’ risk profiles that are taking place as a result of the adoption of the Internet demand a new approach from regulators if they are to achieve their two main objectives: financial stability and protection of consumers and

\textsuperscript{4} Data from BankScope between 1994 and 2002.

\textsuperscript{5} US Regulatory data base between 1997 Q2 and 2001 Q2.

\textsuperscript{6} Measured in terms of overhead expenses over average assets.
investors. As regards protecting consumers, regulators are facing greater challenges to the preservation of transaction security and data privacy. These are two of the major concerns of consumers of Internet banking on both sides of the Atlantic, which highlights the growing need for closer coordination between prudential regulation and consumer and investor protection in the banking services area.

For the purpose of our study, the regulatory approaches to deal with consumer protection in general and technical and financial safety of Internet banking in particular, are most relevant since safety is seen as a crucial factor for the take-up of Internet banking in Europe. By tackling consumers security concerns in this ‘technology neutral’ fashion, European authorities may encourage a larger number of consumers to use this delivery channel on a long term basis. This would allow Internet banks to capture more of the potential scale and learning efficiencies that these banks may generate in excess of those available to traditional banks. In turn, those efficiencies may allow them to perform as well or even better than their peers, the traditional banks.

3. Financial Literature on Scale and Experience Economies

The bulk of the research on experience and bank scale effects has taken place in the USA. The main reason for the paucity of studies on costs of European banking relates mainly to data availability problems in the EU. Comprehensive EU data bases only became available relatively recently. Moreover, it was not until the full implementation of the Second Banking Directive (1993) as well as a number of other relevant directives on capital adequacy, consolidated banking supervision and deposit guarantee schemes, that cross-border banking was cleared. The introduction of the euro in January 1999 removed one of the last obstacles for a competitive single banking market. Among the studies on cost efficiencies on European banking, deserve to be mentioned the studies of Hensel (2003) and Berger et al. (2001). Hensel (2003) examines the role of cost efficiencies on the efficient management of branch networks in the European banks. Berger et al. (2001) conclude that language, culture, regulatory/supervisory structures offset most of any potential efficiency gains from cross-border consolidation.

The concept of scale economies, or returns to scale, refers to the rate at which output changes as all factor quantities are varied. The existence of scale economies means that the average cost of production, in the long run, ceteris paribus, decreases as more of the output is produced. DeYoung (2005) uses ‘total assets’ as a measure of banks’ output. Although the majority of studies refer to the empirical evidence in the USA, a considerable body of research has been done on European banks at the country level (see Molyneux et al. (1996) for a detailed description of the literature). In Spain, Fanjul and Maravall (1985) find significant economies of scale with respect to accounts per branch and deposits per account. Rodriguez et al. (1993) find scale economies for medium-sized savings banks and diseconomies of scale for larger institutions with total assets over $100 million. Maudos (1996) estimates significant economies of scale for savings banks, independently of their size, and for smaller commercial banks (those with total assets below 150,000 million pesetas). In the UK, Hardwick (1989, 1990) and Drake (1992) find scale economies predominantly for small and medium sized building societies. Kolari and Zardkoohi (1987) also find scale economies for medium sized Finnish savings banks. In Ireland, McKillop and Glass (1994) find diseconomies of scale for the largest banks. Altunbas and Molyneux (1996) examine the cost structure of four European banking markets (France, Germany, Italy and Spain). The results indicate that
scale economies are only statistically significant across all output\(^7\) ranges in the case of Italy. In France, statistically significant scale economies appear to exist across a broader output range of banks, up to $3$ billion asset size. In Germany, the estimates for smaller banks suggest evidence of diseconomies of scale although the result is not statistically significant. The evidence of scale economies across European countries is more mixed. Schure and Wagenvoort (2001) studied the cost structure and financial performance of about 2000 credit institutions across the 15 members of the EU, after accounting for changes in output levels and input prices; they found that EU commercial banks lowered their cost base in the period 1993–97 at an annual rate of about 5%. Efficient commercial banks incur two-thirds of the costs of inefficient commercial banks; however they are not more profitable than their inefficient counterparts. The optimal size picture for commercial banks is less transparent than for saving banks, which is possibly due to the fact that commercial banks are highly diverse. Furthermore, the authors find considerable differences in cost efficiency across Europe.

Newer empirical models based on more sophisticated cost functions than the traditional Cobb-Douglas, allow for the study of scale economies by different asset size cohorts. Also, the new cost functions allow for the interplay between bank capital, bank risk levels and investment diversification. Using these empirical models, Hughes et al. (2001) have found scale economies for the largest banks in the USA. However, caution should be taken in extrapolating these results to other countries where, as yet, no empirical evidence exists (Carbó and Humphrey, 2002).

The concept of experience economies refers to the rate at which unit costs fall as a firm accumulates experience using the technology, holding firm size constant, where experience is defined (Ghemawat, 1985) as a 100\% increase in accumulated production between two points in time. This concept was developed to explain the difference in performance between British and US manufactured airframes of similar quality at the end of World War II (Asher, 1956; Arrow, 1962; Alchian, 1963). However, using accumulated production as a measure of firms’ stock of experience may be deceptive partly because firms gain knowledge not only from their own production but also from other sources such as market participants and universities (Griliches, 1979; DeYoung, 2005). On this ground, DeYoung argues in favour of using ‘age’ as a proxy for a newly chartered bank’s stock of experience. He points out that the measure of accumulated production traditionally used to measure experience effects in the economic literature is problematic in the case of banks, which are by definition multiple-product firms and often provide fee-based services that are not shown in the balance sheet as is often the case for primarily Internet banks. An additional problem with using accumulated output for measuring experience for banks is the measure of accumulated output. The analysis of learning by doing in airframes uses the sum of the flow of output, the number of planes built, whereas the data available for banks are for stocks such as balance sheet quantities. For all the above mentioned reasons, experience economies have not been extensively measured in banking and the small number of studies available refers to the experience of the newly chartered banks in the USA.

Against this background, the question that DeYoung (2005) tries to address in his paper is whether US banks that heavily rely on Internet in their business models have access to deeper scale and experience economies than traditional banks of similar age and size. This paper tries to address similar questions for primarily Internet banks in the EU.

\(^7\) Bank outputs are measured as total loans and securities.
4. Scale and Experience Effects of Primarily Internet Banks in Europe

The purpose of this study is to test for the existence of four distinct but simultaneous performance processes at primarily Internet banks in the EU. The analytical framework used by DeYoung (2005) is common to any industry in which new firms enter the market using a business model or production technology that is distinctly different from that employed by already existing firms. The entrance of new market players in the commercial banking industry, whose business models are heavily reliant on Internet for their production function, renders this analytical framework most relevant for the banking industry. The four performance processes to be tested in this study are as follows: general scale and experience effects, which are common to all new chartered banks, regardless of their business models, and technology based scale and experience effects which are specific to new banks that use primarily Internet as the delivery channel.

