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The Long-Term Effect of Digital Innovation on Bank Performance: An Empirical Study of SWIFT Adoption in Financial Services

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Abstract
We examine the impact on bank performance of the adoption of SWIFT, a network-based technological infrastructure for worldwide interbank telecommunication. We construct a new longitudinal dataset of 6,848 banks in 29 countries in Europe and the Americas with the full history of adoption since SWIFT's initial operations in 1977. Our results suggest that the adoption of SWIFT (i) has large effects on profitability in the long-term; (ii) is greater for small than for large banks; and (iii) exhibits significant network effects on performance. We use an in-depth field study to better understand the mechanisms underlying the effects on profitability.

Keywords: Technology adoption, bank performance, financial services, network innovation, SWIFT
JEL Classification: O33; N20

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1. Introduction

The study of digital innovations and their adoption by organizations has generated a field of research whose aim is to unravel analytical challenges such as the *productivity paradox*[1] and establish an empirical knowledge base upon which scholars can build. Our research contributes to this on-going effort by focusing on the effect that digital network innovation adoption has over time on bank performance. The financial services sector was an early adopter of key technologies associated with business transformation and it is currently one of the most intensive users of information and communication technologies (ICT). While attention has been drawn to relatively poor gains from ICT investment in the financial services sector, findings from relevant research are inconclusive (Roach, 1991; Haynes and Thompson, 2000; Beccalli, 2007; Kretschmer, 2012). Can strategic investments in certain information systems provide better explanations than broad analyses of a firm's aggregate IT investment (Aral and Weill, 2007)? The need for research here is acute because, practitioners and policy makers have scarce resources with which to base actions, and scholars lack the datasets and foundational knowledge claims about innovation adoption in financial services with which they can draw up agendas for future research.

In an effort to address these challenges, we begin by examining the approaches used to-date in studies of digital innovation adoption in the financial services. We then add to this emerging knowledge base by presenting an analysis of adoption data from SWIFT, the financial digital network innovation developed in the 1970s to serve as the infrastructure for worldwide interbank payments communication. We construct and analyse a new dataset comprising SWIFT's adoption history from 1977 to 2005 matched to bank-level performance data for the US, Canada and 27 European countries. Our analysis breaks from the majority of past research by utilizing a distinctive longitudinal approach to investigate claims in the literature. While there is now evidence of productivity benefits from ICT adoption, prior research has not considered whether these benefits are sustained in the long term. Our research focuses on the following questions. Firstly, is there evidence that ICT adoption generates long-term benefits for firms? Secondly, do these benefits accumulate over time? Thirdly, do particular kinds of firms benefit more than others in the long term? Fourthly, what are the mechanisms underlying these benefits?

Our findings determine the timeframe in which benefits from digital innovation adoption accrue and establish their correspondence with network effects. In so doing, we reveal

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[1] This trend was appropriately characterized by Robert Solow's famous quote that '*you can see the computer age everywhere but in the productivity statistics*' (Solow, 1987), which eventually became known as the "Productivity Paradox" (Roach, 1991; Brynjolfsson, 1993).

surprising results concerning the performance of small banks relative to large banks. Small and medium enterprises (SMEs) are frequently referred to as the 'backbone' of the economy because they play an important role in job creation (Brynjolfsson et al., 1994), technology investment, and GDP growth (Kuan and Chau, 2001) yet research about the effects of ICT adoption on their economic performance is sparse. There is a tendency in the adoption literature to treat small firms as "scaled-down" replicas of larger businesses (Raymond, 1985; Thong et al., 1996) and generalize about them based on large firm only datasets. We find small firms benefit disproportionately from SWIFT which is remarkable as this means overcoming scarce resources including relatively limited knowledge of technology management (Pfeiffer, 1992; Grandon and Pearson, 2004).

Throughout the paper, we complement the quantitative analysis with an in-depth field study to explore the dynamic interplay between the process of adopting SWIFT and the mechanisms used to realise benefits from that adoption. We argue that this not only has implications for how firms can leverage ICT-investments but also suggests insights into adoption strategies for firms navigating the current business landscape in which potentially value-adding digital infrastructures are an integral part. In the next section, we will review the literature upon which we build our study.

2. ICT adoption and firm performance

In the past, ambiguity concerning the economic impact of information and communication technology adoption or what has been termed the "productivity paradox" was hotly debated. Initial results during the 1980s and 1990s created concerns about whether ICT had any significant effect on economic output, but over the last couple of decades evidence has mounted confirming that ICT does yield sizable economic returns at both macro and micro levels (Brynjolfsson, 1993; Bloom, Sadun and Van Reenen, 2012). More specifically, a large number of recent studies report positive results from ICT investments on a range of measures relating to financial performance (Aral et al., 2006; Bresnahan et al., 2002; Brynjolfsson and Hitt, 1996; 2000; 2003; Dewan and Kraemer, 2000) [2].

These findings are consistent with the Schumpeterian economic theoretical tradition that recognizes the importance of technological change and innovation as being the key drivers of economic growth and firm performance (see Romer, 1990; David, 1990; Aghion and Howitt, 2007). In this line of work, technological innovation plays a key role in explaining the dynamic

[2] For a more detailed review of the literature see surveys by Brynjolfsson and Yang (1996), and Draca et al. (2007).

properties of organizations (Cainelli et al., 2006). According to Schumpeter (1943), innovation puts in motion the mechanism of “creative destruction” in which technological advances override pre-existing market conditions. In the process, firms introduce new products, services and organizational processes thus gaining market share at the expense of their non-innovating competitors. Some are then able to leverage their new competitive position and gradually accumulate “monopolistic rents”, increasing their profitability still further (Cainelli et al., 2006).

Whilst the Schumpeterian approach is useful in describing the link between technological innovation and organizational performance, empirical evidence on the magnitude and nature of the contribution of technology seem to vary considerably across economies, sectors, and firms prompting much discussion about different measures of economic performance and innovation. For example, at the macro-level, most studies focus on measures of economy-wide productivity and labour productivity growth to make claims regarding the aggregate contribution of technology investment (Brynjolfsson and Yang, 1996). A case in point would be Gust and Marquez (2004) who analyse data from 13 OECD countries between 1993 and 2000 and find that ICT expenditure in this period is associated with higher productivity growth. Similarly, Oliner and Sichel (2000) demonstrate that ICT capital makes a significant contribution to the output growth rate of the US economy (between 0.6% and 1.1%) at various intervals during the period 1972-1999. Using data from the UK, Oulton (2002) found evidence of increased ICT contribution to GDP growth (up to 20.7%) for the years 1979-1998. Gordon (2016) provides a more sceptical perspective on the contribution of ICT to US growth, arguing that the main effects were all focused in the short window 1996-2004 period.

Using economy-wide data is problematic as it is difficult to control for many other factors. More recent industry-level studies also found notable returns to ICT investments. Based on an analysis of 61 industries in the U.S., Stiroh (2002) uncovered evidence suggesting faster productivity growth – both total factor productivity (TFP) and average labour productivity (ALP) – in sectors that produced or used ICT more intensely. While several other studies have reported similar conclusions (e.g. Siegel and Griliches, 1992; Berndt and Morrison, 1995; etc.), it is apparent that the degree of the effect varies considerably between countries and industries. Stiroh (2002) found the strongest impact in IT-intensive services whereas others have found manufacturing to be more important (Baily, 1986; Roach, 1991). There has also been much recent work at the firm level. Here, most studies reveal a positive and significant correlation between the adoption of ICT and business performance. In a series of analyses using a large sample of company surveys, Brynjolfsson and Hitt (1993; 1995; 1996), report that ICT capital generates up to 10 times more output than other forms of capital.

Although, other papers have produced similar results that point to a positive effect from ICT adoption (Jorgenson and Stiroh, 1995; Oliner and Sichel, 1994; etc.), there is less agreement on the magnitude of the gains. In a meta-analysis of 20 econometric studies, Stiroh (2002), reports considerable variation with estimates of ICT-elasticity ranging from -0.06 to 0.24. Even though these are largely attributed to differences in production function specifications, the estimation techniques, and quality of data used, there are other important dimensions such as the timing and span of the sample period, the ICT-measures used (Evangelista, 2000), and the characteristics of the adopters included in the sample. Such variations in findings may also be because different types of technologies are lumped together as "ICT capital" or "computers." (Weil, 1992; Baura et al., 1991).

To move forward the research agenda on technology adoption, more detailed empirical data is needed, and Anderson et al. (2006) and Jun (2008) emphasise that this need is particularly urgent in the financial services sector especially with the current wave of "fintech" innovation where different technologies can have various effects on organisations (Evangelista, 2000). To address this, we gather detailed firm-level data that incorporates larger samples of companies across longer periods to account for both sample selection bias and adjustments that take place over time. The availability of a long observation window offers us the unique opportunity to gain valuable information regarding the long-term impact of technological innovation on bank performance.

2.1. Long-term outcomes from technological innovation adoption

A key debate on the value of ICT has been the effect of technology on *long-term profitability* and its capacity to create sustainable competitive advantage (Clemons and Row, 1991; Clemons, 1986). A long standing theoretical claim in this literature asserts that new technology adoption will offer benefits in terms of enhanced cost efficiencies, better product quality, and increased value to customers but the economic rents and value realised from these benefits will not last long due to the high imitability of ICT. Thus, the ICT applications adopted by firms have the status of "strategic necessities" and advantages from their early adoption and use are lost through imitation and do not lead to profitability increases (Clemons and Kimbrough, 1986; Fuentelsaz et al., 2012; Carr, 2003). This hypothesis largely relies on the assumption that ICT is highly commoditized and therefore easily replicable at a low cost (Carr, 2003). In other words, it is expected that technology will be diffused and adopted homogenously – without 'frictions' or delays across competitor firms, a claim that is disputed in the technological diffusion literature where there are many factors that can prevent some firms from speedily adopting a technology (Fuentelsaz et al., 2012). The counter claim holds that there are alternative ways with which organizations incorporate ICT into their productive process, use complementary assets, or reconsider their business strategy in light of technological change, which can lead to persistent differences in performance that cannot be accounted for by the strategic necessity hypothesis (Battisti et al., 2009).

To address these fundamental arguments around long-term performance and sustainability we need a longitudinal approach which enables us to go beyond the short-term effects of technology adoption to reveal the varying temporal profile and impact of innovation. A few papers have attempted to focus on the long-term effects of ICT using micro data. (e.g. Kwon and Stoneman, 1995, for five manufacturing technologies or Haynes and Thompson (2000) on Automated Teller Machine (ATM) networks).

We build our study upon two key insights from this prior literature both of which centre on the importance of constructing long lags. Firstly, intra-firm diffusion and technological adaptation often takes time (Tyre and Orlikowski, 1994; Fuentelsaz et al., 2009). Second, there is often the need for significant organizational changes and learning (Van de Ven, 1986; Brynjolfsson and Yang, 1996; David, 1990). Studies using short lags are unable to capture potential benefits that may accumulate over time from the technology investment. As Fuentelzaz et al. (2012) argue, the uneven patterns of technological diffusion mean that it is possible for benefits accrued by adopters (in comparison to non-adopters) to endure for several years depending on the timing of the diffusion process. Thirdly, beyond firm heterogeneity, particular focus must be given to the specific characteristics of network innovations and their strategic importance for long-term economic performance.

Network externalities can arise when usage benefits increase with network size (Katz and Shapiro, 1985; Shapiro and Varian, 1999; Farrell and Saloner, 1992). For example, Saloner and Shepard's (1995) show that as more ATMs are installed, the network size grows, making it hold higher value for cardholders and banks because the connectivity produced provides more utility. Although there are comparable results in other industries (Economides, 1996), empirical work on financial services network effects is in short supply and very focused on ATMs. This is cause for concern in a sector whose history has been defined by network innovations and network platforms are undergoing critical development.

2.2. Firm size and technology effectiveness

There has been relatively little econometric research on the effects of ICT on smaller firms. For example, Brynjolfsson and Hitt (1996) used data from some of the largest US corporations (367 firms generating approximately $1.8 trillion of gross output annually). Small organizations possess some unique characteristics that matter significantly when new technology is introduced (Raymond, 1985; Thong et al., 1996; Kuan and Chau, 2001). For example, the relative costs and risks from ICT adoption and implementation can be considerably higher for smaller firms due to their limited resources and lack of knowledge around technology management (Pfeiffer, 1992; Grandon and Pearson, 2004).

