Alistair Milne

What's in it for us? Network effects and bank payment innovation

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Bank of Finland Research
Discussion Papers
16 • 2005

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The views expressed are those of the author and do not necessarily reflect the views of the Bank of Finland.

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I am grateful for the comments of Charlie Kahn, colleagues at the Bank of Finland, and an anonymous referee and for research assistance from Emmi Martikainen.

http://www.bof.fi

ISBN 952-462-223-8
ISSN 0785-3572
(print)

ISBN 952-462-224-6
ISSN 1456-6184
(online)

Multiprint Oy
Helsinki 2005

What's in it for us? Network effects and bank payment innovation

Bank of Finland Research
Discussion Papers 16/2005

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Abstract

The developed world exhibits substantial but poorly understood differences in the efficiency and quality of low-value payment services. This paper compares payments arrangements in the UK, Norway, Sweden, and Finland, and discusses the impact of network effects on incentives to adopt new payments technology. A model is presented, in which private benefits for investment in shared inter-bank payments infrastructure are weak. In contrast, due to 'account externalities', there are strong incentives for investment in intra-bank payment systems. These two features, distinguishing bank payments from other network industries, can help explain some of the observed cross country differences in payments arrangements.

Key words: network effects, incentives, payment technology, externalities

JEL classification numbers: G21, L14

Verkostovaikutukset ja pankkien maksujärjestelmäinnovaatiot – miten me hyödymme niistä?

Suomen Pankin tutkimus
Keskustelualoitteita 16/2005

Alistair Milne
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Pienten maksujen maksupalvelujen laadussa ja tehokkuudessa on merkittäviä ja puutteellisesti ymmärrettyjä eroja kehittyneiden kansantalouksien välillä. Tässä tutkimuksessa verrataan Ison-Britannian, Norjan, Ruotsin ja Suomen maksujärjestelmiä ja pohditaan, miten verkostovaikutukset mahdollisesti muuttavat pankkien kannustimia ottaa käyttöön uusi maksutekniikka. Tarkastelujen tukena käytetyssä teoreettisessa mallissa pankkien hyödyt investoinneista yhteiseen pankkien välisten maksujen infrastruktuuriin ovat vähäisiä. ”Pankkitilijärjestelmän ulkoisvaikutukset” sen sijaan kannustavat pankkeja voimakkaasti investoimaan omiin, sisäisiin maksujärjestelmiinsä. Nämä kaksi ominaisuutta, jotka erottavat pankkimaksutoiminnan muista verkostotoimialoista, auttavat selittämään havaittuja maksujärjestelmien eroja maiden välillä.

Avainsanat: verkostovaikutukset, kannustimet, maksutekniikka, ulkoisvaikutukset

JEL-luokittelu: G21, L14

Contents

Abstract ... 3
Tiivistelmä (abstract in finnish) ... 4

1 Introduction ... 7

2 Cross country comparisons ... 8

3 Determinants of innovation in bank payments systems ... 11

4 The adoption of payment innovations ... 15
4.1 Banking services and bank pricing ... 17
4.2 Incentives for shared technology adoption ... 18
4.2.1 Reducing shared fixed costs ... 18
4.2.2 Shared marginal cost reduction or quality improvements ... 19
4.3 Investment with account externalities ... 19
4.3.1 Market share and equilibrium pricing ... 20
4.3.2 Incentives for investment ... 21

5 Policy implications and conclusions ... 22

References ... 25

1 Introduction

Compared to other information technology industries such as personal computers, cell phones, or game consoles, the payments industry exhibits low rates of technological adoption and diffusion. Bank payments are information services, the provision of secure transfer of credits and debits between accounts requiring the verification, manipulation and transfer of information. There is no technical reason why electronic payments cannot be offered as rapidly and at the same low cost as say the secure transfer of files across the internet. Why then do payments technologies often lag so far behind?