General scale effects imply better financial performance of banks as their output grows (asset size is a proxy for output), mainly through lower per unit costs. General experience effects occur as young banks accumulate experience (age is being used as a proxy) and improve their financial performance through learning-based improvements in control, risk management and investment diversification among others. However, because age and size are positively and significantly correlated at young banks, both experience and scale effects overlap.

To the extent that Internet technology is scalable and certain banking activities become more scalable as they incorporate it (e.g. credit scoring models to evaluate credit risk of SMEs) (DeYoung, 2005; Sato and Hawkins, 2001), technology-based scale effects imply even better financial performance of primarily Internet banks as size increases. Technology-based experience effects explain better performance of Internet banks as they age and customers accumulate experience in transacting over the Internet as well as managers better understand the capacities of the new technology. Technology-based scale and experience effects are additive to the general scale and experience effects.

If only significant general experience and scale effects exist in meaningful magnitudes, then the performance of new traditional and Internet banks will improve at similar rates as both types of banks increase in size and age. However, if significant technology based scale and experience effects do exist, then the financial performance of primarily Internet banks will improve more quickly than new traditional banks.

5. Data and Financial Analysis of Primarily Internet Banks in Europe

5.1. The data

Since no regulatory data base exists in Europe, we have used annual audited public financial data from BankScope between 1994 and 2002 in this study, whereas DeYoung

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8 A recent ECB survey on E-banking activity in the EU (2002) shows that one of the explanatory factors for the low penetration rate of Internet banking seems to be the safety concerns of customers.

9 BankScope is a financial database covering 10,500 World Banks on CD-ROM with financial analysis software. It offers subscribers data up to 8 years of detailed spreadsheet information, compiled by FITCHIBCA mostly from the balance sheet, income statement and applicable notes found in audited annual reports. It also includes data details on ownership, produced by Bureau Van Dijk, such as lists of shareholders and lists of banking subsidiaries.
Table 1
EU primarily internet banks in our sample

| Bank                        | Country | Total assets* | Last year |
|-----------------------------|---------|---------------|-----------|
| Activobank SA               | Spain   | 199,286       | 2002      |
| Allgemeine D. Direktbank    | Germany | 21,885,802    | 2002      |
| Banque Covefi               | France  | 498,583       | 2002      |
| Basisbank                   | Denmark | 77,871        | 2002      |
| Consors Discount Broker     | Germany | 2,247,770     | 2002      |
| DAB Bank AG                 | Germany | 1,945,584     | 2000      |
| Egg Banking Plc             | UK      | 16,972,909    | 2002      |
| Entrium Direkt Bankers AG   | Germany | 5,933,551     | 2001      |
| HSB Bank AB                 | Sweden  | 1,210,776     | 2002      |
| Lansforsakringar Bank AB    | Sweden  | 2,325,144     | 2002      |
| Patagon Internet Bank SA    | Spain   | 2,566,061     | 2002      |
| SkandiaBanken AS            | Denmark | 410,997       | 2002      |
| Uno-e bank                  | Spain   | 1,384,510     | 2002      |
| Banque AGF                  | France  | 3,841,023     | 2002      |
| Banque Bipop                | France  | 140,940       | 2002      |

*Total assets in th. USD. Last year available.

(2005) uses quarterly data from a regulatory data base between 1997:Q2 and 2001:Q2. Our data corresponds to three samples of banks chartered in the EU: primarily Internet (15), small traditional (335) and newly chartered banks (45, a subset of the previous sample).

The primarily Internet banks are separately chartered individual (non-consolidated) institutions (i.e. neither a trade name, a non-separate entity that uses a commercial name, nor a dedicated branch) that reported to the European Central Bank\(^\text{10}\) having business models heavily reliant on the Internet as their most important delivery channel. All of these banks were active at the end of 2002 and fulfil the following two conditions: (a) to offer mainly although not exclusively, basic banking services including taking deposits and granting credits\(^\text{11}\) and (b) to be a new start-up (twelve banks) or an existing bank that changed its business model in order to operate primarily by Internet (three banks).\(^\text{12}\) All 15 primarily Internet banks\(^\text{13}\) (four German, three Spanish, three French, two Swedish, two Danish and one British) belong to some financial group. The banks that constitute this sample are listed in Table 1. The average age of the Internet banks sample is 5.1 years.

The small traditional banks are also separately chartered individual (non-consolidated) institutions which fulfil the following conditions: (a) their business models

\(^{10}\) The ECB launched a survey on E-banking activity in the European Union in 2002. The survey is not public.

\(^{11}\) Entities whose single activity is brokerage (e.g. Comdirekt) have been excluded. However, brokers that also accept demand deposits are also included (e.g. Consors Discount Broker).

\(^{12}\) In the event of a change in business model (e.g. Patagon), two different banks have been considered: ‘before’ as a traditional bank and ‘after’ as an Internet bank.

\(^{13}\) Other limitations on the quality of the data stem from the fact that BankScope does not provide information on the exact date on which banks start operating over the Internet and not only providing informational web sites and/or using the telephone as a delivery channels.
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rely mainly, although not necessary exclusively, on traditional delivery channels (b) they are also commercial banks and (c) their asset size is in the same range as that of the primarily Internet banks (see Table 1). Within the sample of small traditional banks, a subset of banks was created (newly chartered traditional banks) that, in addition to these conditions, were launched in or after 1990. This sample of newly chartered traditional banks consists of 45 entities and is used as a performance benchmark. As is the case for Internet banks, the newly chartered traditional banks belong to some financial group. The average age of the newly chartered traditional banks is 6.1 years. If technology-based scale and experience effects exist, they will probably occur with lower intensity at newly chartered traditional banks than at primarily Internet banks. To the degree that the newly chartered traditional banks sample contains banks that use Internet to some extent as a delivery channel, it will be harder to find evidence in favour of the existence of technology-based experience effects and technology based scale effects at the primarily Internet banks.

The combined data set (primarily Internet banks plus newly chartered traditional banks) is an unbalanced panel of 386 observations of 60 banks, over a nine-year period starting in 1994. The banks’ age is in years and the first year of operation had been considered entirely even if the bank has not been fully operating for the whole year. The data panel is unbalanced mainly for two reasons: (1) the newly chartered banks (both traditional and Internet) started in different years and (2) the BankScope database does not include financial data for all banks for all years due to changes in coverage, which a priori do not seem to pose a selection problem.

5.2. The financial analysis of the data

Several financial performance ratios have been used to perform financial analysis of these three groups of banks as described in this section. Table 2 shows, means, medians and standard deviations of these ratios as well as the statistical significance of the differences between the means and medians for small established traditional and newly chartered traditional banks as well as that of the differences between the latter and primarily Internet banks. Those ratios measure operational performance (non interest expenses over average assets), profitability (return on equity, ROE, return on assets, ROA, net interest financial margin over earning assets), capitalisation (equity over total assets) and leverage (equity over liabilities), as well as business activity (net lending over total assets and net lending over deposits and short term debt) of the three bank samples.