In contrast to positive outcomes relating to the introduction and use of ICT in large organizations, research findings regarding the effect of technology in SMEs have been ambiguous at best. Empirical evidence from the literature on small business ICT suggests that a number of factors inhibit the uptake of technological innovation and impede the benefits of ICT adoption. These include a vital lack of financial resources with which to acquire ICT capital, invest in technological skills and achieve systems integration (Pfeiffer, 1992; Grandon and Pearson, 2004; Saunders and Clark, 1992). Similar results are also reported by Cragg and King (1993), who identify economic costs and shortage of technical knowledge as key barriers to ICT gains in the context of small organizations. Finally, Ballantine et al. (1998) identified distinctive features of SMEs such as narrow access to capital supplies, absence of business and IT strategy, and greater emphasis on using technology to automate (Zuboff, 1988). A more optimistic outlook is given by Dos Santos and Peffers (1995) who found inconclusive results regarding firm size and the impact of ICT on market share and income gains. Looking at a sample of banks and the benefits from ATM adoption they conclude that there are no economies of scale or scope for this technology that favour larger institutions in particular, however, they did not find any significant results to suggest that such a technology can specifically benefit smaller firms either. A similar view is shared by Lacity et al. (2014) who suggest that certain technologies, for example cloud computing can provide equal benefits to both large and smaller firms albeit in different ways.

Of particular interest for our study are hypotheses that contradict the generally accepted view and suggest that small organizations may hold certain *advantages* over their larger competitors. For instance, perhaps smaller enterprises can adapt faster to internal and external changes in their operating environment, whereas larger organizations may respond slowly to technological transformation due to legacy systems that demand substantial modifications (Dos Santon and Peffers, 1995). Evidence of this would be remarkable because it would mean that small businesses achieve benefits from ICT adoption that *in the long run* outweigh more obvious big firm advantages such as ample financial resources, ICT expertise, and economies of scale.

The literature on the effects of ICT has shown that firms benefit mostly from cost reductions due to automation and increase of efficiencies in the production process and less from an increase in revenue streams. Bigger firms are commonly expected to be more efficient and thus anticipate better results in this regard (Hall and Weiss, 1967), but as we will go on to argue there is also evidence that despite their size smaller businesses may also achieve significant leverage from ICT adoption. Indeed, some of the existing literature points to the realisation of a range of benefits including operational savings, improvements in business processes, the cultivation of new markets, higher sales turnover and increases in profitability (Currie and Parikh, 2006; Kuan and Chau, 2001).

In sum, thus far research examining the impact of ICT adoption on smaller firms, including mechanisms of value creation and the benefits generated has remained largely inconclusive. This leaves considerable scope for the study that we have undertaken here in which we ask not only if there is evidence that ICT adoption generates long-term benefits for firms but whether particular kinds of firms – small firms – benefit more than others in the long term.

2.3. Financial technology and bank performance

Traditionally, finance has been the highest spender across all sectors. For example, data from the U.S. Bureau of Economic Analysis measure computer (OCAM) expenditure in financial services between 32.5%-38.7%, from 1979 to 1992 (cf. Brynjolfsson and Yang, 1996; Griliches, 1995). Recent aggregate figures on technology investment worldwide place the banking and securities sector at the top of ICT spenders' list with a total expenditure of $486.28 billion– approximately 18% of the total technology investment or 24.8% if we include the insurance industry[3]. Consequently, the implications of ICT adoption and use for the global financial system have been fundamental. ICT did not only transform transaction processes but is also associated with shifting organizational boundaries (Scott and Walsham, 1998), facilitating the creation of new financial products, changing the nature of work (Barrett and

[3] Source: Gardner (September 2015). Manufacturing and natural resources followed with 476.55 billion USD. These figures are based on real data and partial projections for 2015, however, ICT expenditure in 2014 follows a similar pattern.

Walsham 1999), globalizing financial markets (Sassen, 2002; Weber, 1994) and restructuring the character of financial intermediation (BIS, 2002).

Some qualitative case studies have been used to study the effects of ICT on financial performance (e.g. Scott and Barrett, 2005; Clemons and Weber, 1990). For example, Autor et al. (2002) examine the introduction of automatic image processing on one of the top 20 US banks, arguing that the introduction of complementary organizational changes were crucial in understanding the impact on performance. In Weill and Olson (1989), the authors use six case studies to investigate the impact that the level of ICT investment has on firm performance. Their results, from a series of interviews with banking professionals, demonstrate the organizational complexities involved in defining ICT and difficulties encountered when searching for an appropriate measure to estimate the impact of technology. Such findings are particularly useful in order to understand the richness of processes and technology strategies in specific contexts, but are hard to generalise due to their specific nature.

In terms of econometric studies on ICT in financial services, Casolaro and Gobbi (2007) estimate profit and cost functions for a panel of 600 Italian banks 1989-2000 and find that ICT capital intensive techniques significantly increase total factor productivity (TFP). Jun (2008), examines findings from several studies showing a positive relationship between ICT and banking performance, and also presents results indicating that ICT investments are associated with higher returns on assets in a sample of 22 South Korean securities firms. Similarly, Anderson et al. (2006) investigate the value implications of ICT investments on a panel of 62 *Fortune 100* banks and find that firm value increased on average with Y2K spending on technology. Also, Parsons et al. (1993) estimate a cost function using data from a single large Canadian bank between 1974 and 1987 finding a weak but significant correlation between productivity growth and the use of computers. Finally, Alpar and Kim (1990) explore the impact of ICT on the production of bank services finding that technology is cost saving, labour saving and capital using.

Although these studies are useful in order to understand the general effect of ICT, treating technology as a single aggregated category makes it hard to disentangle which aspects of ICT led to performance increases and identify the dynamic effects of technology adoption. As a result, many authors have pointed out the scarcity of longitudinal studies examining particular ICT innovations in financial services. In a survey, Frame and White (2004) could only identify eight studies of which six use the same data on ATM diffusion (Hannan and McDowell, 1984; 1987; Sinha and Chandrashekaran, 1992; Saloner and Shepherd, 1995; etc.). Although they represent an important body of research, these studies focus more on the diffusion of specific innovations and less on their impact upon business performance. Thus, Frame and White (2004) conclude that we have a lot of “talk” about financial innovation but “little action”. In other words, given the size and importance of the financial sector, the number of relevant studies is surprisingly limited and further scholarly efforts are needed.

In this paper, we combine insights from several different research approaches. As a result, the approach taken here presents some distinct advantages, for example: firstly it proposes the in-depth investigation of a particular ICT-related innovation (SWIFT) in the banking sector rather than examining ‘general purpose technologies’ or ICT broadly, followed by an econometric analysis on the impact of SWIFT of bank performance. Secondly, the span of the data allows us to track the effects of SWIFT adoption in a large sample of banks (6,848 in total) across 29 countries. Previous micro-econometric studies have limited themselves to a single country[4] even though many industries, such as financial services, are international in scope. Thirdly, based on the whole population of SWIFT adopters we are able to track the long-run effects of adoption (up to 30 years) which is important as the impact of innovation is unlikely to be realised in the short run (Geroski et al., 1993). Finally, in order to explore the impact of SWIFT adoption on bank performance and the value–creating mechanisms that come into play once the technology is implemented – for both small and large banks – we draw on insights from previous qualitative research (Scott and Zachariadis, 2012; 2014). The complementary data was gathered through archival research as well as interviews with SWIFT employees, bank executives, and domain experts who described the SWIFT implementation process, its cost and potential benefits for different kinds of financial services organizations.

3. Overview of SWIFT and research setting

Our empirical analysis focuses on the adoption of an ‘inter-bank’ financial telecommunication network called SWIFT. Launched in 1973, SWIFT’s mission was to facilitate correspondence banking by automating communication between banks through the introduction of machine readable encrypted messaging standards, thus, enabling banks to send funds directly to counterparts at increased speed, in higher volumes, for reduced cost, and with improved security (Winder, 1985). In some regards, SWIFT can be compared to an electronic data interchange (EDI) or co-operative interorganizational system (IOS) allowing trading

[4] An exception to this is Beccalli (2007), who looks at a total of 737 banks in 5 European countries, however, the panel data used cover only 5 years in total and fail to identify any long-term effects which may last up to 10 years.

partners – in this case financial institutions – to "exchange structured business information[5] electronically" (Iacovou et al., 1995, p.466). SWIFT's diffusion began with European-based banks and gradually moved to countries such as the US and UK (see figure 1)[6]. In this section, we provide a detailed overview of SWIFT's proprietary communications platform: its network, the costs and benefits from its adoption, and its mission. We conclude by considering the assumptions made by practitioners in financial services about the benefits of SWIFT membership.

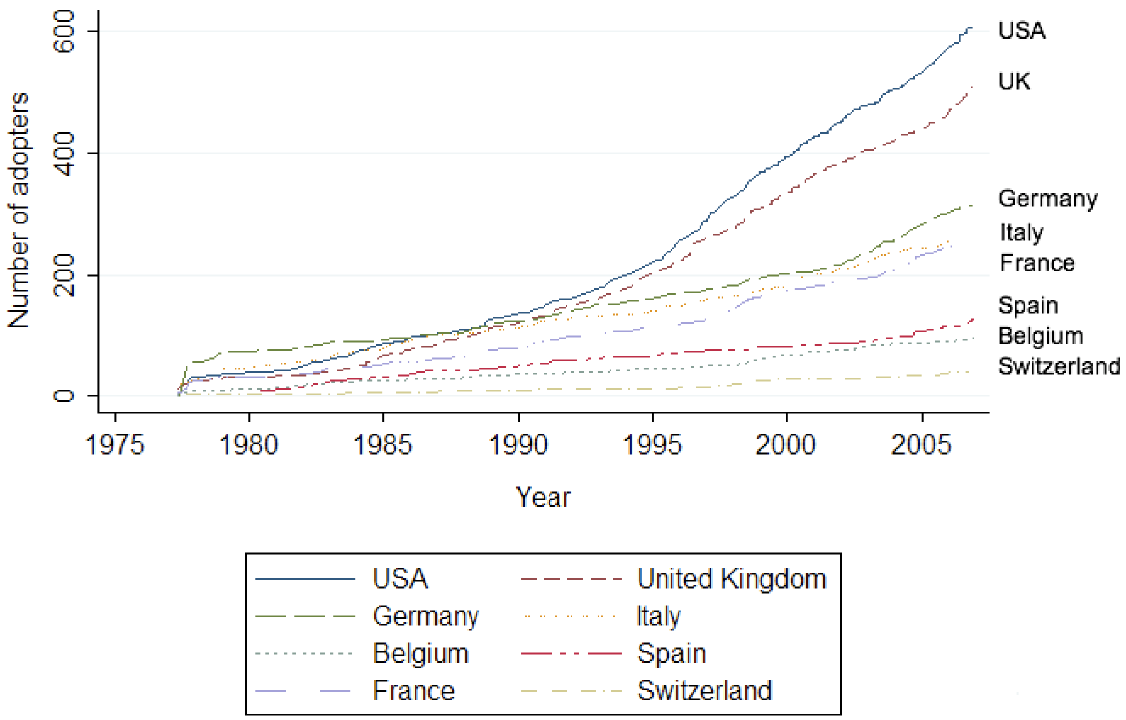

Fig.1. SWIFT diffusion in eight chosen countries (1977-2006).

SWIFT has established itself as a trusted third party, functioning as the core gateway especially for large-value payments. Weirdt et al. (2005) described it "as an obligatory passage

[5] In the case of SWIFT these are financial messages such as instructions for payments, confirmations, settlement messages, letters of credit, securities transactions, and other types of standardized processes.
[6] Figure 1 presents the accumulative diffusion curve of all SWIFT adopters across eight of the countries in our sample between 1977 and 2006. Even though Germany led the way until approx. 1985, the US and UK SWIFT population base grew substantially making these two countries the largest SWIFT adopters. As it can be seen the diffusion curve does not seem to follow the traditional "S" shape, which could suggest that the SWIFT diffusion process has not been completed by any means.

point to other parts of the transactional infrastructure, which gives it effective control of the [global] payment system". Since its founding, there has been a working concord among SWIFT members to support its operation as a not-for-profit "industry co-operative", reinvesting any surplus in process and product improvement. During its lifetime, there have been some business and connectivity 'solutions' in the tech market that engaged in competition, however they only accounted for a small fraction of business, and did not offer a comparable level of service or global coverage, nor they performed its standards and community development roles.

As the first network innovation of its kind in financial services, SWIFT necessitated the development of messaging standards to reduce operational complexity and advancements in network security protocols. Today SWIFT operates a highly reliable and secure IP network (SIPN) that offers a single window access to the financial world and allows for interoperability and high end-to-end automation (also known as "Straight-Through-Processing") through a vast range of standards, technological applications and connectivity solutions.