This is an economically significant question. As currently delivered in many countries, payments services are resource intensive, absorbing a surprisingly large share of national output. Humphrey, Pulley, and Vesala (2001) estimate the total cost of payments activities in the US at about 3% of GNP. An unpublished survey in the mid-1990s by APACs similarly found the total costs to the UK banking industry of providing payments serviceswas also around 3% of GNP. These figures are some years old, but payments technologies have not since changed in any fundamental way in either country, so updated figures are unlikely to be very much lower.[1]

Widespread use of electronic payments can achieve much lower costs. Greswig and Owre (2003) report that the 2001 expenditure by Norwegian banks providing payments in Norway were some 5.9 billion Norwegian Kroner (NOK), ie around 0.4% of the 2001 GDP. Shift to the most efficient payment technologies and exploitation of economies of scale could yield as low or even lower costs of payment provision in other countries. Moreover, if anything, this comparison understates the potential resource savings from technological innovation in payments, since it excludes the further large potential savings from the automation of invoicing and payment reconciliation within large companies and public organisations ('straight through processing').

There is also considerable variability in the quality of payment services. For example in some countries, including those in Scandinavia, it is both easy and relatively inexpensive to transfer payments within a single working day from one bank account to another. Elsewhere an equivalent transaction can take three working days or more. Again these are economically significant differences.[2]

This paper addresses the cross-country variation in the rate of innovation in payments services in some countries, focussing on network externalities and the incentives for banks to invest in improved quality of payment service. Section 2 compares the use of electronic payment methods and speed of payment operation in the UK, the US, Norway, Sweden, and Finland; documenting the great contrast in both the costs and quality of payments provision in the UK, the US, and in Scandinavia. Section 3 discusses the presence of network externalities in payment provision and the implications for incentives to introduce innovations in payment services to lower costs and improving

[1] For recent assessments see Board of Governors of the Federal Reserve System (2002), OFT Payments Task Force (2005).

[2] See Milne and Tang (2005) for a discussion of the economic benefits of faster payments clearing

service quality. This section also reviews some empirical literature. The key point made here is that, unlike in many other network and information industries, payments infrastructures are to an important degree shared by all or many banks. Adoption of innovation therefore requires that all banks move together or, at a minimum, that many banks co-operate.

Section 4 presents a stylised model of payments innovation, framed so as to capture the two principal network effects identified in the discussion of Section 3, a negative exterality associated with investment in shared infrastructure, and a positive account externality associated with investment in individual bank payment systems. These two characteristics – shared infrastructure and account externalities – are what make bank payments different from other network industries. As the number of banks increases the negative externality becomes more important and the positive externality less important. This suggests one potential explanation of why payments innovation has typically gone furthest in smaller economies with more cocentrated banking systems.

The model is limited, particularly because it makes no allowance for co-ordination problems between banks, but doing so would only strengthen the prediction that technology adoption will be slowest in more fragmented systems. The concluding Section 5 discusses this and other limitations and provides a brief policy discussion, noting implications for the design of the shared infrastructure – the case of Finland where this infrastructure is rather minimal is of particular interest – and any possible public interventions in payments arrangements.

2 Cross country comparisons

This section compares the provision of low value payments services in the UK, the USA, and three Scandinavian countries (Norway, Sweden, and Finland) comparing in particular the quality of payments services, as measured by indicators such as the time taken for clearing and settlement.

The following table summarises their use of different payments instruments.

Table 1. **Payment activities in UK, Scandinavia and USA (2002)**

	UK	Norway	Sweden	Finland	USA
ATM withdrawals[1]	38	23	36	46	37
Card transactions[3]	80	135	59	84	116
Cheque usage[2]	21	0	0	0	49
Credit transfers[2]	18	38	39	49	5
(of which paper)[2]	0	10	na	na	na
Direct debits[2]	20	3	10	5	4
Payment cards[2]	41	58	51	45	43

Notes: [1]per capita. [2]% of total non-cash payments.
[3]debit and credit cards combined, transactions per capita.
Sources: ECB blue book, national information.