14 Three of these banks do not provide shareholding information to BankScope.

15 As in DeYoung (2005), the difference of means tests are generated from regressions that pool the data from the two groups of banks being compared. These regressions are specified as: \( X_{it} = a + b \times D_{it} + e_{it} \), where \( X_{it} \) is the variable being tested, \( D_{it} \) is a dummy equal to 1 for banks in the second of the two pooled samples, and \( e_{it} \) is a random disturbance term with zero mean. The statistical difference of \( b \) from zero provides the test of statistical significance for the difference of means. In turn, the difference of median tests are non-parametric two-sample tests for the null hypothesis that the two samples of banks being compared were drawn from populations with the same median.

16 Non interest expenses include mainly overhead expenses. The terms ‘overhead’ and ‘non-interest’ expenses will be used interchangeably for the reminder of this article.
Table 2
Summary Statistics, 1994–2002

|                                | Small established banks | Newly chartered traditional banks | Primarily internet banks |
|--------------------------------|--------------------------|-----------------------------------|--------------------------|
|                                | k = 290                  | k = 45                            | k = 15                   |
| Mean                           | Median                   | Std Dev                           | Mean                     | Median                   | Std Dev                          |
| Loan loss reserves/gross loans | 4.80                     | 2.91                              | 6.46                     | 2.77                     | 1.43                            | 2.87                             | 5.95                     | 3.01                             | 8.34                             |
| Capital adequacy ratio         | 18.21                    | 12.90                             | 21.92                    | 14.88                    | 11.67                          | 8.87                             | 15.95                    | 11.99                            | 11.12                            |
| Equity/total assets            | 8.53                     | 5.82                              | 11.89                    | 9.84                     | 6.19                           | 11.97                            | 9.09                     | 6.17                             | 8.48                             |
| Equity/liabilities             | 13.28                    | 7.85                              | 41.72                    | 13.35                    | 8.18                           | 21.60                            | 12.12                    | 7.46                             | 14.42                            |
| Net interest financial margin/earning as Return on assets | 2.59 | 2.04 | 4.27 | 1.70 | 1.36 | 1.39 | 2.79 | 1.79 | 3.08 | -2.75 | -0.20 | 7.24 |
| Return on equity               | 9.28                     | 7.73                              | 33.09                    | 10.96                    | 5.86                           | 32.64                            | -19.02                   | -2.05                            | 41.83                            |
| Net loans/total assets         | 46.27                    | 46.98                             | 28.63                    | 35.94                    | 28.35                          | 30.65                            | 41.45                    | 36.93                            | 29.37                            |
| Net loans/customer and ST fund | 61.07                    | 56.69                             | 55.81                    | 50.60                    | 33.80                          | 59.66                            | 47.82                    | 40.41                            | 33.71                            |
| Liquid assets/customer and ST fund | 36.76                    | 28.95                             | 41.76                    | 40.14                    | 30.97                          | 33.72                            | 33.96                    | 26.38                            | 43.13                            |
| Non interests expenses/avg. assets | 2.86                     | 2.31                              | 3.08                     | 2.37                     | 1.58                           | 2.70                             | 7.45                     | 5.18                             | 8.86                             |
|                                | 2.03*** | 1.48** | −3.18*** | −1.58  |
|--------------------------------|---------|--------|----------|--------|
| Loan loss reserves/gross loans |         |        |          |        |
| Capital adequacy ratio         | 3.33    | 1.23   | −1.07    | −0.32  |
| Equity/total assets            | −1.31** | −0.37  | 0.75     | 0.02   |
| Equity/liabilities             | −0.07   | −0.33  | 1.23     | 0.72   |
| Net interest financial margin/earning as return on assets | 0.89*** | 0.68*** | −1.09*** | −0.43*** |
|                                | 0.16    | 0.08   | 3.37***  | 0.56*** |
| Return on equity               | −1.68   | 1.87***| 29.98*** | 7.91*** |
| Net loans/total assets         | 10.33***| 18.63***| −5.51    | −8.58  |
| Net loans/customer and ST fund | 10.47***| 22.89***| 2.78     | −6.61  |
| Liquid assets/customer and ST fund | −3.38 | −2.02  | 6.18     | 4.59   |
| Non interests expenses/avg. assets | 0.49*** | 0.73*** | −5.08*** | −3.60*** |

***/** denote significance at the 1%/5%/10% level.
Small established traditional banks and newly chartered traditional banks. The performance of the newly chartered traditional banks falls somewhat short of the small established traditional banks. Although this difference is neither substantial nor statistically significant in terms of average ROA (16 basis points), it is in terms of median ROE\(^{17}\) (187 basis points), while overhead expenses are somewhat lower (49 basis points) being the results statistically significant in terms of average and median. The newly chartered traditional banks have difficulty generating business volume, as evidenced by lower levels of net lending over total assets and net lending over deposits and short term debt\(^{18}\) which, in turn, seems to explain their lower net financial margin (89 basis points) being the results statistically significant in terms of median and average. Also, it seems to explain the higher equity to total asset ratio (131 basis points) of the newly chartered banks being the result statistically significant only in terms of average. The very sparse data on the level of non-performing loans available in the BankScope data base has not allowed rigorous comparison of the credit quality of the loan portfolios among bank samples. However, the lower level of loan loss reserves over gross loans of newly traditional banks (203 basis points) seems to indicate the low level of substandard loans.

Figures 1 (a) and (b) map out size performance paths of these two samples of banks in terms of ROA (a) and overhead expenses (b), where the banks’ size is measured discretely along the horizontal axis in ten asset size categories. None of the two samples of banks show a clear relationship between performance and asset size. Figures 2 (a) and (b) map out time performance paths of these two same groups of banks also in terms of ROA (a) and overhead expenses (b), where the banks’ age is measured in years along the horizontal axis. The differences between the small established traditional banks and the new chartered traditional banks both in terms of ROA and of overhead expenses are of a small magnitude for all age ranges.

Newly chartered traditional banks and primarily Internet banks. Profitability of primarily Internet banks is significantly lower in terms of ROA (337 basis points) and ROE (2,998 basis points), these results being statistically significant both in terms of ROA and ROE. Figure 1 (a) maps out size performance paths of these two samples of banks in terms of ROA. Internet banks performance lies below both the newly chartered traditional banks and the small established traditional banks for all size categories but this performance gap diminishes for larger Internet banks. This difference in performance seems to be mainly explained by higher overhead spending of Internet banks (508 basis points), which is statistically significant both in terms of mean and median. This category includes general expenses on contracts with vendors to service and maintain the website and, most importantly, marketing expenditure to gain name recognition. Figure 1(b) maps out size performance paths of these two samples of banks in terms of overhead spending. Internet banks show higher but significantly decreasing costs as banks asset size increases. All of which seem to provide some evidence of cost related technology based scale effects. Furthermore, primarily Internet banks show, contrary to what could be expected, higher net interest financial margins

\(^{17}\) The high leveraged balance sheet of some of the newly chartered traditional banks may be distorting the average ratio. For this reason, the median is more representative of the return on shareholder funds.