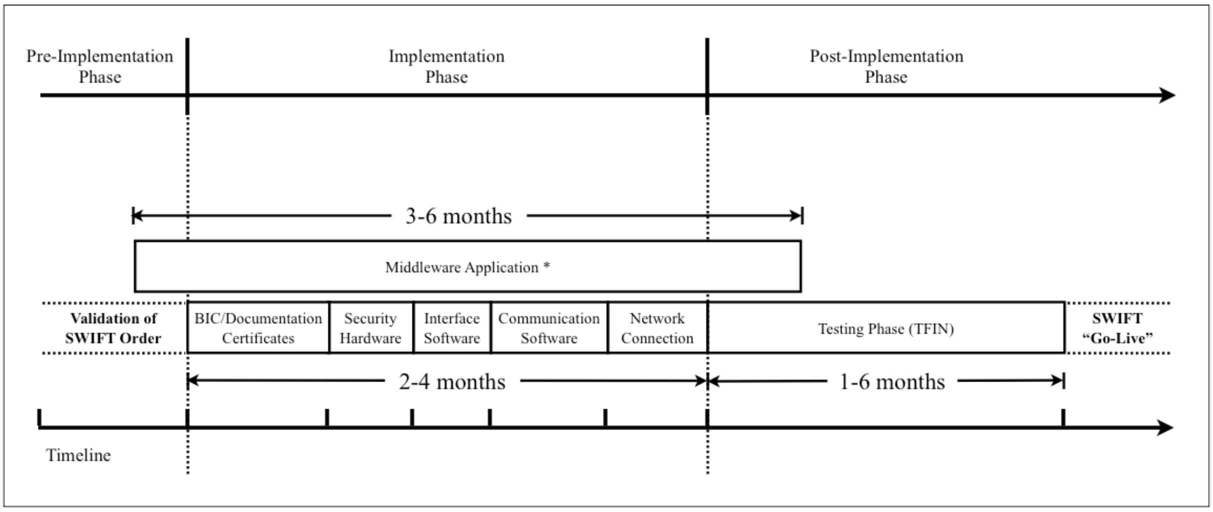

Fig.2. SWIFT implementation timeline

3.1. Costs and benefits of SWIFT adoption

The costs and benefits of adoption for different banks can vary significantly which means a thorough analysis of deployment (usage needs, interfaces, standards compliance, etc.) must be undertaken in the pre-implementation phase (see Figure 2). The main fixed costs relate to the original installation which includes all the items in the implementation phase. Once SWIFT is up and running (post-implementation stage) there are additional costs associated with maintenance, fees, training, software and hardware upgrades, and improvement expenses.

Going forward there may be further adjustment costs and subsequent software development to integrate the system with the internal banking processes.

In contrast to the expenses, benefits are typically not realized until the infrastructure is properly configured and used. The benefits that SWIFT can be distinguished into *intangible* and *tangible* aspects. Potential intangible benefits are related to the reduction of operational risk and fraud (due to the less manual intervention and more secure transaction environment), enhancement of customer satisfaction, security and resilience, easier regulatory compliance, greater visibility and control (allowing for better cash management), reliability and timing. These benefits are difficult to measure and therefore are not directly dealt with in our study, however, we would expect that they can contribute towards profitability.

Probably the most obvious tangible benefit, especially in the case of larger financial institutions, is the reduction of operating expenses. While the implementation of SWIFT can be a costly investment it is regarded as having a cost-saving effect. At a basic level, SWIFT replaces direct links to corresponded banks with a centralised cloud-based solution that allows member to contact anyone on the network (see figure 3). However, it also helps to reduce user's costs by providing automation (through greater standardization and interfacing), security, speed, and economies of scale thus reducing marginal costs in the long-term via increases in labour productivity. These benefits extend across numerous business processes and transactions commonly used in banking such as payments, confirmations, financial reporting, pre-trade, trade, and post-trade activities. Interviews with financial services professionals enabled us to document this step-by-step progressive roll-out of SWIFT adoption through each business area. They confirmed that after the initial investment period, long-term operating costs decreased as SWIFT became further integrated into their back-office automated production systems.

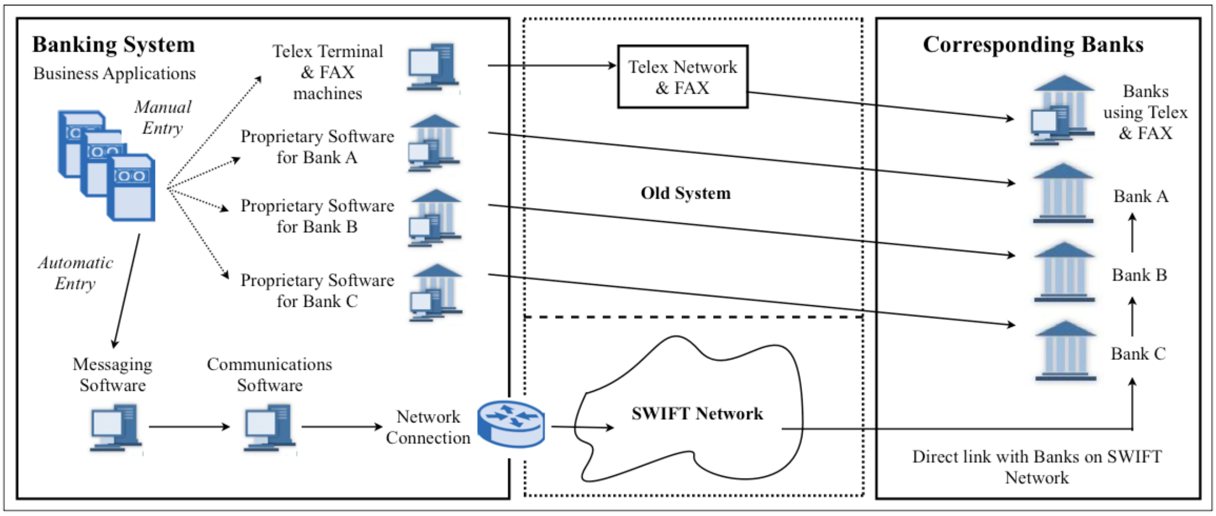

Fig.3. Value added from SWIFT adoption

Note: Figure 3 presents a detailed illustration of the mechanism through which SWIFT adds value in comparison to the old system of communication between banks (telex, FAX, and other proprietary networks).

The mutuality generated by SWIFT's industrial cooperative governance structure ensured a phase of initial reciprocal adoption by its founding members with subsequent momentum achieved by leveraging the counterpart banking relationship. In other words, firms compelled trading partners to connect as a condition of business. Large banks were able to assert new terms of business and thus realise the economies of scale promised by SWIFT adoption. Other smaller firms were actively recruited as SWIFT executives realized from the outset that network coverage was vital. Indeed, we documented on-going programmes to connect countries and enroll the widest possible range of financial institutions in our field study.

SWIFT delivers very high reliability and is now a core part of the largely taken-for-granted international financial services information systems infrastructure. Indeed, during our field study we frequently heard SWIFT referred to as the "plumbing" of international financial services. In other words, financial services professionals had come to regard SWIFT as a utility that fulfilled a basic but low-value facility. Moreover, its continued drive to reward high volumes led one interviewee to claim that SWIFT was built "by big banks, for big banks". This value neutral "utility" status and the claim that its benefits accrue mainly to large financial firms, represents the dominant 'industry wisdom.' Neither claim has been systematically investigated, however.

Challenging these active working assumptions lies beyond the mandate of the actors involved. SWIFT's attention is on "lean management" and their main interest is in the analysis of members' usage patterns along functional lines (rather than size of firm). By definition, SWIFT membership relieves firms of the need to analyse core transactional network technology so that they can focus on developing other kinds of service innovation. Regulators have oversight but their attention is on audit, systemic risk and compliance. The impact of SWIFT adoption on firm performance thus remains a blind spot both in the financial services industry and the academic literature.

4. Data and methods

Our main dataset is the entire population of SWIFT adopters worldwide from 1977 to 2006. This consists of the complete list of live SWIFT users operating on their “SwiftNet FIN” (or “SNFIN”) network – the most popular service and core SWIFT product – across 219 countries and territories. Considering the complexity of the financial systems around the world and the constraints that are placed from national financial regulatory bodies, we also limited our initial analysis to Europe and the Americas. Since 1977, SNFIN has been adopted by 3,380 banks in the 29 countries of our sample.

To this panel, we matched information from Bankscope, a global database containing information on more than 28,000 public and private banks (adopters and non-adopters of SWIFT) around the world. This is compiled by Bureau van Dijk (BVD), a European electronic publisher of business information. The database combines data from seven sources including Fitch Ratings, Capital Intelligence, the Economist Intelligence Unit, Moody’s, Standard and Poor’s etc. It includes all the information in the banks’ published accounts and is reasonably comprehensive in coverage. The product of this merge is a unique dataset containing a large sample of firm-level longitudinal information on ICT adoption and financial performance. Our financial data run from 1997 (the first year that Bankscope was produced) through 2006, but due to the small number of observations in years 1997 and 2006, we exclude them from our estimations and exploit the years from 1998 to 2005. After cleaning[7] we are left with an unbalanced panel of 6,848 firms and up to eight years of financial data.

[7] We clean our dataset from extreme negative and positive values that appear in our factor inputs. We also avoid dropping the data by winsorising our performance variables on the top and bottom percentiles. Results are similar if we simply trim the outliers.

Table 1
Country Statistics.

Country name	(1) Sample firms	(2) Percent	(3) Number of SWIFT adopters	(4) Percentage of SWIFT population	(5) Matched adopters in sample	(6) Proportion (%) of adopters in sample
Austria	230	3.36	100	1.22	69	30.00
Belgium	98	1.43	88	1.08	43	43.39
Canada	83	1.21	62	0.76	31	37.35
Cyprus	29	0.42	38	0.46	15	51.72
Czech Republic	32	0.47	28	0.34	16	50.00
Denmark	121	1.77	59	0.72	41	33.88
Estonia	10	0.15	13	0.16	7	70.00
Finland	19	0.28	22	0.27	7	36.84
France	468	6.83	250	3.06	118	25.21
Germany	1710	24.97	298	3.65	178	10.40
Greece	23	0.34	41	0.50	19	82.60
Hungary	40	0.58	43	0.53	25	62.50
Ireland	70	1.02	81	0.99	37	52.85
Italy	782	11.42	258	3.16	167	21.35
Latvia	23	0.34	27	0.33	23	100.00
Lithuania	10	0.15	12	0.15	10	100.00
Luxembourg	115	1.68	148	1.81	83	72.17
Malta	14	0.20	15	0.18	9	64.28
Netherlands	101	1.47	98	1.20	45	44.55
Norway	88	1.29	34	0.42	17	19.31
Poland	52	0.76	47	0.57	39	75.00
Portugal	47	0.69	45	0.55	31	65.95
Slovakia	21	0.31	20	0.24	14	66.67
Slovenia	20	0.29	23	0.28	17	85.00
Spain	166	2.42	120	1.47	71	42.77
Sweden	139	2.03	35	0.43	14	9.35
Switzerland	539	7.87	270	3.30	162	30.00
United Kingdom	455	6.64	538	6.58	177	38.90
USA	1343	19.61	567	6.94	204	15.19
Total	6848	100.00	3380	41.34	1689	24.66

Notes: Our sample (first column) includes 6,848 firms from 29 countries (adopters & non-adopters). Adoption information is from 1977 to 2006. The third column contains data on the population of SWIFT adopters in the 29 countries of our sample. Column 5 reports the number of adopters by country that were matched in the sample and column 6 reports what is the proportion (%) of the matched adopters in the whole sample.

Table 2
Descriptive statistics.

	Obs.	Median	Mean	Stdev
Variables				
Total assets (m$)	29970	729.43	10300	62000
Total sales (m$)	29970	49.705	637.6793	3701.933
Pre-tax profits (m$)	29970	5.936	104.894	759.944
Employees	29970	164	1460.54	8479.635
Operating expenses (m$)	29901	20.1	259.637	1674.894
Ratios				
Profit margin	29970	0.1384	0.1522	0.1524
Return on assets	29970	0.61	0.7822	0.9919
Return on equity	29946	7.43	8.5566	8.1563
Cost to income	29789	67.13	68.337	29.8822
	Small Firms			
Total assets (m$)	14300	255.992	294.235	211.316
Total sales (m$)	14300	17.273	22.053	27.465
Pre-tax profits (m$)	14300	1.808	3.396	9.0938
Profit margin	14300	0.1308	0.1418	0.156
	Big Firms			
Total assets (m$)	15670	2429.1	19400	84700
Total sales (m$)	15670	162.521	1199.482	5054.607
Pre-tax profits (m$)	15670	22.23	197.518	1042.361
Profit margin	15670	0.1459	0.1618	0.1483

Notes: Sample includes 6,848 firms in 29 countries, from 1998 to 2005; m$ = Millions of US Dollars. Small and Big firms are split according to the overall median of the Total Assets sample. In order for firms not to switch definition (between small and big) in our sample we first construct an average of the total assets for every firm. We then use this median for our split.