As Table 1 indicates, there is a pronounced difference in the use of paper-based instruments. While in the UK and USA cheque transactions still accounted for a large proportion of non-cash low value payments, cheque usage has virtually disappeared in all three Scandinavian countries. As the available figures for Norway indicate, even if one includes paper based giro-credit transfers, the use of paper based payment instruments in Scandinavia is substantially lower than in either the UK or US.

Norway has gone furthest in the substitution of card payments for cash (it is common to use debit or credit cards to pay for small expenditures such as bus fares); reflected in the relatively low number of ATM withdrawals per inhabitant and large number of card payments at point of sale.

Table 2 compares various aspects of the service quality offered by their major clearing systems for credit transfers (used for 'bulk credit files' such as salary and pension payments as well as for individual credit transfer instructions used to settle invoices and transfer money between accounts). In reading this table, it should be appreciated that the institutional arrangement in the USA are very different from those of any other country. In the USA there are a number of competing providers of 'ACH' (Automated Clearing House) services including the American Clearing House Association, Federal Reserve, Electronic Payments Network, and Visa. These ACHs compete with each other for bank customers. The different clearing houses are then linked together in a National ACH network to provide nationwide coverage.

In most other countries bank credit clearing services are dominated by a single provider, most often industry owned and operated on a mutual not-for-profit basis or government owned provider. A major part of the payments infrastructure is thus often industry owned and run, raising potential concerns about the incentives to reduce costs or improve the quality of payment services.

Table 2. **Features of the credit clearings in UK, Scandinavia and USA**

	UK	Norway	Sweden	Finland	USA
Principal Credit Clearing	BACS	NICS	BGC	Bilateral	linked ACHs
Clearing time	T+3	T or T+1	T or T+1	T or T+1	T+2
Express clearing?	via RTGS	via RTGS	No	via POPS	via Fedwire
Information limits per field	18 characters	none	none	none	na

Notes: Information for UK and Scandinavia taken from personal interviews (described in greater detail in Milne and Tang (2005)). Information for the USA from www.nationalach.com. Information limit for UK taken from www.bacs.co.uk

Two main points can be highlighted from this table. First the very slow period taken for clearing and settlement in UK, relative to the three Scandinavian countries, where the standard service is same afternoon clearing and settlement for electronically submitted instructions (typically internet) by around the noon or a little later (the precise cut off varies from system to system); and for overnight clearing and settlement for such items submitted in the afternoon or evening. ACH clearing times in the USA are also slower than in Scandinavia.

The second main point is that, in comparison to the UK, there is no effective constraints on information accompanying credit transfers in these three Scandinavian countries, because of their use of SWIFT based messaging standards. This difference continues to limit the ability of UK corporates to make use of automated systems for invoicing and payments and for payments reconciliation.

The table also indicates the availability of supplementary real time or quasi real-time express clearing. In Finland there is a special interbank 'POPS' system designed to provide bank customers with immediate payment transfers. This is relatively expensive but is still quite frequently used especially for business to business transfers. In the UK, Norway, and the USA private customers use the interbank RTGS system for such express payments, but this also attracts a relatvely high charge.

Table 3. **Further economic and banking indicators**

	UK	Norway	Sweden	Finland	USA
GDP pc, US $, PPP	26 234	37 857	26 911	26 291	35 424
Number of bank transaction accounts[1]	143 700	11 534[3]	na	9 951	na
Market share of top 5 banks[2]	30	50	63	79	na
Number of banks	447	145	128	344	14 120

[1]thousands. [2]assets as % of total assets [3]number for year 2000.
Sources: ECB Blue Book, BIS Red Book, national information, IMF. All numbers are for year 2002 unless otherwise indicated.