\(^{18}\) Both ratios are statistically significant in terms of average and median.
over earning assets (109 basis points) than their peers, this result being statistically significant. Nonetheless, this ratio may be distorted by the low level of earning assets of Internet banks. As is the case with their peers, Internet banks have difficulty generating business volume, as evidenced by comparable levels of net lending over total assets and net lending over deposits and short term debt. Neither of these two ratios is statistically significant. Nonetheless, the higher level of loan loss reserves over gross loans of Internet banks (318 basis points) seems to indicate the high level of substandard loans.

Figure 2 (a) maps out ROA time paths in years of these two samples of banks. Again, the Internet banks performance lies below both the newly chartered traditional banks and the small established traditional banks, but this performance gap diminishes with age. Figure 2 (b) maps out time performance paths in terms of overhead spending over average assets. Internet banks show higher, but significantly decreasing, non-financial costs as they age although this pattern is only clearly observed for 5 years. These results provide, in principle, some evidence in favour of the existence of technology based experience effects. However, each of these effects is
best represented by the estimated coefficients in the multivariate analysis below. The regressions control for other effects, so the estimated coefficients are much better indicators of experience and scale effects than the summary statistics displayed in the figures.

6. Regression Analysis

Following DeYoung (2005) methodological framework, the regression analysis in this part attempts to identify and discriminate between the technology based scale effects and the technology based experience effects, showing whether the above described profitability gaps disappear as Internet banks grow larger and capture economies of scale and as they gain experience with the new business model.

6.1. Regression framework

The regression analysis of scale and experience effects consists of one equation in which we allow for the simultaneous existence of both technology-based scale effects (INTERNET * LnASSETS)\(^{19}\) and technology-based experience effects (INTERNET * LnAGE).

\(^{19}\) Assets are measured in year 2000 euros.
Equation:

\[ \text{PERFORMANCE}_{i,t} = \alpha + \beta \ast \text{INTERNET}_{i,t} + \delta \ast \ln \text{AGE}_{i,t} + \lambda \ast \ln \text{ASSETS}_{i,t} + \gamma \ast \text{INTERNET}_{i,t} \ast \ln \text{AGE}_{i,t} + \eta \ast \text{INTERNET}_{i,t} \ast \ln \text{ASSETS}_{i,t} + \sigma_1 \text{DRGD}_{j,t} + \sigma_2 \text{INFL}_{j,t} + \sum_{j=1}^{14} \theta_j \ast \text{DUMC}_j + \varepsilon_{i,t} \]

where subscripts \( i, t, \) and \( j \) index banks, time in years and the EU country, respectively.

\( \text{PERFORMANCE} \) can be any of the six ratios that summarise the financial performance of the sample banks (equity over liabilities, net lending over total assets, net interest financial margin over earning assets, ROA, ROE and non-interest expenses over average assets).

\( \text{INTERNET} \) is a dummy variable that equals 1 (primarily Internet banks) or 0 (newly chartered traditional banks).

Real GDP growth (\( \text{DRGD} \)) and inflation rate (\( \text{INFL} \)) are included to control for the effects of macroeconomic conditions over the data sample period (1994–2001) on the performance variables. Dummy variables for each of the EU countries\(^20\) (\( \sum_{j=1}^{14} \theta_j \ast \text{DUMC}_j \)) are also included to control for the effect of banks nationality on the performance variables (e.g. different absolute minimum capital requirements for licensing purposes across the European Union).

\( \beta \) indicates the different financial performance, at the means of the data, between primarily Internet banks and newly chartered banks when there are no significant technology-based effects. In the more general case, the effect on performance of being an Internet bank (performance gap) would take the following form: \( \beta \ast \gamma \ast \ln \text{AGE}_{i,t} + \eta \ast \ln \text{ASSETS}_{i,t} \) where \( \ln \text{AGE} \) and \( \ln \text{ASSETS} \) denote the mean values of the corresponding variables.

\( \eta \) indicates the importance of any technology-based scale effect.

\( \lambda \) shows the importance of general scale effects.

\( \gamma \) indicates the importance of any technology-based experience effect.

\( \delta \) shows the importance of general experience effects.

As noted by DeYoung (2005) empirically separating both types of technology-based effects may be difficult as a result of the colinearity between \( \ln \text{AGE} \) and \( \ln \text{ASSETS} \)\(^21\) for all the newly chartered banks both Internet and traditional. For that reason, two equations\(^22\) have been run in parallel that test for technology-based scale and technology-

\(^{20}\) As the regression is run with a constant, one of the country dummies has been dropped.

\(^{21}\) Correlation between \( \ln \text{ASSETS} \) and \( \ln \text{AGE} \) for Internet banks is 25.2% (significant at 10% level) while this correlation for newly chartered traditional banks is 17.7% (significant at 5% level).

\(^{22}\) Equations (a) and (b) test for the existence of technology-based-scale effects (\( \text{INTERNET} \ast \ln \text{ASSETS} \)) and technology-based-experience effects (\( \text{INTERNET} \ast \ln \text{AGE} \)) respectively in isolation without restricting the primarily Internet banks to follow the same performance size and time paths as the newly chartered traditional banks.

Equation (a)

\[ \text{PERFORMANCE}_{i,t} = \alpha + \beta \ast \text{INTERNET}_{i,t} + \lambda \ast \ln \text{ASSETS}_{i,t} + \eta \ast \ln \text{AGE}_{i,t} + \sigma_1 \text{DRGD}_{j,t} + \sigma_2 \text{INFL}_{j,t} + \sum_{j=1}^{14} \theta_j \ast \text{DUMC}_j + \varepsilon_{i,t} \]
based experience effects in isolation without restricting the primarily Internet banks to follow the same performance size and time paths as the newly chartered traditional banks. These two equations serve as a robustness test of the equation below to investigate the potential effects of collinearity on the parameter estimates.

The regressions performed in this study use pooled data sets that combine the primarily Internet banks with the newly chartered traditional banks in Europe, and are estimated using both OLS and GLS-RE estimation techniques. The random effects approach includes, in addition to the usual random disturbance term, a bank-specific random disturbance term that accounts for unexplained variation in the dependent variable that it is specific to bank \( i \) during the sample period. As explained by DeYoung (2005), a fixed effect estimation approach is not feasible here, because the phenomena being tested for are themselves fixed effects. As a consequence, much of the variation necessary to estimate the coefficients \( \beta \), \( \gamma \), and \( \eta \) in the equations would disappear in a bank fixed effects model.