In Table 1, we present our sample size by country including a separate column for SWIFT adopters. While SWIFT is *adopted* by many organizations including broker/dealers, corporates, custodians, investment managers, payment and securities market infrastructures (i.e. stock exchanges) and other non-financial institutions, we only keep the matched data from the SWIFT-Bankscope merge including the *non-adopter* firms from Bankscope. Thus, the resulting dataset exclusively contains banking institutions of all kinds existing in Bankscope. Looking down column (1), we see that almost a quarter of firms are in Germany (mostly due to the popularity of local savings banks known as *Sparkassen*) and almost one fifth in the US. Other countries which have many banks in the sample are the UK (6.6%), France (6.8%), Switzerland (7.9%) and Italy (11.4%)[8]. In order to avoid any duplication in our data we

[8] The 29 countries and 3,380 SWIFT adopters in our database cover 41.34% of the entire SWIFT population globally which is about 8,176 firms in 219 countries and territories. From the 3,380 SWIFT adopters we managed to match 1,689 onto the Bankscope database. As mentioned above, SWIFT is adopted by a number of non-banking organizations that are not included in Bankscope (about half).

excluded the unconsolidated accounts if we had their consolidated companions and used unconsolidated accounts of a subsidiary when there were no consolidated companions (results were robust when using only consolidated or only unconsolidated accounts).

Measuring productivity is extremely challenging in the financial sector, mainly due to the difficulties involved in developing an adequate price index for value added. In this paper, we focus on the profit margin defined as gross pre-tax operating profits divided by revenue ("return on sales") as our key performance measure (we also compare the results to alternative normalizations such as assets or equity). Accounting profits can diverge from economic profits, but the two are likely to be correlated at the firm level and there is a tradition in industrial economics which supports using profitability as a key measure of firm performance (Slade, 2004).

Table 2 presents descriptive statistics. The median bank in the sample is not large: it has 164 employees, sales of $49 million and $5.9m in profit. The profit margin is 0.13. Note, however, that the data is quite skewed as mean sales are $638m with a standard deviation of $3,702m. The other parts of the table break down the descriptive statistics by firm size and country. Profits are the difference of revenues and costs, so we also present results that disaggregate profitability into the revenue and cost components. We also examine the change in employment following SWIFT adoption as a further outcome.

Our main indicator of diffusion is simply an adoption dummy equal to unity in the year that the bank adopts SwiftNet Fin marked by the end of the post-implementation and the start of the "Live" phase (recall figure 2). It is unclear when the pre-implementation phase begins so we are careful to test for the exact timing (see below). In particular, it is likely that the benefits of SWIFT will not be observed in the first year, but instead there will be a longer-term dynamic at work between the introduction of SWIFT and its eventual effect on the bottom line. The fact that we have the entire history of all adoptions of SWIFT is helpful here because we are able to construct long lags back to 1978 for each firm. In other words, we are able (in 1998) to include up to a twenty-year distributed lag for SWIFT adoption to examine the dynamic effects on firm performance.

We do not have data on the intensity of usage of SWIFT for the whole period - some proxies exist in one or two years but these are not consistent across countries. Consequently, we focus on the simple adoption dummy as is standard in the diffusion literature.

4.1. Modelling strategy

The main equation of interest is:

$$(\Pi/S)_{it} = \sum_{j=0}^{L} \alpha_j SWIFT_{i,t-j} + \beta_1 X_{it} + \eta_i + T_t + \varepsilon_{it} \qquad (1)$$

Where $(\Pi/S)_{it}$ is the profit margin, the ratio of pre-tax profits to sales of firm i at time t. X_{it} denotes a vector of control variables such as the log of total assets to employees as proxy for the fact that firms of different capital intensity have different profit sales margins (e.g. if there are high fixed costs gross margins will be higher). We include a full set of firm fixed-effects, η_i to control for permanent unobserved heterogeneity (the country dummies are absorbed into this) and time dummies to control for macro-economic shocks, T_t. Finally, ε_{it} is an idiosyncratic error term whose properties we discuss below. $SWIFT_{it}$ is an adoption variable that is a binary dummy variable taking the value of one in the year of the "go-live" phase of adoption and all years after (and zero in the years before the go-live year). We allow a distributed lag up to L on this where empirically we estimate that L is approximately 9, in other words it takes about a decade for the full effect of SWIFT to play out on bank performance. This was also generally confirmed by the people we interviewed in banks.

An econometric problem that arises while trying to estimate the effects of technology adoption on firm performance is unobserved heterogeneity. This occurs when there are many factors correlated with firm performance that we do not measure. In our case, this may create an upwards bias for the coefficient of SWIFT. We assume that these unobserved factors stay constant over time and we treat them as fixed effects. Then we proceed with our estimation by including a full set of firm-level dummy variables (the *within-groups* estimator). A problem with the fixed effects estimator is that it will exacerbate classical measurement error causing the SWIFT coefficient to be attenuated towards zero. But since this is administrative data there is probably little measurement error. A second concern, however, is that there may still be unobserved shocks, so that SWIFT adoption is correlated with the error term, ε_{it} .In the absence of an instrumental variable it is difficult to do much about this, but the fact that the main effects come not from the current variables but the long-lagged variables gives some reassurance that the positive effects we identify are not due to endogeneity bias.

Finally, note that all standard errors are clustered by firm to allow for arbitrary patterns of autocorrelation over time (serial correlation is typical in firm panels even after removing fixed effects).

5. Analysis and discussion of findings

In the next part of the paper we report on our analysis and discuss the implications of our results for the research questions in our study. In the first sub-section, we consider whether there is evidence that ICT adoption generates long-term benefits for banks and whether these benefits accumulate over time. The timeline that is produced is important because whereas previous studies rest on aggregated or cross sectional data, our findings are based upon a longitudinal panel of data for a particular network technology. Next, we focus in more detail on whether particular kinds of firms benefit more than others in the long-term. Finally, we investigate the mechanisms through which SWIFT adoption adds value to banks in the long-run and identify, among other things, network effects to be of significance. For each section we draw on insights from prior in-depth field studies, and discuss how we might interpret the benefits that we have identified and their implications for further research.

5.1 The long-term effects of SWIFT adoption

Table 3 reports our basic regression results using the specification in equation (1). Column (1) simply regresses profitability on a nine-year distributed lag of SWIFT adoption (all columns include year and firm dummies). SWIFT appears to have a significant impact on firm profitability for up to 9 years. Lags at ten years and beyond were insignificant. As shown at the base of the column the sum of the SWIFT coefficients are significantly different from zero (p-value = 0.0018) and the coefficients are jointly significant (p-value = 0.0006). The dynamics are interesting: there is little effect, even a negative coefficient in some of the early years of SWIFT on profits. The larger effects do not materialise for several years. We illustrate these dynamic effects in figure 4 which presents the cumulative effect of SWIFT over time. The figure illustrates that positive returns are not clearly visible until two years after SWIFT adoption and only gradually build up the long-run effect of 0.0823, which is sizeable.

Table 3
SWIFT adoption and firm performance.

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	OLS	OLS	OLS	OLS
Sample	All firms			Small firms	Large firms
Dependent variable	Π/S_{it}	Π/S_{it}	Π/S_{it}	Π/S_{it}	Π/S_{it}
$\log\left(\frac{Assets}{Employees}\right)_{it}$	–	0.0358***	0.0358***	0.0543***	0.0268***
		(0.0076)	(0.0076)	(0.013)	(0.0093)
$SWIFT_{it+1}$	–	–	0.0155	–	–
			(0.0138)		
$SWIFT_{it}$	0.0011	0.0006	–0.0087	0.0012	0.0023
	(0.0177)	(0.0171)	(0.0162)	(0.0273)	(0.0216)
$SWIFT_{it-1}$	–0.0087	–0.0106	–0.0102	–0.0001	–0.0187
	(0.0205)	(0.0201)	(0.0201)	(0.0309)	(0.0261)
$SWIFT_{it-2}$	0.0269*	0.0243	0.0246	0.0376	0.0114
	(0.016)	(0.0159)	(0.0158)	(0.0288)	(0.0155)
$SWIFT_{it-3}$	–0.0051	–0.0057	–0.0056	0.0059	–0.0162
	(0.0133)	(0.0132)	(0.0132)	(0.023)	(0.014)
$SWIFT_{it-4}$	0.0263**	0.026**	0.0262**	0.0411**	0.0105
	(0.0113)	(0.0112)	(0.0112)	(0.0173)	(0.0141)
$SWIFT_{it-5}$	0.038	0.002	0.002	–0.0002	0.0028
	(0.0108)	(0.0108)	(0.0108)	(0.0161)	(0.0145)
$SWIFT_{it-6}$	0.0057	0.0055	0.0055	0.0027	0.0074
	(0.011)	(0.011)	(0.011)	(0.0172)	(0.0141)
$SWIFT_{it-7}$	0.0105	0.0098	0.0098	0.0147	0.0062
	(0.0104)	(0.0104)	(0.0104)	(0.0171)	(0.0132)
$SWIFT_{it-8}$	0.0034	0.0026	0.0026	–0.0015	0.0042
	(0.0089)	(0.0089)	(0.0089)	(0.016)	(0.0105)
$SWIFT_{it-9}$	0.0184**	0.0154**	0.0155**	0.0167	0.0138
	(0.0077)	(0.0076)	(0.0076)	(0.0135)	(0.009)
Sum of coefficients	0.0823	0.07	0.0618	0.1181	0.0238
Mean of Dependent variable	0.1522	0.1522	0.1522	0.1382	0.1652
Significance of the sum of SWIFT coef. (Prob>F)	0.0006	0.003	0.01	0.0024	0.4053
Joint significance of SWIFT coef. (Prob>F)	0.0018	0.0093	0.0096	0.0215	0.6004
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Number of firms	5615	5615	5615	2832	2783
Number of obs.	29970	29970	29970	14300	15670
R^2	0.6694	0.6726	0.6727	0.6622	0.6852

Notes: *significant at 10%, **significant at 5%, ***significant at 1%. Standard errors in brackets are clustered by firm. All equations include a full set of country and year dummies. The dependent variable in all columns (Π/S_{it}) is the Profit Margin denoting Pre-tax Profits over Total Revenues (Sales). In all columns we include a 9-year lag structure to test the long-term effect of SWIFT on firm performance. In column 3 we have also constructed a lead to investigate the causal direction of SWIFT adoption and firm performance. In columns 4 & 5, we split our data between "Small" and "Big" firms we use a mean of the Total Assets of each firm as size indicator to make the categorisation. The time period of our sample is 1998-2005 (eight years).

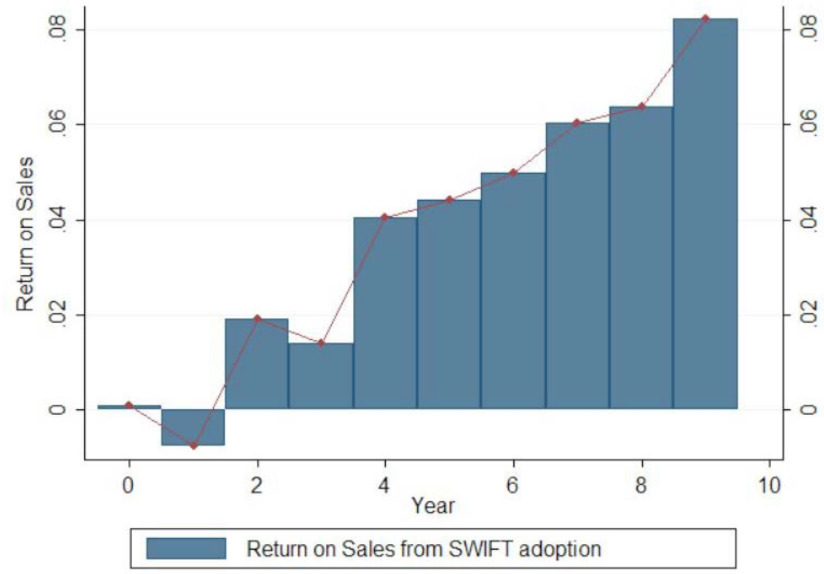

Fig.4. Long-term returns from SWIFT. *Notes:* Figure 4 is a graphical representation of column (1) in Table 3. It presents the long run effect of SWIFT adoption on Profit Margin in the whole sample. Our full sample includes 6848 firms in 29 countries (adopters & non-adopters). Adoption data run from 1977 – 2006 and financial data from 1998 – 2005.

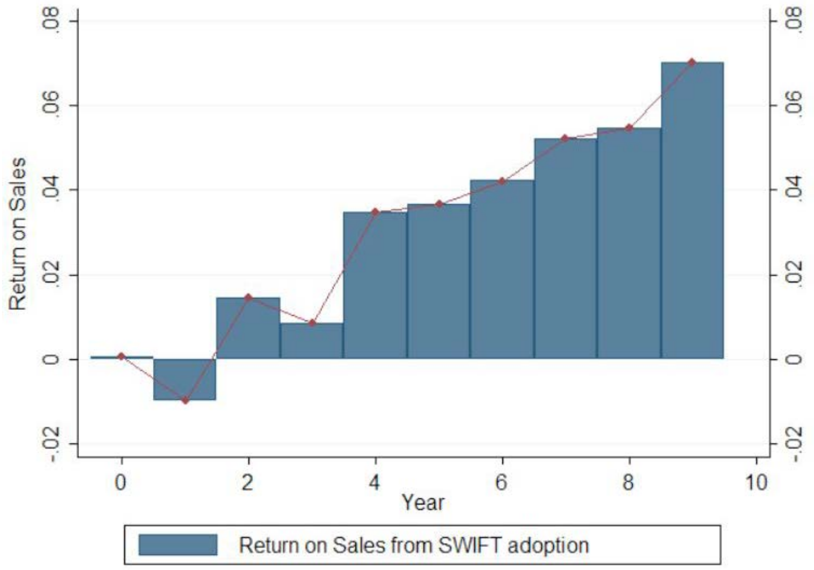

Fig.5. Long-term returns from SWIFT. *Notes:* Figure 5 is a graphical representation of column (2) in Table 3. It presents the long run effect of SWIFT adoption on Profit Margin in the whole sample. Our full sample includes 6848 firms in 29 countries (adopters & non-adopters). Adoption data run from 1977 – 2006 and financial data from 1998 – 2005.