Table 3 provides some economic and banking indicators for these five countries. Measured at purchasing power parity, Norway and the USA enjoy rather higher GDP per capita than the other three countries. As indicated by the number of banks and of bank transaction accounts, the banking markets in Scandinavia are very much smaller than in either the UK or the USA. and their banking markets are also relatively more concentrated. The relatively concentration of their banking markets may be one reason why Scandinavian countries have adopted payments technologies more rapidly than either the UK or the USA.

Similar contrasts in payment efficiency and quality could be made between other countries; for example France and Germany, like the UK, still making a relatively large number of paper based payment instructions; New Zealand and Australia making relatively greater use of automated electronic payments. It remains unclear why the quality of payment services, as measured for example by the length of the clearing and settlement cycle, or the amount of information incorporated into a payment instruction, continue to lag so far behind in some countries relative to others; most notably in many of the larger industrial countries.

3 Determinants of innovation in bank payments systems

This section reviews the factors affecting the adoption and diffusion of technology in banking and in other information industries. The industrial organisation literature distinguishes two determinants of innovation rates:

- incentives to invest in the research and development of new technologies.
- incentives to adopt and make economically efficient use of available technologies.

These are of course related. Where there are weak incentives to adopt new technologies then there will also be weak incentives for investment in their research and development.

A substantial literature on research and development explores inter-alia the appropriate scope of patents, and the relationship between industrial structure, patentability, and the rate of innovation. This literature is however of relatively little help in understanding the implementation and diffusion of bank payments technologies. The technology is already available for increasing the efficiency and quality of bank payments. The central puzzle of bank payments is why rates of technology *adoption* vary so much from one country to another; and in particular why adoption seems to have gone so much further in smaller countries with relatively concentrated banking systems.

A classic argument for associating faster rates of innovation with greater industrial concentration is Schumpeter's doctrine of creative destruction, Schumpeter taking the position that innovation was incompatible with zero-profit perfect competition because the innovating firms would obtain at least temporary market power.[3] Subsequent debate has taken his argument further, arguing that that monopoly power may be necessary for companies to mobilise the resources to engage in research and development.[4]

While Schumpeter's argument is relevant to understanding the determinants of research and development expenditures, it does not obviously predict a positive relationship between industrial concentration and the rate of technology *adoption*. Standard theory suggests that the relationship between concentration and incentives to deploy innovations may be exactly opposite to that suggested by Schumpeter. In accepted paradigms, such as Cournot competition, innovations that reduce marginal costs lead to temporary increases in market share. Thus, while all firms including monopolies have incentives to adopt cost reducing innovations, the relative strength of this incentive is greater in competitive markets.[5]

The literature on network externalities is more relevant for understanding incentives to adopt new technologies. This literature has paid particular

[3] Schumpeter (1947).

[4] A line of argument put forward by Arrow (1962). See also the discussion of Dasgupta and Stiglitz (1980), modelling both the impact of industrial structure on R&D and the imapct of R&D on industrial structure.

[5] For a textbook illustration of this point see for example Neumann (2001), 52–54.

attention to incentives to introduce new compatibility standards. Because of switching costs, consumers or producers find it expensive to switch to new technological standards. In effect participants have invested in existing standards, both in the design of capital in place and in their stock of human capital. Costs of re-training and re-investment can discourage innovation. Slow adoption of new standards may therefore be economically efficient. But adoption of new technology also requires co-ordination, and failure to co-ordinate may delay or prevent economically efficient changes of standards (so called 'excess inertia').[6] Another potential inefficiency is that a dominant group of producers may set inefficient standards designed in such a way so as to raise the costs of new entry or the costs of other competitors.[7]

A second network externality is that arising from using a system (or platform) that is widely used by others, with a variety of implications for competition.[8] The presence of such an installed base is a further reason for potential problems of excess inertia, a lock in to inferior standard, with widely cited examples such as the success of the VHS video format over the supposedly technically superior betamax.[9] However there is disagreement about whether this is a widespread problem and it has been argued that network externalities lead sometimes to 'insufficient friction', an inefficient abandoning of existing standards.[10] Efficient or not, the emergence of standard races (PCs, audio and video media, games platforms etc), in which one proprietary design becomes dominant, suggest examples where economic incentives to develop new technological standards can be extremely powerful.