6.2. Regression results

Regression results for the equation defined above are shown in Tables 3 and 4. As has been already mentioned, the different financial performance, at the means of the data, between primarily Internet banks and newly chartered banks when there are significant technology-based effects is given by the following expression:

\[
\text{PERFORMANCE}_{i,t} = \alpha + \beta \times \text{INTERNET}_i + \delta \times \text{LgAGE}_{i,t} + \gamma \times \text{INTERNET} \times \text{LgAGE}_{i,t} + \sigma_1 \text{DRGD}_{i,t} + \sigma_2 \text{INFL}_{i,t} + \sum_{j=1}^{14} \theta_j \text{DUMC}_j + \epsilon_{i,t}
\]

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consistent with the performance gap inferred by the difference means test in Table 2. Finally, no significant performance gap is found for leverage (equity over liabilities) and lending activity (net loans over total assets).

The regression analysis of the joint effects of scale and experience. The regression analysis of the joint effects of scale and experience is shown in Tables 3 and 4 that display the regression coefficients ($\eta$, $\gamma$, $\lambda$, and $\delta$). In summary, the results indicate that newly chartered traditional banks show no significant evidence of general scale effects both in terms of ROA and ROE. However, significant evidence of cost related scale economies exists. The regression results also show that the financial margin tends to narrow while leverage increases as new traditional banks get larger. Except for lending activity, no general experience effects are observed, being the outcome generally consistent across estimation techniques. Newly chartered traditional banks show experience effects of large magnitude and statistical significance in terms of lending activity. Primarily Internet banks show significant scale economies in terms of ROA and ROE. The primary source of the technology based scale seems to be the ability of primarily Internet banks to control operational expenses even more efficiently than the new traditional banks. No conclusive evidence of technology based experience effects seems to exist in terms of ROA, ROE, operational expenses and leverage when these effects are analysed jointly with the scale effects. Internet banks do not seem to show a greater capability for increasing their lending activity than the traditional banks as they (and their customers) gain experience. Note, however, that the null hypothesis that the effect of technology based learning is zero conditional on no technology based scale effect ($\gamma = 0$ conditional on $\eta = 0$) is rejected in most of the equations. As we suggested earlier, this is explained by the colinearity between $\ln{AGE}$ and $\ln{ASSETS}$, which makes it difficult to disentangle scale and experience effects. For this reason, we also report results of estimations considering scale and experience effects in isolation.

General scale effects. There is no significant evidence of general scale effects in the data, both in terms of ROA and ROE, this outcome being robust to the choice of estimation technique. The coefficient $\lambda$ ($\lambda \cdot \ln{ASSETS}_{it}$) of the regression of non interest expenses over average is significant and with a negative sign being robust to the choice of estimation technique. This outcome confirms the hypothesis that new banks, regardless of their business model, access mainly cost related scale economies and that the cost economies are somewhat larger in absolute terms when scale and learning effects are considered jointly ($\lambda = -0.81$). As per net interest financial margin over earning assets, the coefficient ($\lambda = -0.27$) is statistically significant and robust to the choice of estimation technique. The coefficient $\lambda$ of the regression of the leverage ratio (equity over liabilities) is highly statistically significant and has a negative sign being robust to the choice of estimation technique ($\lambda = -13.61$). These results show that leverage of new traditional banks increases and their interest financial margin narrows as they grow larger in size.

General experience effects. The $\delta$ coefficients of the regressions ($\delta \cdot \ln{AGE}_{it}$) of ROA, ROE, non interest expenses over average assets, net interest financial margin over earning assets are not statistically significant. Only the regression of net loans over

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23 Unless otherwise stated, the figures reported in the main text correspond to GLS-RE estimates.
Table 3
Regression analysis of scale and experience effects.

| Variable              | Return on assets | Return on equity | Non interest expenses/avg. assets | Net interest margin/earning assets | Equity/ liabilities | Net loans/ total assets |
|-----------------------|------------------|------------------|----------------------------------|----------------------------------|---------------------|-------------------------|
| DUMINT                | β                | −29.63***        | 48.96***                         | 7.14***                          | −19.62              | 5.46                    |
|                       |                  | (6.79)           | (9.35)                           | (4.04)                           | (0.74)              | (0.16)                  |
| lnASSETS              | λ                | −0.14            | −0.76***                         | −0.36***                         | −6.76***            | 1.74                    |
|                       |                  | (0.81)           | (3.81)                           | (5.42)                           | (6.62)              | (1.31)                  |
| lnASSETS*DUMINT       | η                | 1.73***          | −3.13***                         | −0.67***                         | 1.18                | −1.84                   |
| lnAGE                 | δ                | 0.47             | −0.21                            | 0.05                             | −4.41***            | 9.56***                 |
|                       |                  | (1.58)           | (0.59)                           | (0.43)                           | (2.46)              | (4.16)                  |
| lnAGE*DUMINT          | γ                | 1.58***          | 11.37*                           | −0.03                            | 2.39***             | 1.74                    |
|                       |                  | (2.67)           | (0.05)                           | (9.90)                           | (0.48)              | (3.06)                  |
| DRGD                  | σ₁               | 0.11             | −0.04                            | 0.02                             | −0.23               | 0.90                    |
|                       |                  | (1.13)           | (0.31)                           | (0.42)                           | (0.38)              | (1.20)                  |
| INFL                  | σ₂               | −0.30            | −2.51                            | 0.26                             | 0.06                | 1.42                    |
|                       |                  | (1.74)           | (1.33)                           | (1.28)                           | (0.82)              | (1.33)                  |
## European Internet Banks

Denote significance at the 10%/5%/1% level. t-statistics in brackets.  

| Number of observations | 386 | 386 | 382 | 382 | 385 | 385 |
|------------------------|-----|-----|-----|-----|-----|-----|
| Number of banks        | 60  | 60  | 60  | 60  | 60  | 60  |
| S.e. of residuals      | 3.06| 32.89| 3.67| 1.24| 18.67| 23.94|
| R2                     | 0.31| 0.18| 0.43| 0.55| 0.18| 0.38|
| Effect of being an Internet bank (1) | −3.09***| −31.00***| 5.44***| 1.63***| −0.46| 2.54|

**Tested hypothesis (2):**

1. All coefficients are zero  
   10.67  5.73  16.88  26.99  5.53  14.10
   0.00  0.00  0.00  0.00  0.00  0.00

2. (H0: \( \beta = \gamma = \eta = 0 \))  
   30.11  15.13  51.00  50.12  0.28  3.15
   0.00  0.00  0.00  0.00  0.84  0.03

3. (H0: \( \beta = \eta = 0 \) conditional on \( \gamma = 0 \))  
   40.93  20.99  76.71  20.70  0.31  0.04
   0.00  0.00  0.00  0.00  0.73  0.97

4. (H0: \( \eta = 0 \) conditional on \( \gamma = 0 \))  
   39.43  5.18  70.98  4.82  0.58  0.01
   0.00  0.02  0.00  0.03  0.45  0.90

5. (H0: \( \beta = \gamma = 0 \) conditional on \( \eta = 0 \))  
   28.70  21.14  37.38  58.01  0.25  4.47
   0.00  0.02  0.00  0.03  0.78  0.01

6. (H0: \( \gamma = 0 \) conditional on \( \eta = 0 \))  
   17.26  5.44  4.84  72.71  0.45  8.88
   0.00  0.02  0.00  0.00  0.50  0.00

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(1) This effect is computed as: \( \beta + \gamma \ln \text{AGE} + \eta \ln \text{ASSETS} \) where \( \ln \text{AGE} \) and \( \ln \text{ASSETS} \) denote the mean values of the corresponding variables.