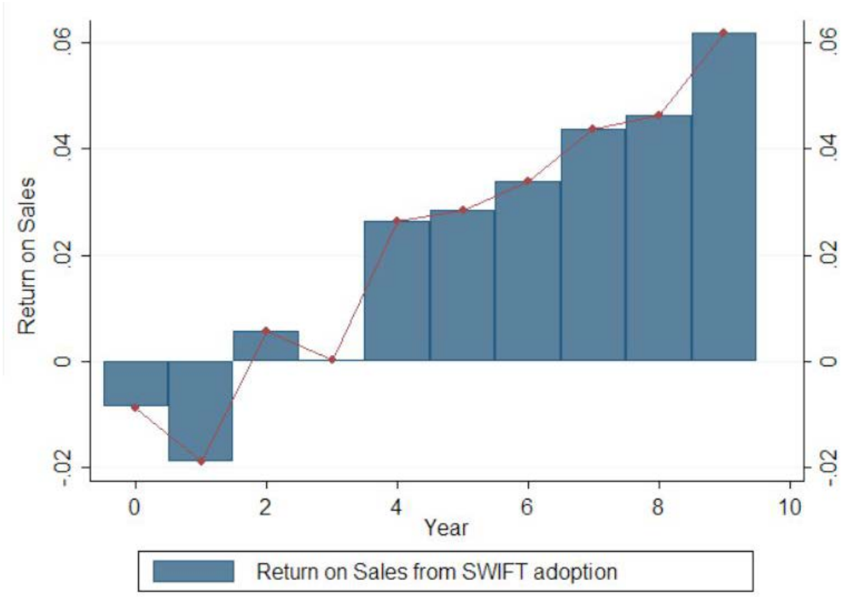

Fig.6. Long-term returns from SWIFT. *Notes:* Figure 6 is a graphical representation of column (3) in Table 3. It presents the long run effect of SWIFT adoption on Profit Margin in the whole sample. Our full sample includes 6848 firms in 29 countries (adopters & non-adopters). Adoption data run from 1977 – 2006 and financial data from 1998 – 2005.

Column (2) includes the capital-labor ratio as an additional control, whose coefficient is positive and highly significant. The dynamics are illustrated in figure 5 and show an even slower build-up of profit margins than the previous column – the long-run effect falls to 0.07. Column (3) includes a lead in SWIFT to pick up whether there were costs in the year prior to the "go-live" year of SWIFT (figure 6). The coefficient is insignificant and actually positive rather than negative. This suggests either that the costs before the go-live point are insubstantial or that most of these are captured in the year when the go live period occurs (given that the implementation period may just be months). The first three columns all suggest a positive long-run impact of SWIFT on performance of between 0.06 and 0.08. Taking the lower bound, this is still an increase in profitability of around 40% throughout the ten years of SWIFT adoption, which is large[9].

The positive and statistically significant effect of SWIFT adoption on firm performance (measured in terms of profit margin) is important because it challenges the practitioner notion of "the plumbing". In other words, it overturns the prevalent assumption that adopting a network innovation like SWIFT is analogous to connecting a neutral system of 'pipes' with little or no effect. Archival material and interviews with practitioners involved in the founding

9 The results are robust even when we put in country dummy and year dummy interactions (year*country) for all years and countries.

of SWIFT emphasised the effectiveness of its original mission to "kill telex", eliminate telegrams, and stop facsimiles. Having such an easily communicated objective seems to have played a key role in adoption providing historical insight for innovation strategists. As for the focus of our study, rally cries to "kill telex" help us to understand increases in efficiency but are there further insights from our field study that can speak to more generative mechanisms at work?

As a ground-breaking network innovation, many problems were encountered not least of which was the realisation that multi-jurisdictional legal agreements would need to be drawn up if the status of its international messaging systems was going to be recognized. What emerged was a "community of practice" (Wenger, 1998) in which expertise of many kinds was pooled and made accessible to members. As one interviewee put it: "…the uniqueness of SWIFT was and still is today the absolute impressive accessibility…The great idea behind SWIFT was that this would be a platform for all financial institutions and that its advantage terms of cooperation should outweigh the individual benefits". Banks that were normally competitors sent their staff to inter-organizational workshops to collaboratively examine the technical challenges of network innovation ranging from legal/regulatory issues, industry standards, process reengineering, organizational restructuring, and new approaches to management. A domino effect of process innovation followed as SWIFT updates rolled out and legacy systems were replaced as part of the adoption process.

5.2 Firm size and financial performance

In columns (4) and (5) we repeat the analysis by splitting the sample into larger and smaller firms based on median assets[10]. The specifications are identical to column (2) and the dynamic responses are plotted in figures 7 and 8. The coefficients are much larger for smaller firms than bigger ones: smaller firms have a long-run SWIFT effect of 0.12 whereas this is only 0.02 for larger firms. Since the margins are larger for bigger firms the implied proportionate effect is even greater for the small firms than the large firms. A possible explanation for this is that the larger firms have to bear a lot more re-organization costs because of their legacy proprietary

[10] Median assets were calculated using all available financial data from 1998 – 2005. The results largely stay the same if we split our sample based on the number of employees instead of using total assets as a size indicator. In the Appendix we also include a breakdown of our sample in terciles reporting figures for small, medium and large banks (Table A9). The accumulative benefit decreases as the size of the firms in the sample increase confirming our initial findings that smaller firms benefit more from the adoption of SWIFT in the long-term.

systems. However, this does not explain the long-term difference in performance resulting from SWIFT adoption.

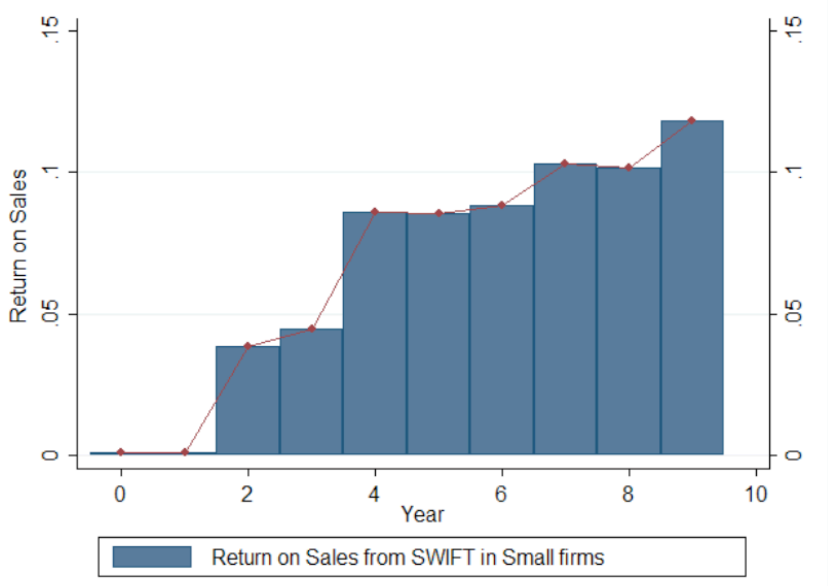

Fig.7. Long-term returns in small firms. *Notes:* Figure 7 is a graphical representation of column (4) in Table 3. It presents the long run effect of SWIFT adoption on Profit Margin in the sub-sample of Small firms. Our full sample includes 6848 firms in 29 countries (adopters & non-adopters). Adoption data run from 1977 – 2006 and financial data from 1998 – 2005.

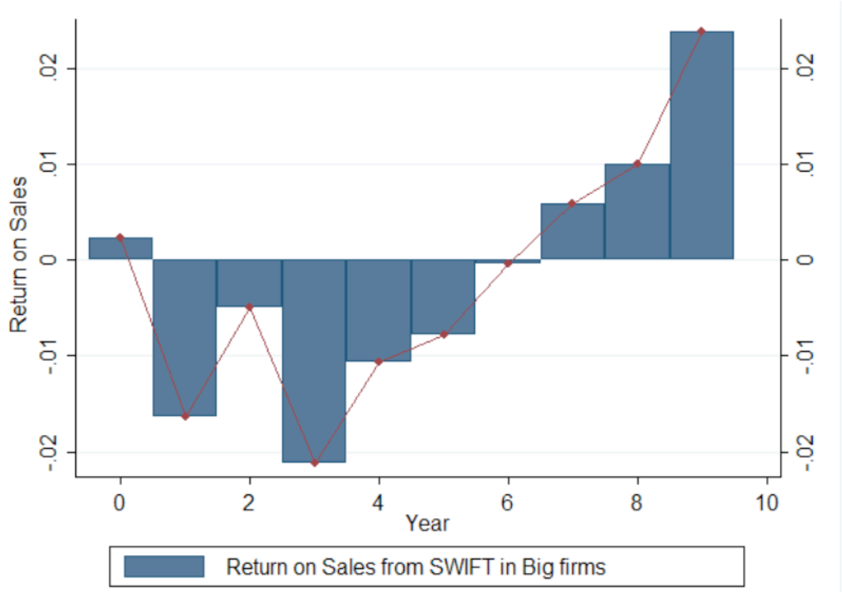

Fig.8. Long-term returns in big firms. *Notes:* Figure 8 is a graphical representation of column (5) in Table 3. It presents the long run effect of SWIFT adoption on Profit Margin in the sub-sample of Big firms. Our full sample includes 6848 firms in 29 countries (adopters & non-adopters). Adoption data run from 1977 – 2006 and financial data from 1998 – 2005.

In summary, and taking all columns together, we have two key results. First, there seems to be a positive and statistically significant effect of SWIFT adoption on firm performance (measured in terms of profit margin), and this effect appears to be substantial in magnitude. This is consistent with other recent findings on ICT and firm performance. Secondly this effect is much higher on smaller firms rather than big firms.

The result for small firms is important because by mapping this original data set onto a timeline for adoption benefits we are not only able to contribute baseline findings to the scholarly knowledge base but also raise a number of key questions for further research. For example, going forward, do we need to differentiate between network technologies such as EDI and ATM (the focus of prior literature) and network innovations which through their membership associate small firms with a mode of governance, audit and accountability that would otherwise be out of reach? If as a senior member of the executive team has suggested, SWIFT is "the first cloud", can we claim that particular forms of network innovation serve, as Lacity et al. (2014) suggest, as "a great equaliser for SMEs [providing] an unprecedented opportunity to access economically the same IT infrastructure and software as large-sized firms"? Does SWIFT membership amplify small scale specialist offering with world-class infrastructure?

Our results mean we are also able to better reflect upon practitioner claims that SWIFT was developed "by big banks, for big banks". Interviews with 'SWIFT pioneers' and founding members indicate that small banks were integral to its formation.[11] According to our analysis, if we take a long-term view of SWIFT adoption we find consistent and significant evidence that small banks have both benefitted from SWIFT membership and been an asset to other members in the SWIFT network.

5.3 Other outcomes: sales, expenses and labour

Table 4 presents the estimates of three other outcome variables: ln(Sales), ln(costs) and ln(labor-capital ratio). As in the previous tables, in all columns, we control for firm fixed effects and we include a full set of country and year dummies. The dynamic responses are graphically presented in Figures 9-11.

[11] One described SWIFT's approach to members at the time of its found as follows: "…everybody paid the same tariff and they paid the same entry fee, it was really, you know, everybody's on the same level, the small [local] bank […] to the big U.S. or big European bank".

Table 4
SWIFT adoption and sales, expenses and labour capital.