Recent work on 'two-sided platforms' has further elucidated this network externality focussing (mostly) on the pricing of the two sides of a platform, where buyers and sellers pay different participation and transaction fees, and impact of pricing on the usage of the platform.[11] Payments cards (credit and debit cards used for point of sale purchase) are a standard example of a two-sided payment platform. Here merchant charges are levied by card payment providers on retailers and and an interchange fee paid by merchant acquirers to card issuers. These charging arrangements can have a critical impact on the take-up of the platform, especially when there is competition between platforms. Low usage volumes and lack of participation may undermine the viability of the platform, hence deterring innovation. In the case of credit cards, the use of the interchange fee to subsidise card issue and hence encourage card holding seems to have been a critical factor in overcoming

[6] Farrell and Saloner (1985).

[7] An example of the strategy of raising rival's costs, identified by Salop and Scheffman (1983).

[8] Katz and Shapiro (1985) analyse the impact of 'installed base' on the choice between compatible and incompatibile standards.

[9] Katz and Shapiro (1986) argue that such lock in is likely, that if a competing technology cannot be 'sponsored' by a company or group of companies, charging for its use.

[10] Liebowitz and Margolis (1994, 1995), argue forcefully that economically inefficient lock in is not, in practice, the outcome of market choices over standardisation. Katz and Shapiro (1992) provide one model of insufficient friction.

[11] See Rochet and Tirole (2003, 2004), Armstrong (2004) and in particular Guthrie and Wright (2003) and Chakravorti and Roson (2004) who apply the analysis of the two-sided platform to the case of payment cards.

the ‘chicken and egg’ problem – merchants are reluctant to devote resources to accepting cards until there are a large volume of card holders, while card holders are not interested in card holding until there is a large volume of merchants accepting cards.[12]

Credit cards and, to a lesser extent debit cards, have indeed achieved relatively fast rates of technological adoption compared to other payment arrangements. Through the major bank-owned card associations, Visa and Mastercard, card technology has developed continously and offers high service quality, with most payments guaranteed by card issuers.[13]

The puzzle over slow rates of adoption of new technology is more pronounced for other forms of payments, business to business (eg invoice settlement), business to consumer (eg salary and pension payments), and from consumer to consumer. The two-sided platform literature is less helpful for explaining adoption and diffusion of innovation for these other payment arrangements. This is because in B2B and C2C payments there is no distinction between the two sides of the payment and, in the case of B2C payments, improvements have most often been undertaken through the upgrading of existing platforms rather than competitive rivalry from a new technologically more advanced platform.

In these cases it can be more helpful to think of a payment system as an *ownership network* rather than as a platform competing with other platforms. The phrase ‘ownership network’ is here used to refer to those arrangements which allow transfer of ownership without change of physical possession and which provide evidence of ownership independently of physical possession.[14] Ownership networks help overcome costs associated both with ownership itself and with transfer of ownership. These costs include: the security costs associated with physical possession; management costs of ownership, such as keeping track of all the assets and dealing with, for example, the income they earn or necessary maintenance and investment; the legal and other costs of establishing ownership in order to make a sale; and finally the costs of physical transfer.

Payment instruments are not themselves ownership networks. The use of a credit or debit card to make a ‘point-of-sale’ payments create an entitlement for transfer of money (into the merchant account) but needs to be supported by an underlying bank payment (ownership) network for settlement of these transfers. Similarly trading on securities and derivative exchanges (or on a variety of other competing two sided trading platforms) creates obligations such as making payments and delivering securities, but again these obligations must be fulfilled using a separate ownership network.

[12] See Evans and Schmalansee (1999).

[13] A major concern over card arrangements, especially for credit cards and in particular for card use on the interntet, are the costs of fraud and repudiation. These are in turn reflected in relatively high charges for many merchants.