(2) The reported statistic is distributed as an F with \( q \) numerator degrees of freedom and \( d \) denominator degrees of freedom. Specifically, \( q \) is 17 in hypothesis 1, 3 in hypothesis 2, 2 in hypotheses 3 and 5, and 1 in hypotheses 4 and 6 and \( d \) is equal to the number of observation minus 19 in hypothesis 1 and 2 and the number of observations minus 18 in hypothesis 3 to 6. p-values in italics.
Table 4

Regression analysis of scale and experience effects.

Estimation method: generalised least squares with random effects (GLS-RE)

| Variable                  | Return on assets | Return on equity | Non interest expenses/ avg. assets | Net interest financ. margin/earning assets | Equity/ liabilities | Net loans/ total assets |
|---------------------------|------------------|------------------|-----------------------------------|---------------------------------------------|---------------------|--------------------------|
| DUMINT β                  | -57.36***        | -163.67***       | 81.19***                          | -1.84                                       | -95.33***           | -26.11                   |
|                            | (9.43)           | (2.59)           | (11.38)                           | (0.99)                                      | (2.60)              | (0.66)                   |
| InASSETS λ                | -0.22            | 3.15             | -0.81***                          | -0.27***                                    | -13.61***           | -0.26                    |
|                            | (0.93)           | (1.26)           | (2.95)                            | (4.12)                                      | (9.43)              | (0.18)                   |
| InASSETS*DUMINT η         | 3.93***          | 8.83**           | -5.63***                          | 0.14                                        | 7.11**              | 1.55                     |
|                            | (8.35)           | (1.81)           | (10.13)                           | (1.00)                                      | (2.50)              | (0.51)                   |
| InAGE δ                   | 0.28             | -1.46            | 0.26                              | -0.07                                       | 0.04                | 3.66**                   |
|                            | (0.86)           | (0.42)           | (0.69)                            | (0.79)                                      | (0.02)              | (1.96)                   |
| InAGE*DUMINT γ            | -0.83            | 2.78             | 1.71*                            | 0.34                                        | 0.90                | -1.02                    |
|                            | (1.07)           | (0.34)           | (1.89)                            | (1.49)                                      | (0.19)              | (0.21)                   |
| DRGD σ1                   | 0.06             | 0.80             | 0.03                              | 0.00                                        | -0.27               | 0.40                     |
|                            | (0.71)           | (0.93)           | (0.40)                            | (0.26)                                      | (0.59)              | (1.02)                   |
| INFL σ2                   | -0.20            | -2.44            | 0.21                              | 0.07**                                      | 1.40*               | -2.42***                 |
|                            | (1.38)           | (1.53)           | (1.35)                            | (2.27)                                      | (1.65)              | (3.33)                   |
| Number of observations | 386 | 386 | 382 | 382 | 385 | 385 |
|-------------------------|-----|-----|-----|-----|-----|-----|
| Number of banks         | 60  | 60  | 60  | 60  | 60  | 60  |
| S.e. of individual component (u) | 2.22 | 22.13 | 2.99 | 1.38 | 14.14 | 25.16 |
| S.e. of idiosyncratic error term (e) | 2.32 | 27.03 | 2.53 | 0.54 | 13.76 | 12.16 |
| Fraction of total variance due to u | 0.48 | 0.40 | 0.58 | 0.87 | 0.51 | 0.81 |
| Effect of being an Internet bank (1) | -4.09*** | -36.60*** | 5.71*** | 0.65 | 5.01 | -6.20 |

Tested hypothesis (2):
1. All coefficients are zero
   | 166.91 | 49.17 | 284.92 | 61.40 | 144.62 | 44.87 |
   | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  |
2. (H0: β = γ = η = 0)
   | 107.91 | 21.92 | 153.52 | 11.60 | 10.79 | 0.69 |
   | 0.00  | 0.00  | 0.00  | 0.01  | 0.01  | 0.88 |
3. (H0: β = η = 0 conditional on γ = 0)
   | 106.31 | 22.11 | 148.90 | 9.81  | 10.72 | 0.65 |
   | 0.00  | 0.00  | 0.00  | 0.01  | 0.00  | 0.72 |
4. (H0: η = 0 conditional on γ = 0)
   | 87.31  | 5.63  | 127.81 | 9.07  | 10.32 | 0.25 |
   | 0.00  | 0.02  | 0.00  | 0.00  | 0.00  | 0.62 |
5. (H0: β = γ = 0 conditional on η = 0)
   | 34.66  | 18.20 | 41.17  | 10.68 | 4.36  | 0.44 |
   | 0.00  | 0.00  | 0.00  | 0.00  | 0.11  | 0.80 |
6. (H0: γ = 0 conditional on η = 0)
   | 17.25  | 2.39  | 21.41  | 9.70  | 3.97  | 0.04 |
   | 0.00  | 0.12  | 0.00  | 0.00  | 0.05  | 0.84 |

*/*/** *** denote significance at the 10%/5%/1% level. Z-statistics in brackets.

(1) This effect is computed as: \( \beta + \gamma \ln \text{AGE} + \eta \ln \text{ASSETS} \) where \( \ln \text{AGE} \) and \( \ln \text{ASSETS} \) denote the mean values of the corresponding variables.

(2) The reported statistic is distributed as a chi-squared with \( g \) degrees of freedom, where \( g \) is 18 in hypothesis 1, 3 in hypothesis 2, 2 in hypotheses 3 and 5, and 1 in hypotheses 4 and 6. p-values in italics.
total assets show a significant $\delta$ coefficient with positive sign ($\delta = 3.66$). This outcome seems to indicate that new traditional banks increase their lending activity as they age.