	(1)	(2)	(3)
Estimation method	OLS	OLS	OLS
Dependent variable	$\log(Sales)_{it}$	$\log(Opex)_{it}$	$\log\left(\frac{Employees}{Assets}\right)_{it}$
$\log(Assets)_{it}$	–	0.633***	–
		(0.031)	
$SWIFT_{it}$	0.0386	0.0174	–0.0162
	(0.0646)	(0.0473)	(0.0468)
$SWIFT_{it-1}$	0.1569**	0.0219	–0.0527
	(0.0714)	(0.0395)	(0.0385)
$SWIFT_{it-2}$	0.0813**	–0.0217	–0.0708**
	(0.0373)	(0.0249)	(0.0278)
$SWIFT_{it-3}$	0.0449	–0.0473	–0.0165
	(0.0308)	(0.0303)	(0.0312)
$SWIFT_{it-4}$	0.0605**	–0.0146	–0.0067
	(0.0247)	(0.0249)	(0.0239)
$SWIFT_{it-5}$	0.0064	–0.0217	–0.0504*
	(0.0247)	(0.024)	(0.0293)
$SWIFT_{it-6}$	–0.0078	–0.0131	–0.0043
	(0.0271)	(0.0258)	(0.0298)
$SWIFT_{it-7}$	–0.0095	–0.0385*	–0.0196
	(0.0239)	(0.0221)	(0.0239)
$SWIFT_{it-8}$	0.003	–0.0102	–0.0232
	(0.0252)	(0.0202)	(0.0236)
$SWIFT_{it-9}$	0.0327	–0.0662***	–0.0846***
	(0.0338)	(0.025)	(0.0275)
Sum of coefficients	0.4072	–0.1939	–0.345
Mean of Dependent variable (level)	653.6921	254.3271	–8.395
Significance of the sum of SWIFT coef. (Prob>F)	0.0000	0.0023	0.0000
Joint significance of SWIFT coef. (Prob>F)	0.0022	0.0036	0.0007
Firm fixed effects	Yes	Yes	Yes
Number of firms	6727	6720	5620
Number of obs.	39395	39259	30039
R^2	0.9722	0.9822	0.9429

Notes: *significant at 10%, **significant at 5%, ***significant at 1%. Standard errors in brackets are clustered by firm. All equations include a full set of country and year dummies. The dependent variable in column 1 is the log of total revenues, in column 2 the log of operating expenses, and in column 3 the log of employees over assets. The time period is 1998-2005.

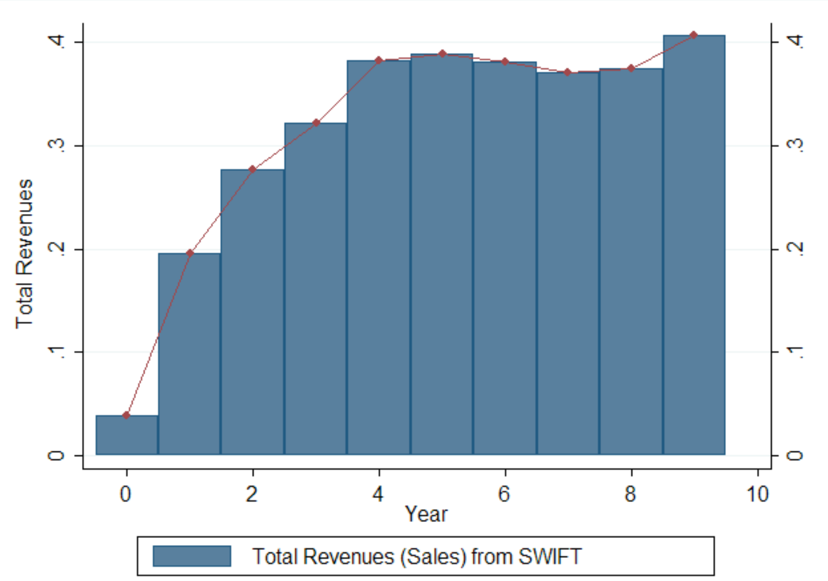

Fig.9. SWIFT effect on total sales. *Notes:* Figure 9 is a graphical representation of column (1) in Table 4. It presents the long run effect of SWIFT adoption on the Total Revenues (Sales) of the firms of the whole sample. Our full sample includes 6848 firms in 29 countries (adopters & non-adopters). Descriptive Statistics of our variables are reported in Table 2. Adoption data run from 1977 – 2006 and financial data from 1998 – 2005.

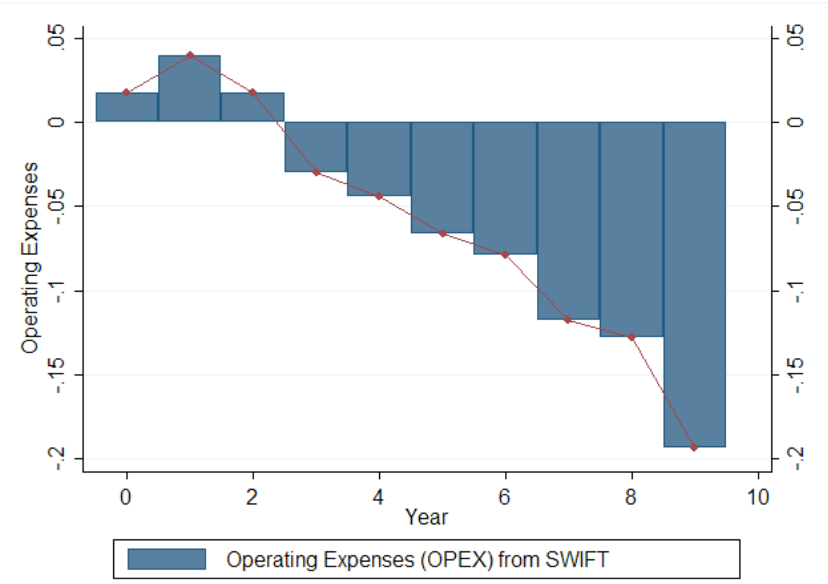

Fig.10. SWIFT effect on operating expenses. *Notes:* Figure 10 is a graphical representation of column (2) in Table 4. It presents the long run effect of SWIFT adoption on the Operating Expenses of the firms in the whole sample. Again we can observe the dynamic effect of SWIFT. According to our analyses on SWIFT, expenses are expected to increase the first two years of the technology implementation. After that, operating expenses experience a drop since automates a list of processes in the organisations. Our full sample includes 6848 firms in 29 countries (adopters & non-adopters). Descriptive Statistics of our variables are reported in Table 2. Adoption data run from 1977 – 2006 and financial data from 1998 – 2005.

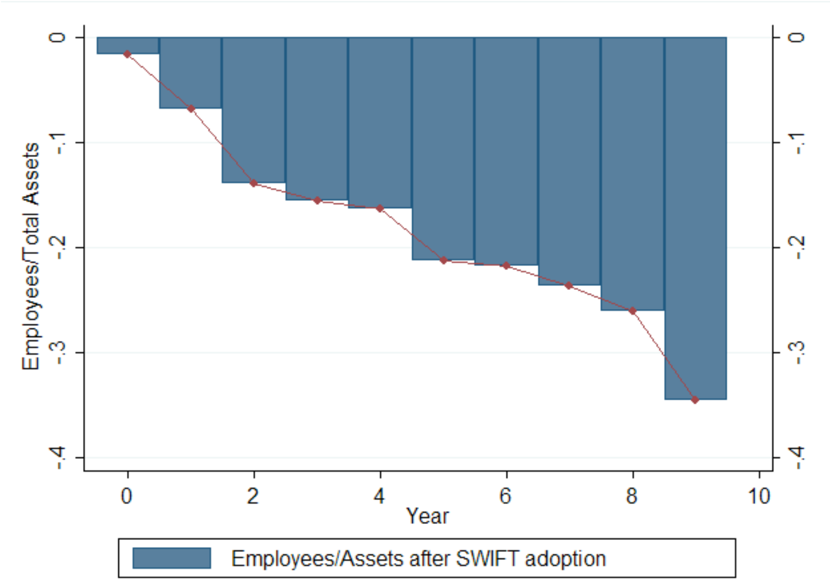

Fig.11. SWIFT effect on labour/assets. *Notes:* Figure 11 is a graphical representation of column (3) in Table 4. Here we observe a fall in the numbers of employees relatively to the assets of the firm sample. Our full sample includes 6848 firms in 29 countries (adopters & non-adopters). Description Statistics of our variables are reported in Table 2. Adoption data run from 1977 – 2006 and financial data from 1998 – 2005.

Column (1) of Table 4 presents the sales equation. Sales are positively and significantly associated with SWIFT adoption: the long-run effect of SWIFT on sales is 41 log points, implying the firm sales increase by approximately 50% (= [exp(0.407) - 1]x100) over the decade when SWIFT was adopted. These results are consistent with our prior qualitative findings that SWIFT creates new revenue streams and results into an increase in sales.

The second column uses costs – operating expenses – as a dependent variable. Controlling for assets, we find that the first two years' expenses actually increase and start to decrease only from the third year after adoption. The long-run effect is negatively correlated with SWIFT adoption and is statistically significant. The initial increase the long-term decrease of the costs is consistent with our story of how SWIFT affects firm operating expenses. While SWIFT in various cases demands a considerable initial amount of investment to implement and use, it substitutes different inputs that account for a large piece of the operating costs. From the results, we can presume that operating costs fall by approximately 20% in the 10-year period following SWIFT adoption. This is smaller than the proportionate increase in revenues, suggesting that SWIFT increases profits both by reducing costs and increasing demand, but the effect is stronger on revenues.

In column (3) we use the ratio of employees over assets as a dependent variable. There appears to be a substantial shakeout of workers relative to capital following SWIFT adoption, presumably because SWIFT enables reductions in manpower. The results here are also statistically significant.

The above findings suggest that the value-added mechanism from SWIFT adoption does not only concern the reduction of operating expenses (due to efficiencies) as one would expect from the adoption of a production technology (Fuentelsaz et al., 2012). Through the enhancement of banks' communication capabilities and the development of new standards, SWIFT provided the opportunity to increase firms' transactional capacity, develop new products and services and create new markets that led to further revenue gains. One of the interviewees at a small bank, which has been back and forth with the decision to adopt SWIFT solely on the basis of cost reductions, said "…then there was a feedback from our marketing effort, which said that we would be able to increase our business, increase our volume, if we have SWIFT." Being a network innovation, the benefits from SWIFT adoption rely largely on the number of network adopters that a bank is able to transact with over the SWIFT network. In the next section, we make an attempt to identify any existing network effects that boost the marginal benefit of SWIFT adopters as the size of the network grows.

5.4 SWIFT network externalities

In table 5, we augment equation (1) to include a network variable defined as the cumulated aggregate number of SWIFT adopters in a country in a year from the entire SWIFT population. Columns (1) and (2) report the coefficients for network effects and lagged network effects respectively. In both columns we find a positive and significant coefficient on the network variable. Even though the coefficients seem small, they suggest a considerable profitability effect if the number of the adopters increases rapidly every year in each country. The literal interpretation of the current results is that, for every additional firm that adopts SWIFT in a specific country, other adopters will increase their average profit margin ratio by approximately 0.0002. If the number of adopters for example grows by 10 in a country in a year, firms are going to benefit from another 0.002 increase on their profit margin (1.3%).[12]

[12] The full network effects are hard to credibly estimate as many are international rather than national. Unfortunately, the aggregate number of adopters is collinear with the time dummies so cannot be separately identified.

Table 5
SWIFT network effects.

	(1)	(2)
Estimation method	OLS	OLS
Sample	All firms	
Dependent variable	Π/S_{it}	Π/S_{it}
$\log(\text{Assets})_{it}$	0.0362***	0.0362***
	(0.0076)	(0.0076)
Network Effect_{jt}	0.0001808***	–
	(0.0000575)	
Network Effect_{jt-1}	–	0.0002741***
		(0.0000547)
SWIFT_{it}	0.001	0.0013
	(0.017)	(0.017)
SWIFT_{it-1}	–0.0102	–0.0107
	(0.02)	(0.02)
SWIFT_{it-2}	0.025	0.025
	(0.0158)	(0.0158)
SWIFT_{it-3}	–0.0053	–0.0054
	(0.0132)	(0.0132)
SWIFT_{it-4}	0.0264**	0.0264**
	(0.0112)	(0.0112)
SWIFT_{it-5}	0.0023	0.0023
	(0.0108)	(0.0109)
SWIFT_{it-6}	0.006	0.0061
	(0.011)	(0.011)
SWIFT_{it-7}	0.0106	0.0108
	(0.0103)	(0.0104)
SWIFT_{it-8}	0.0033	0.0034
	(0.0089)	(0.0089)
SWIFT_{it-9}	0.0176**	0.0183**
	(0.0076)	(0.0076)
Sum of coefficients	0.0765	0.0776
Mean of Dependent variable	0.1517	0.1517
Significance of the sum of SWIFT coef. (Prob>F)	0.0011	0.0009
Joint significance of SWIFT coef. (Prob>F)	0.0027	0.0020
Firm fixed effects	Yes	Yes
Number of firms	5615	5615
Number of obs.	29970	29970
R^2	0.6730	0.6735

Notes: *significant at 10%, **significant at 5%, ***significant at 1%. Standard errors in brackets are clustered by firm. All equations include a full set of country and year dummies. The time period is 1998-2005. The Network Effect variable is the aggregate number of SWIFT adopters by country *j* and per year *t* from 1977-2006. The Global stock variable is the accumulated number of SWIFT adopters globally per annum. Global stock * SWIFT_{it} is the interaction between Global stock and the adoption dummy SWIFT_{it}.