[14] There are several examples of ownership networks including bank transaction accounts, securities accounts, contracts on derivative exchanges, systems of deeds or property registries, and vehicle registration systems. Milne (2005a) provides a more detailed discussion of ownership networks and their role in both payments and post-trade securities processing.

While different platforms (payment instruments) can compete against each other within the same ownership network, for the issues addressed in the present paper it is necessary to analyse technological innovation for the ownership network as a whole. It is then reasonable to assume that individual transaction volumes are unaffected by payments pricing. This is the maintained assumption for the analysis of this paper.

This perspective on payment systems, as 'ownership networks' rather than as two-sided platforms, highlights the need for co-ordination in order for new payments technologies to be adopted. In order for adoption to take place, either all banks must move together, or, at a minimum, a consortium of banks representing a significant share of the total banking market must introduce the innovation. This then suggests that bank payments is an area where 'excess inertia' may well arise. The model of the next section explores this point in more detail.

To complete this review of incentives to adopt payment innovations, it is worth noting that payment arrangements have been one of the more popular subjects for empirical studies of network externalities. In addition to the work on card payments, cited above, researchers have studied ATM networks and automated clearing houses. Technology adoption in ATM networks has been examined by Saloner and Shephard (1992), but recent empirical work on ATM externalities has focussed on implications for charging arrangements, ATM deployment, and competition between banks; not on the technology per se (see for example Knittel and Stango (2004a, 2004b)). In any case ATMs are another example of a payment related mechanism that creates an obligation for transfer of ownership (in this case settlement of the cash withdrawal between two banks) and is not itself an ownership network.

More relevant to understanding the cross-country variation in the adoption of electronic payments technologies is the recent empirical estimation of network externalities in ACHs (automated clearing houses that route electronic payments such as bill payments and salary and pensions) reported by Gowrisankaran and Slavin (2002) and by Ackerberg and Gowrisankaran (2003). These papers use a common data set, reflecting institutional factors specific to the United States where the Federal Reserve bank is the principal provider of ACH services, and where banks have an option to provide ACH services for their customers and where the geographical diversity of the bank industry allows the identification of 456 seperated local banking networks. These papers use quarterly data for these networks over the period 1994–1997 to quantify network externalities.[15]

While this research has identified network externalities in ACH adoption, such externalities can only be part of the explanation of differences in adoption

[15] Gowrisankaran and Stavins (2002) report separate panel data estimates of (a) the clustering of ACH adoption; (b) the impact on local bank's ACH adoption of the adoption by other banks in the same network (using bank size as an instrument to identify the exogenous adoption decision); and (c) the impact on local bank's ACH adoption of assumed exogenous ACH adoption by branched national banks. Their results suggest network impact on adoption is important. However Ackerberg and Gowrisankaran (2002), using a structural maximum likelihood model of ACH adoption and ACH and cheque usage, find that network externalities are relatively small, and mostly associated with consumer (firm and household) preferences.

of payments technologies between countries. Externalities are an important determinant of the usage of a new payments platform, but the commercial return to banks from providing a new payments platform must also take account of loss of business from existing payments platforms. To the extent that the new platform cannabilises the existing customers of promoting banks, then the business case for adoption is weak. The formal model set out in the next section, explores the possibility of weak incentives for the adoption of improved payments technology across the entire industry; while at the same time adoption incentives for a single bank or subset of banks can be relatively strong.

4 The adoption of payment innovations

This section presents a simple model of the adoption of innovations affecting payments quality and payment costs. It contrasts the relatively large commercial incentives to invest in individual bank payment systems, with the relatively weak commercial incentives to invest in shared infrastructure.