**Technology-based scale effects.** Significant evidence of technology-based scale effects, when considered jointly with the experience effects, exists for primarily Internet banks in terms of ROA and ROE. This result is robust to the choice of estimation technique yielding positive and highly significant coefficients $\eta$ ($\eta \times \text{INTERNET} \times \text{LnASSETS}_{i,t}$) for the regressions of ROA ($\eta = 3.93$) and ROE ($\eta = 8.83$). Thus, an increase in asset size by 50% results in a 1.50 percentage points increase in ROA and 4.85 percentage points increase in ROE at primarily Internet banks.\(^{24}\) The coefficient $\eta$ of the regressions of non interest expenses over average assets ($\eta = -5.63$) is significant and with a negative sign being robust to the choice of estimation technique. The sum of $\lambda + \eta = -6.44$ gives the slope of the performance size path for Internet banks (general scale effects plus technology based effects). On average, an increase in asset size by 50% is associated with a 2.61 percentage points decrease in the ratio of overhead expenses at primarily Internet banks, compared to only a 0.33 percentage point decrease at newly chartered traditional banks.\(^{25}\) This result confirms the hypothesis that new banks that rely heavily on Internet have access to even larger cost related scale economies than their peers. As per net interest financial margin over earning assets, the estimates of the coefficient $\eta$ are not robust to the choice of estimation technique. The GLS-RE estimate for the coefficient $\eta$ of the regression of the leverage ratio (equity over liabilities) is significant and has a positive sign. The sum of $\lambda + \eta = -6.50$ gives the slope of the performance size path for Internet banks. This result shows that leverage of primarily Internet banks increases as they become larger but the magnitude of this effect is smaller (approximately 50%) than in the case of the new traditional banks. However, the result is not robust to the choice of estimation technique. The coefficient $\eta$ in the regressions of net loans over total assets are not statistically significant. Figures 3 (a) and (b) map out the estimated size performance paths for primarily Internet banks, in terms of ROA and non-interest expenses over average assets, which display similar overall trends than the corresponding observed paths.

**Technology-based experience effects.** The estimated $\gamma$’s ($\gamma \times \text{INTERNET}_i \times \text{LnAGE}_{i,t}$) of ROA and ROE although significant under OLS are not consistent across estimation techniques when considering size and experience jointly. Moreover, the regression coefficients $\gamma$ of non-interest expenses over average assets and net interest financial margin over earning assets are not robust across estimation techniques. Moreover, experience does not have an impact on the leverage of primarily Internet banks as shown by the lack of statistical significance of $\gamma$ in the regression of equity over liabilities. The $\gamma$ coefficient of net loans over total assets is also not robust across estimation techniques. New banks that rely heavily on Internet as a distribution channel do not increase their lending capability with age as compared to the new traditional banks. The Internet distribution channel does not seem to have an impact on the lending activity of banks which mainly relies on their capability to assess risk credit. Figures 4 (a)

\(^{24}\) This figure is the result of: $\eta + \lambda \times \ln(1.5 \times \text{ASSETS}) - (\lambda + \eta) \times \ln(\text{ASSETS}) = (\lambda + \eta) \times \ln(1.5)$.

\(^{25}\) The first figure is the result of: $\eta + \lambda \times \ln(1.5 \times \text{ASSETS}) - \eta + \lambda \times \ln(\text{ASSETS}) = \eta + \lambda \times \ln(1.5)$. Analogously, the second figure is: $\lambda \times \ln (1.5)$. 

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Fig. 3. (a) Average ROA (%) vs. asset size category; (b) Average non-interest expenses over average assets (%) vs. asset size category. The break points between the ten asset size categories are 250 million, 500 million, 750 million, 1 billion, 1.5 billion, 2 billion, 3 billion, 5 billion, 10 billion and 15 billion.

and (b) display the estimated time performance paths for primarily Internet banks in terms of ROA and non-interest expenses over average assets and compare them with the corresponding observed paths.

The regression analysis of scale and experience effects in isolation. As already mentioned, in order to assess the potential effects of colinearity on our estimates, in parallel to assessing the joint impact of general as well as technology based both scale and experience effects, we have run the regression analysis of scale and experience effects taken in isolation for each of the six performance variables, which is shown in Table 5. The main results indicate that newly chartered traditional banks show no significant evidence of either general scale or experience effects when these are considered individually, in terms of ROA and ROE, although significant evidence of cost related scale economies exists. The newly chartered banks with business models heavily reliant on Internet show significant technology based scale economies in terms of ROA ($\eta = 3.62$). The primary source of the technology based scale effects seems to be the ability of primarily Internet banks to control operational expenses even more efficiently than the new traditional banks as shown by the ratio of operational expenses over average assets which, being statistically significant, has a negative sign and whose absolute amount is even larger for the Internet banks ($\eta = -4.98$). Internet banks show technology based experience effects in terms of ROA ($\gamma = 2.92$). The primary source of
the technologically based experience effects is the access to even greater cost economies as compared to traditional new banks.

An overall assessment of these results and those obtained from the joint analysis of the scale and experience effect confirm the existence of significant technology based scale effect and suggest that the weakness of the evidence obtained for the technology based experience effect might be partly due to the colinearity between age and size. As an example, technology-based experience effects in terms of ROA are found when experience effects are analysed in isolation whereas these effects are not significant when considered jointly with scale effects.

Finally, it is worth mentioning, that our results are consistent with those obtained by DeYoung (2005) for a sample of Internet banks in the USA. This author finds evidence of technology based scale economies while the evidence on experience effects is rather weak. Nevertheless, the magnitude of the technology based scale economies we have found is substantially larger than that estimated by DeYoung. Thus, for instance, according to our estimates, an increase in asset size by 50% results in a 1.50 percentage points increase in ROA and 4.85 percentage points increase in ROE at primarily Internet banks, while according to DeYoung’s results this same increase in size would yield a 0.87 and 0.83 percentage point increase in ROA and ROE respectively. However, comparisons should be made with caution given the differences in the asset size and time period range of DeYoung’s analysis and ours. Unlike DeYoung, we have not found significant general scale or experience effects.
Table 5

Regression analysis of scale and experience effects in isolation.

Estimation method: generalised least squares with random effects (GLS-RE)

| Variable      | Scale effects | Experience effects |
|---------------|---------------|--------------------|
|               | Return on assets | Return on equity | Non interest expenses/avg. assets | Net interest margin/earning assets | Equity/total assets | Return on assets | Return on equity | Non interest expenses/avg. assets | Net interest margin/earning assets | Equity/total assets |
| DUMINT β      | -54.18***     | -172.28***       | 74.05***            | -3.66**                         | -96.76***          | -20.26        | -7.47***        | -51.01***       | 9.75***                    | -0.12                        | -7.28          |
|               | (10.02)       | (2.99)            | (11.94)             | (2.46)                          | (3.01)              | (0.63)        | (5.89)          | (3.93)             | (5.70)                     | (0.21)                      | (0.92)        |
| lnASSETS λ    | -0.11         | 2.68              | -0.72***            | -0.30***                        | -13.47***          | 1.43          | 0.19            | 0.63               | -0.47                      | -0.33***                   | 9.06***        |
|               | (0.56)        | (1.21)            | (3.07)              | (5.93)                          | (10.90)             | (1.24)        | (0.61)          | (0.21)             | (1.19)                     | (4.76)                      | (4.89)        |
| lnASSETS* η   | 3.62***       | 9.74**            | -4.98***            | 0.30**                         | 7.28***             | 0.90          | 2.92***         | 11.81*             | -3.94***                   | 0.44***                    | 4.12          |
| DUMINT        | (9.40)        | (2.36)            | (11.28)             | (3.06)                          | (3.17)              | (0.41)        | (4.27)          | (1.72)             | (4.52)                     | (2.68)                      | (1.00)        |
| lnAGE δ       | 0.19          | 0.63              | -0.47               | -0.33***                        | 9.06***             | 2.62          | (0.61)          | (0.21)             | (1.19)                     | (4.76)                      | (4.89)        |
| lnAGE* γ      | 2.92***       | 11.81*            | -3.94***            | 0.44***                         | 4.12                | 1.74          | (4.27)          | (1.72)             | (4.52)                     | (2.68)                      | (1.00)        |
| DRGD σ₁       | 0.06          | 0.81              | 0.01                | 0.00                            | -0.28               | 0.32          | 0.08            | 0.84               | 0.01                       | 0.00                       | -0.18         |
|               | (0.71)        | (0.95)            | (0.16)              | (0.31)                          | (0.61)              | (0.82)        | (0.87)          | (0.96)             | (0.13)                     | (0.13)                      | (0.34)        |
| INFL σ₂       | -0.23         | -2.30             | 0.20                | 0.08***                         | 1.40*               | -2.72***      | -0.28           | -2.70*             | 0.33                       | 0.06                       | 1.52          |
|               | (1.61)        | (1.48)            | (1.27)              | (2.60)                          | (1.70)              | (3.87)        | (1.76)          | (1.69)             | (1.64)                     | (1.43)                      | (1.60)        |