Despite the challenges, we can say that network effects were significant to some degree for every firm that adopts SWIFT. In other words, every time a firm adopts SWIFT, other firms increase their profit margin. Taken with our other findings, it seems clear that over time firms experience more than the straight forward replacement of one technology (telex) with another (SWIFT). 'Over time' is the key phrase here because we show that network effects are not some singular force of nature but rather that when network innovations become industry standards their sustainability depends upon a continued capacity to produce value for their members.

Returning to our findings about small firms above, the qualitative data that we gathered is in line with evidence from Iacovou et al. (1995) who found that the primary reason for EDI adoption across small businesses is external pressure from trading partners (especially larger institutions) seeking to reduce ongoing operating costs with counterparties (Kuan and Chau, 2001). As one of the original SWIFT implementation team put it, "If you were not on SWIFT but, you know, 25 other banks were, you were going to lose the business, because the other banks who were 'on' are not going to go back to sending telexes." Complying with such pressure may have brought initial difficulties for small banks but over time they benefit from access to a wider range of potential clients with whom they can securely transact.

We close our exploration of innovation adoption and network effects by posing a question for further research: does our study of SWIFT adoption suggest (following Bonardi and Durrand 2003) that network effects can be managed? As one interviewee said when asked about the active on-boarding of small bank members during the early years of SWIFT adoption: "In general, during the development period, the biggest support came from the small-to-medium size banks who always have been the pro SWIFT…If we had created a SWIFT banking community and a non-SWIFT banking community, the SWIFT banking community would have suffered as much as the non-SWIFT banking community…I mean it's like making a road only for BMW's, it doesn't fit, the philosophy is wrong." Do our findings about small firms and network effects point to the possibility that relational governance has the potential to influence how adoption benefits evolve over time?

6. Conclusion

In this paper, we focus on the impact of ICT adoption on the performance of firms in the financial services sector using an original dataset from SWIFT, one of the first and probably the most widely used network technologies in the banking world. SWIFT has been part of the core financial infrastructure for over 40 years; it provides global information processing services, transmits more than 20 million transaction messages a day, and effectively serves as the world's most reliable third party network. Yet for most of its history it has 'flown under the radar'. Most people will have a SWIFT code in the corner of their bank account statement and many will have used it when making an international funds transfer but few know anything about its founding, development, operations or impact.

Using an uncommonly rich longitudinal panel of data on 6,848 banks in 29 countries in Europe and North America we construct long lags and investigate the dynamics characterizing the effect of SWIFT adoption on firm performance. We provide robust evidence that SWIFT adoption has a positive and significant association with firm performance even after controlling for many factors, including firm fixed effects. Our main results show that the returns from SWIFT can take up to ten years to be fully realised. As expected for most technology investments, we observe an extremely weak or negative result within the first few years of the adoption of SWIFT. This is consistent with previous findings that demonstrate that technological and organizational changes take time to implement and realise the benefits. Additionally, the profitability effects of SWIFT derive mainly from an increase in sales, not just a fall in long-term operating expenses (due to fewer employees per unit of capital). We believe that the most interesting result to emerge from our analysis – beyond the positive impact on performance (measured in terms of profit margin) and evidence of network effects – is the realisation that smaller firms benefit from relatively higher returns than the larger ones.

There are many outstanding issues and areas for further research here which will intrigue scholars of ICT adoption, particularly those specialising in financial services. Using additional data from an in-depth field study, we explore potential generative mechanisms that may be implicated in the benefits of adoption. We point to the 'domino' effect as SWIFT network innovations are enfolded into "productive process advances" (Fuentelsaz et al., 2009, p.1174), the value that access to a community of practices has for SME's, and SWIFT's role as a non-state actor working with legislators to write the legal terms for international business when gaps between national jurisdictions were discovered. Aware that scholars are interested in the specific characteristics of network innovations in order to understand their distinctive strategic importance (Katz and Shapiro, 1985; Farrell and Saloner, 1985), we note that SWIFT is an industry cooperative. In other words, SWIFT was funded and developed through voluntary action rather than being created by regulatory instruction and as a mutual it rebates profit to its members each year. This leads us to ask not only whether SWIFT membership provides (especially small firms) access with a mode of governance, audit and accountability that would otherwise be out of reach but also whether this points to the possibility of using relational governance to manage network effects. Finally, but not insignificantly, we overturn a number of assumptions about SWIFT in the practitioner community. We would suggest that it is important for financial services organizations not only to ‘know your customer’ but also to ‘know thyself’. Our findings reinforce the need to explore, substantiate and then pursue evidence-based strategy when making ICT investments in the evolving financial services technoscape.

Appendix A. Definitions, descriptive statistics, and selected results using alternative specifications

Table A1

SWIFT adoption and firm performance.

	(1)	(2)	(3)
Estimation method	OLS	OLS	OLS
Sample	All firms		
Dependent variable	ROA_{it}	ROE_{it}	C/I_{it}
$SWIFT_{it}$	0.0343	–0.5141	0.7632
	(0.0854)	(0.742)	(3.9223)
$SWIFT_{it-1}$	–0.1119	–0.8495	–1.3863
	(0.0971)	(0.7396)	(4.7286)
$SWIFT_{it-2}$	0.0223	0.5512	–5.6947
	(0.085)	(0.6489)	(4.633)
$SWIFT_{it-3}$	0.023	0.2414	–0.51
	(0.0782)	(0.6768)	(4.0055)
$SWIFT_{it-4}$	0.139*	0.9697	–3.0426
	(0.0737)	(0.611)	(3.0944)
$SWIFT_{it-5}$	0.0035	0.1633	2.1921
	(0.0706)	(0.6274)	(2.518)
$SWIFT_{it-6}$	0.0418	–0.1904	–1.6541
	(0.0643)	(0.5242)	(3.178)
$SWIFT_{it-7}$	0.0445	0.5961	–0.7196
	(0.0618)	(0.5321)	(1.8542)
$SWIFT_{it-8}$	0.0055	–0.3878	–2.2
	(0.0621)	(0.5107)	(1.3238)
$SWIFT_{it-9}$	0.0236	0.5366	–1.6793
	(0.0619)	(0.5092)	(1.4007)
Sum of coefficients	0.2257	1.1165	–13.9313
Mean of Dependent variable	0.7751	8.3774	68.149
Significance of the sum of SWIFT coef. (Prob>F)	0.1238	0.3507	0.0023
Joint significance of SWIFT coef. (Prob>F)	0.4117	0.3680	0.1101
Firm fixed effects	Yes	Yes	Yes
Number of firms	6754	6739	6624
Number of obs.	39661	39602	38785
R^2	0.6258	0.6052	0.5830

Notes: *significant at 10%, **significant at 5%, ***significant at 1%. Standard errors in brackets are clustered by firm. All equations include a full set of country and year dummies. The dependent variable in column 1 is Return on Assets, in column 2 Return on Equity, and in column 3 Cost to Income Ratio. The time period is 1998-2005.

Table A2
Definition of measures.

Measures	Ratio	Description
Performance		
Profit Margin	Pretax Income/Sales (PCM)	Increase in PCM indicates higher Profits generated by Sales
Return on Assets	Pretax Income/Assets (ROA)	Increase in ROA indicates higher Profits generated by Assets
Return on Equity	Pretax Income/Equity (ROE)	Increase in ROE indicates higher Profits generated by Equity
Efficiency		
Cost to Income	Operating Expenses (OPEX)/Operating Income	Efficiency Inverse Ratio: the higher the ratio, the worse the perceived efficiency

Notes: This table includes the definitions of the main ratios that we use in our analysis. We have categorized them into two distinct groups: Performance measures and Efficiency measures. Performance ratios measure the returns of SWIFT, whereas, efficiency ratios measure the costs behaviour of the banks relative to their Profits and Assets. Efficiency ratios are both inverse ratios.

Table A3
Descriptive statistics on SWIFT adopters.

	Mean Size (Total Assets in millions$)	Mean Profit Margin	Number of Adopters	Number of Firms
SWIFT adopters				
early 1977-1999	22200	0.1648	1108	
late 2000-2006	9459.479	0.134	263	
In our sample				
1998-2005	10100	0.1352	329	
1998-1999	9519.264	0.1546	98	
2000-2005	10400	0.1264	231	
Non-adopters				
whole sample	5945.563	0.1496		5159

Notes: Sample includes 6,848 firms in 29 countries, from 1998 to 2005; millions$ = Millions of US Dollars. Figures reported here are the ones used in the regressions in table A4. In total 6,530 firms are being utilized by the regressions from which 1,371 are SWIFT adopters (1,108 + 263), and 5,159 are non-adopters. We can observe that early adopters that adopted SWIFT before 2000 are bigger in size than firms that adopted SWIFT after 2000. The smallest firms in our sample are the ones that haven't adopted SWIFT yet, however, these are not necessarily the least profitable in terms of Profit Margins.

Table A4
SWIFT adoption and firm performance – robustness checks.

	(1)	(2)	(3)	(4)
Estimation method	OLS	OLS	OLS	OLS
Sample	All firms		SWIFT adopters	
Dependent variable	Π/S_{it}	Π/S_{it}	Π/S_{it}	Π/S_{it}
$\log\left(\frac{Assets}{Employees}\right)_{it}$	0.0404***	–	0.0509***	–
	(0.0084)		(0.0098)	
$\log(Assets)_{it}$	–	0.0119*	–	0.0133
		(0.0066)		(0.0098)
$SWIFT_{it}$	0.0014	–0.0023	–0.0012	–0.0052
	(0.0168)	(0.0153)	(0.017)	(0.0155)
$SWIFT_{it-1}$	–0.0015	–0.0054	–0.0106	–0.0052
	(0.0191)	(0.0178)	(0.02)	(0.0177)
$SWIFT_{it-2}$	0.0172	0.0133	0.0227	0.012
	(0.0157)	(0.0141)	(0.0158)	(0.0141)
$SWIFT_{it-3}$	–0.0073	0.0072	–0.0069	0.0055
	(0.0125)	(0.0121)	(0.0133)	(0.0122)
$SWIFT_{it-4}$	0.0206*	0.0184*	0.025**	0.017
	(0.0112)	(0.0104)	(0.0112)	(0.0105)
$SWIFT_{it-5}$	0.0015	0.001	0.0015	0.0009
	(0.01)	(0.0106)	(0.0109)	(0.0106)
$SWIFT_{it-6}$	0.0032	0.0028	0.0056	0.0021
	(0.0095)	(0.0103)	(0.011)	(0.0104)
$SWIFT_{it-7}$	0.0027	0.0096	0.0086	0.0081
	(0.0098)	(0.0096)	(0.0104)	(0.0097)
$SWIFT_{it-8}$	0.0009	0.0098	0.0028	0.0093
	(0.009)	(0.0093)	(0.0091)	(0.0093)
$SWIFT_{it-9}$	0.0167**	0.013	0.0128	0.0107
	(0.0077)	(0.0083)	(0.0079)	(0.0086)
Sum of coefficients	0.0555	0.0672	0.0604	0.0554
Mean of Dependent variable	0.1522	0.1517	0.1593	0.1584
Significance of the sum of SWIFT coef. (Prob>F)	0.0155	0.0020	0.0274	0.0296
Joint significance of SWIFT coef. (Prob>F)	0.2009	0.0299	0.1387	0.3271
Firm fixed effects	Yes	Yes	Yes	Yes
Number of firms	5615	6727	1371	1642
Number of obs.	29970	39393	7320	9357
R^2	0.6919	0.6778	0.6337	0.6271

Notes: *significant at 10%, **significant at 5%, ***significant at 1%. In this table we perform some robustness check on the relationship between SWIFT adoption and firm performance. Standard errors in brackets are robust to heteroskedacity and autocorrelation of unknown form and are clustered by firm. All equations include a full set of country and year dummies and in column 1 their interaction. In all columns we include a 9-year lag structure to test the long-run effect of SWIFT on firm performance. We test our data using the whole sample (col. 1 and 2), and SWIFT adopters sample (col. 3 and 4).

Table A5
SWIFT adoption and firm performance – robustness checks.