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Table 5
Continued.

| Scale effects | Experience effects |
|---------------|--------------------|
|               | Return on assets   | Return on equity | Non interest expenses/ avg. assets | Equity/ liabilities | Net loans/ total assets | Return on assets | Return on equity | Non interest expenses/ avg. assets | Equity/ liabilities | Net loans/ total assets |
| Number of observations | 386 | 386 | 382 | 382 | 385 | 385 | 389 | 389 | 385 | 385 | 388 | 388 |
| Number of banks | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| S.e. of individual component (u) | 2.26 | 22.57 | 3.03 | 1.61 | 13.85 | 27.17 | 2.09 | 22.46 | 3.07 | 1.47 | 13.94 | 24.96 |
| S.e. of idiosyncratic error term (e) | 2.40 | 27.07 | 2.62 | 0.53 | 13.87 | 12.18 | 2.75 | 27.33 | 3.29 | 0.56 | 16.16 | 12.58 |
| Fraction of total variance due to u | 0.47 | 0.41 | 0.57 | 0.90 | 0.50 | 0.83 | 0.37 | 0.40 | 0.47 | 0.87 | 0.43 | 0.80 |
| Effect of being an Internet bank (1) | $-3.90^{***}$ | $-36.99^{***}$ | $4.88^{***}$ | 0.51 | 4.36 | $-7.76^{***}$ | $-2.83^{***}$ | $-32.23^{***}$ | $3.49^{***}$ | 0.58 | $-0.73^{**}$ | $-4.87^{**}$ |
| Tested hypothesis (2): | | | | | | | | | | | | |
| 1. All coefficients are zero | 166.33 | 48.45 | 275.78 | 56.89 | 143.90 | 38.31 | 80.80 | 38.87 | 71.75 | 45.64 | 40.67 | 41.98 |
| 2. ($H_0: \beta = \eta = 0$) | 107.55 | 21.51 | 146.96 | 10.16 | 10.48 | 0.58 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3. ($H_0: \beta = \gamma = 0$) | 34.71 | 17.12 | 33.59 | 7.75 | 1.12 | 0.58 | 0.00 | 0.00 | 0.00 | 0.02 | 0.57 | 0.75 |

$^{*}/**/^***$ denote significance at the 10%/5%/1% level. Z-statistics in brackets.

(1) This effect is computed as: $\beta + \eta \ln ASSETS$ in the models for scale effects and $\beta + \gamma \ln AGE$ in the models for experience effects, where $\ln ASSETS$ and $\ln AGE$ denote the mean values of the corresponding variables.

(2) The reported statistic is distributed as a chi-squared with $g$ degrees of freedom, where $g$ is 16 in hypothesis 1, and 2 in hypotheses 2 and 3. p-values in italics.
7. Conclusions

This study attempts to identify and estimate the magnitude of technology based scale and technology based learning economies of European Internet banks. The empirical analysis uses public annual audited data from Bankscope between 1994 and 2002 corresponding to 15 Internet banks and 45 newly chartered banks of similar size and age as a performance benchmark. In addition, banks in both sets (Internet and benchmark) belong to financial groups. The results indicate that, on the one hand, newly chartered traditional banks show significant evidence of cost related general scale economies. On the other hand, Internet banks show strong evidence of scale economies in terms of ROA and ROE. Our results show that an increase in asset size by 50% results in a 1.50 percentage points increase in ROA and 4.85 percentage points increase in ROE for these banks. The primary source of the technology based scale effects seems to be the ability of primarily Internet banks to control operational expenses even more efficiently than the new traditional banks. On average, a 50% increase in asset size is associated with a 2.61 percentage points decrease in the ratio of non interest expenses over average assets at primarily Internet banks, compared to only a 0.33 percentage point decrease at newly chartered traditional banks. There is no conclusive evidence that either new traditional banks or Internet banks enjoy experience economies as they age. However, we find strong evidence suggesting that traditional banks seem to show the ability to increase lending activity as they gain experience, while Internet banks do not show any superior lending capability.

Our results are consistent, to some extent, with those obtained by DeYoung (2005), who finds, for a sample of US Internet banks, significant technology based scale economies stemming from the use of Internet while not finding evidence of the existence of technology based experience effects. Nevertheless, the magnitude of the technology based scale economies we have found is substantially larger than that estimated by DeYoung. This seems to be explained by the larger size of the Internet banks in Europe. At the same time, general scale or experience effects in terms of ROA and ROE have not been found in our study, which might be explained by the large size of some of the banks in our sample that could have already exploited all or nearly all the scale economies.

The empirical test suggests the success of the Internet bank model in Europe relies on the ability of these banks to save on overhead costs from technology based scale economies and on whether these savings are sufficient to close the remaining profitability gap with traditional banks. Nonetheless, a note of caution must be introduced given the preliminary character of the findings of this study, which are based on only 15 European Internet banks. It is worth noting that the sample size is a common problem in this type of analysis. For instance, De Young’s study is based on information for twelve Internet banks.

Finally, to the extent that Internet banks are struggling to prove themselves a viable business model, banking regulators and supervisors are encouraged to respond to the challenges posed by the incorporation of Internet in accordance with the principle of neutrality with regard to the distribution channel (Nieto, 2001). It is in the realm of consumer protection in which, in order to protect consumers’ interests, financial regulators are encouraged to specify for this distribution channel the general rules on transparency of operations and customer protection. By tackling consumers security concerns, authorities may encourage a larger number of consumers to use this delivery channel, which would allow Internet banks to capture more of the potential scale efficiencies implied in our estimations.
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