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation method	OLS	OLS	OLS	OLS	OLS	OLS
Sample	Commercial Banks		Non-Commercial Banks		Selection of Banks	
Dependent variable	Π/S_{it}	Π/S_{it}	Π/S_{it}	Π/S_{it}	Π/S_{it}	Π/S_{it}
$\log\left(\frac{Assets}{Employees}\right)_{it}$	0.0395*** (0.013)	–	0.0319*** (0.0088)	–	0.0391*** (0.009)	–
$\log(Assets)_{it}$	–	0.0137 (0.01)	–	0.0098 (0.0089)	–	0.016** (0.0076)
$SWIFT_{it}$	0.0005 (0.0261)	–0.0076 (0.0235)	–0.001 (0.0207)	–0.0004 (0.0179)	–0.0086 (0.0209)	–0.0103 (0.0184)
$SWIFT_{it-1}$	–0.0052 (0.0255)	–0.0041 (0.0234)	–0.0194 (0.0332)	–0.0085 (0.0277)	–0.0205 (0.0241)	–0.0166 (0.0209)
$SWIFT_{it-2}$	0.0209 (0.0175)	0.0116 (0.0166)	0.0273 (0.0308)	0.0108 (0.0255)	0.0287 (0.0181)	0.0163 (0.016)
$SWIFT_{it-3}$	–0.0043 (0.0165)	0.012 (0.0158)	–0.0141 (0.0208)	–0.0089 (0.0172)	–0.0096 (0.0146)	0.0072 (0.0136)
$SWIFT_{it-4}$	0.0319** (0.0137)	0.0235** (0.0128)	0.0055 (0.0181)	0.0005 (0.018)	0.0327*** (0.0117)	0.0241** (0.0112)
$SWIFT_{it-5}$	0.0000 (0.0137)	–0.0018 (0.0134)	0.0018 (0.0156)	0.0017 (0.0169)	–0.0013 (0.0117)	–0.0005 (0.0114)
$SWIFT_{it-6}$	0.0116 (0.0127)	0.0112 (0.0131)	–0.014 (0.0211)	–0.0193 (0.0164)	0.0063 (0.0111)	0.0057 (0.0108)
$SWIFT_{it-7}$	0.0191 (0.0117)	0.0122 (0.0113)	–0.0171 (0.0213)	–0.0037 (0.0181)	0.0087 (0.0105)	0.0053 (0.0099)
$SWIFT_{it-8}$	–0.0014 (0.0107)	0.005 (0.0109)	0.0044 (0.0161)	0.0125 (0.0176)	–0.0004 (0.0094)	0.006 (0.0093)
$SWIFT_{it-9}$	0.0171* (0.0092)	0.0175* (0.0098)	0.0041 (0.0139)	–0.0059 (0.0155)	0.0153* (0.0082)	0.0195** (0.0086)
Sum of coefficients	0.0902	0.0796	–0.0225	–0.0211	0.0513	0.0567
Mean of Dependent variable	0.1717	0.1629	0.1445	0.1474	0.1601	0.1554
Significance of the sum of SWIFT coef. (Prob>F)	0.0045	0.0085	0.5608	0.5222	0.0507	0.0193
Joint significance of SWIFT coef. (Prob>F)	0.0059	0.0460	0.9422	0.9811	0.0110	0.0170
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of firms	1565	1910	4050	4817	3903	4659
Number of obs.	8516	10840	21454	28553	21272	27516
R^2	0.6552	0.6452	0.6829	0.6165	0.6625	0.6575

Notes: *significant at 10%, **significant at 5%, ***significant at 1%. In this table we perform some robustness check on the relationship between SWIFT adoption and firm performance. Standard errors in brackets are robust to heteroskedacity and autocorrelation of unknown form and are clustered by firm. All equations include a full set of country and year dummies and in column 1 their interaction. In all columns we include a 9-year lag structure to test the long-run effect of SWIFT on firm performance. We test our data using Commercial Banks sample (col. 1 and 2), Non-

Commercial Banks and other financial institutions sample (col. 3 and 4), and a selection of Financial Institutions[1] (col. 5 and 6).

Table A6

SWIFT adoption and firm performance – robustness checks.

	(1)	(2)	(3)	(4)
Estimation method	OLS	OLS	OLS	OLS
Sample	All firms		All firms	
Dependent variable	Π/S_{it}	Π/S_{it}	Π/S_{it}	Π/S_{it}
$\log\left(\frac{Assets}{Employees}\right)_{it}$	0.023** (0.009)	–	–	–
$\log\left(\frac{Assets}{Employees}\right)_{it-1}$	0.0149** (0.0073)	–	0.0247*** (0.0076)	–
$\log(\text{Assets})_{it}$	–	–0.0008 (0.009)	–	–
$\log(\text{Assets})_{it-1}$	–	0.0011 (0.0073)	–	0.0007 (0.0073)
$SWIFT_{it}$	0.0113 (0.0214)	0.008 (0.0171)	0.0115 (0.0214)	0.0079 (0.0171)
$SWIFT_{it-1}$	–0.025 (0.0243)	–0.016 (0.019)	–0.0274 (0.024)	–0.0161 (0.019)
$SWIFT_{it-2}$	0.0127 (0.0199)	0.009 (0.0164)	0.016 (0.0191)	0.0091 (0.0164)
$SWIFT_{it-3}$	0.004 (0.0143)	0.0093 (0.0135)	0.0028 (0.014)	0.0093 (0.0135)
$SWIFT_{it-4}$	0.0238** (0.0107)	0.0191* (0.011)	0.0172 (0.0113)	0.019* (0.011)
$SWIFT_{it-5}$	0.0053 (0.0104)	0.0061 (0.0106)	0.0117 (0.0109)	0.0061 (0.0105)
$SWIFT_{it-6}$	–0.0029 (0.0109)	–0.0081 (0.0105)	–0.0074 (0.0106)	0.0081 (0.0105)
$SWIFT_{it-7}$	0.0078 (0.0109)	0.0086 (0.0098)	0.0115 (0.0107)	–0.0085 (0.0098)
$SWIFT_{it-8}$	–0.0043 (0.0092)	0.0012 (0.009)	–0.005 (0.0093)	0.0012 (0.009)
$SWIFT_{it-9}$	0.0144 (0.0088)	0.0087 (0.0095)	0.0135 (0.0087)	0.0087 (0.095)
Sum of coefficients	0.0471	0.0458	0.0443	0.0457
Mean of Dependent variable	0.1582	0.1545	0.1554	0.1545
Significance of the sum of SWIFT coef. (Prob>F)	0.0859	0.0652	0.1134	0.065
Joint significance of SWIFT coef. (Prob>F)	0.1023	0.3932	0.1338	0.391
Firm fixed effects	Yes	Yes	Yes	Yes
Number of firms	5061	6504	5253	6504
Number of obs.	23347	32554	24746	32554
R^2	0.7054	0.6938	0.6956	0.6938

Notes: *significant at 10%, **significant at 5%, ***significant at 1%. In this table we perform some robustness check on the relationship between SWIFT adoption and firm performance. Standard errors in brackets are robust to heteroskedacity and autocorrelation of unknown form and are clustered by firm.

Table A7
Bank specialisations in the sample.

Bank Specialisations	Number of Firms	SWIFT Adopters (firms)	SWIFT Non-adopters (firms)
Bank Holding & Holding Companies[1]	717	38	679
Central Banks	28	27	1
Commercial Banks[1]	1927	1034	893
Cooperative Banks[1]	1620	87	1533
Investment Banks /Securities Houses[1]	498	226	272
Islamic Banks	1	1	0
Medium & Long Term Credit Banks	48	18	30
Multi-lateral Governmental Banks	2	1	1
Non-banking Credit Institutions	463	52	411
Real Estate /Mortgage Banks	189	31	158
Savings Banks	1280	138	1142
Specialised Governmental Credit Institutions	75	36	39
	6848	**1689**	**5159**

Notes: Sample includes 6,848 firms (205,440 observations) in 29 countries, from 1977 to 2006.
[1]These banks are included in the sample for columns (5) and (6) in Table A5.

Table A8
SWIFT early and late adopters.

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	OLS	OLS	OLS	OLS
Sample	All firms			Years ≤2001	Years ≥2002
Type of SWIFT adopters	Early	Early	Late	All	All
Dependent variable	Π/S_{it}	Π/S_{it}	Π/S_{it}	Π/S_{it}	Π/S_{it}
$\log\left(\frac{Assets}{Employees}\right)_{it}$	0.029***	0.0297***	0.0351***	0.0283***	0.044***
	(0.0078)	(0.0078)	(0.01)	(0.0098)	(0.0169)
$SWIFT_{it}$	–0.0096	–0.0105	–0.0014	–0.0046	0.0148
	(0.0245)	(0.0245)	(0.0194)	(0.0258)	(0.0351)
$SWIFT_{it-1}$	–0.0069	–0.0078	–0.0206	–0.0047	–0.0158
	(0.0247)	(0.0247)	(0.0272)	(0.0192)	(0.0425)
$SWIFT_{it-2}$	–0.0024	–0.0037	0.0439*	0.0024	0.0592*
	(0.0205)	(0.0205)	(0.023)	(0.0202)	(0.0345)
$SWIFT_{it-3}$	–0.0155	–0.017	0.0134	0.0071	0.0075
	(0.0185)	(0.0185)	(0.0155)	(0.016)	(0.0184)
$SWIFT_{it-4}$	0.0278*	0.0269*	0.035*	0.0149	0.0692***
	(0.0146)	(0.0146)	(0.0181)	(0.0181)	(0.0214)
$SWIFT_{it-5}$	0.0042	0.0172	0.0102	0.0339*	–0.0025
	(0.0121)	(0.0107)	(0.0213)	(0.0187)	(0.0166)
$SWIFT_{it-6}$	0.0084			0.0143	0.0018
	(0.0112)			(0.0186)	(0.0198)
$SWIFT_{it-7}$	0.0093			0.022	0.0033
	(0.0104)			(0.0206)	(0.0138)
$SWIFT_{it-8}$	0.0024			0.0291	–0.0082
	(0.0089)			(0.0202)	(0.0097)
$SWIFT_{it-9}$	0.0157**			0.0073	0.0072
	(0.0076)			(0.0155)	(0.0131)
Sum of coefficients	0.0335	0.005	0.0806	0.1216	0.1366
Mean of Dependent variable	0.1531	0.1386	0.1491	0.1406	0.1616
Significance of the sum of SWIFT coef. (Prob>F)	0.4066	0.8986	0.0087	0.0122	0.0414
Joint significance of SWIFT coef. (Prob>F)	0.0405	0.0915	0.0647	0.2090	0.1089
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Number of firms	5352	5352	4507	4233	5260
Number of obs.	28654	28654	23966	13354	16616
R^2	0.6729	0.6725	0.6903	0.7725	0.7775

Notes: *significant at 10%, **significant at 5%, ***significant at 1%. In this table we investigate the SWIFT-effects in two separate sub-samples: early SWIFT adopters (from 1977 to 1999) in columns 1 and 2, and late SWIFT adopters (from 2000 to 2006) in column 3. In columns 4 and 5 we run two additional regressions using a sample of all the observations prior 2002 and after 2002 respectively. Standard errors in brackets are robust to heteroskedacity and autocorrelation of unknown form and are clustered by firm. All equations include a full set of country and year dummies.

Table A9
Small and large firms in terciles.

	(1)	(2)	(3)
Estimation method	OLS	OLS	OLS
Dependent variable		Π/S_{it}	
Firm size	Small Q1	Medium Q2	Large Q3
$\log\left(\frac{Assets}{Employees}\right)_{it}$	0.0750***	0.0285***	0.0239**
	(0.0200)	(0.0086)	(0.0118)
$SWIFT_{it}$	–0.0291	0.0048	0.0204
	(0.0348)	(0.0312)	(0.0228)
$SWIFT_{it-1}$	–0.0174	0.0284	–0.0305
	(0.0403)	(0.0417)	(0.0258)
$SWIFT_{it-2}$	0.0605	0.0121	0.0003
	(0.0373)	(0.0292)	(0.0173)
$SWIFT_{it-3}$	0.0102	–0.0129	–0.0159
	(0.0314)	(0.0215)	(0.0165)
$SWIFT_{it-4}$	0.0684***	0.0096	0.0179
	(0.0239)	(0.0178)	(0.0162)
$SWIFT_{it-5}$	0.0023	0.0147	–0.0123
	(0.0244)	(0.0170)	(0.0158)
$SWIFT_{it-6}$	–0.0149	0.0065	0.0188
	(0.0299)	(0.0151)	(0.0161)
$SWIFT_{it-7}$	0.0059	0.0393**	–0.0183
	(0.0268)	(0.0155)	(0.0152)
$SWIFT_{it-8}$	0.0042	–0.0134	0.0165
	(0.0257)	(0.0138)	(0.0103)
$SWIFT_{it-9}$	0.0259**	–0.0018	0.0173
	(0.0214)	(0.0109)	(0.0107)
Sum of coefficients	0.2069	0.0711	0.0142
Mean of Dependent variable	0.1400	0.1475	0.1682
Significance of the sum of SWIFT coef. (Prob>F)	0.0090	0.0442	0.6731
Joint significance of SWIFT coef. (Prob>F)	0.0103	0.0436	0.6071
Firm fixed effects	Yes	Yes	Yes
Number of firms	1827	1982	1807
Number of obs.	8464	11672	9842
R^2	0.6473	0.6866	0.6936

Notes: *significant at 10%, **significant at 5%, ***significant at 1%. In this table we split our data in terciles between “Small”, “Medium” and “Large” firms. We use a mean of the Total Assets of each firm as size indicator to make the categorisation. The time period of our sample is 1998-2005 (eight years). Standard errors in brackets are robust to heteroskedacity and autocorrelation of unknown form and are clustered by firm. All equations include a full set of country and year dummies.

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