The model differs from those more typically applied to other information industries such as telecommunications or hardware/software. As the previous section has indicated, in many information industries achieving a sufficient platform usage (or installed base) is a key determinant of the success or failure of a new innovation. A firm that owns the infrastructure or platform seeks to maintain or achieve a competitive advantage. This also means that in many cases, eg cell phone technology, there can be a perceived substantial first mover advantage. All this leads to substantial incentives for adoption of new technology.

A key reason why payments services differ from these other industries,as identified in the previous section, is that important elements of payment networks need to be shared by all banks, in order that the package of payment services offered to the individual customer will allow payments to be made both to and from customers of all other banks.

This feature of bank payments plays a central role in this model. Note also that the model assumes away any co-ordination problems. But it should be apparent that these will only strengthen the models predictions, making it relatively more difficult to introduce adopt payment innovations for a large number of banks.

The model is less well adapted to explaining competition between different payment instruments – but such competition can again arise only if a large group of banks can co-ordinate to provide the necessary technology as a joint venture or if a public authority – such as the Federal Reserve in the US – provides an improved payment service in such a way that individual banks have an incentive to adopt. The model assumes that there is no intervention of this kind by public authorities.

In this model customers chose to obtain banking transaction services from one of a number of competing banks. There is a demand for a payment transaction from each individual to every other individual. The number of individuals choosing a particular bank is a linear function of both quality and the price of transaction services. There are J banks in monopolistic competition and a fixed number of potential customers.

Transaction volumes are fixed so the pricing of individual payments is immaterial. The customer choice of which bank to hold their transaction accounts with depends upon the quality of service, the total per period charge p_j for the entire package of bank transaction services, including both direct charges for payment services and indirect charges such as interest foregone on transactions accounts, and the costs of switching to an alternative supplier. The model of this section does not explicitly include switching costs, instead it assumes a linear demand function with a parameter m capturing the volume of customers switching banks in response to changes in price and service quality. This can be thought of as a linearised reduced form of an underlying switching cost model.[16] m will be relatively small when switching costs are relatively high.

There are two periods. At $t = 0$ banks decide what investments to make (to what extent to improve the quality or reduce the costs of transactions services.). At beginning of $t = 1$ individuals decide which bank they will bank with and during $t = 1$ payments are made and charges made for the package bank transaction services. There is no discounting so that \$1 in period 1 has a present value of \$1 in period 0.

We are concerned with investment in the quality of existing payment instruments, not with the adoption of new payment instruments (debit card or ACH replacing cheques, e-money replacing bank notes, etc.) We therefore neglect the choice of payment instrument – there is no competition between platforms. Since there is no choice between payment services, and the transaction volumes are the same for all customers, we can also ignore the pricing of particular payment instruments and consider only a single price per customer, covering a bundle of all transaction services.[17]

The first subsection considers the pricing of transaction services and the determination of bank profits, for the case where individual bank quality is unaffected by bank pricing or market share. The next sub-section discuss the incentives for banks to invest in a shared adoption of new technology, along with all other banks, distinguishing:

1. reduction of shared infrastructural overhead costs;
2. reduction of shared marginal costs
3. improved quality of payment service.

[16] As Shy (2001) chapter 8 argues, it is natural to think of competition between banks in terms of customer switching costs and it is surprising how little research has adopted this perspective. For empirical application see also Shy (2002).

[17] Both payment and settlement systems are characterised by large fixed costs. The principal impact of altering per-transaction pricing arrangements in onwership networks is to shift the burden of these fixed costs between lower and higher volume users. On this point see the interview evidence for UK retail payment systems presented in Ganguly and Milne (2002). Since the model assumes payment volumes are the same for all users, this aspect of pricing can be neglected.

The following subsection then extends the model to take account of an 'account externality', a dependence of the quality of payment services on the market share of the individual bank, and uses this extended model to analyse incentives by banks to adopt innovations that affect their individual costs and service quality.

4.1 Banking services and bank pricing

This subsection describes the determination of bank pricing and profits in period 1 when both costs and service quality are exogenous. The J banks, indexed by $j = 1, ...J$, are in monopolistic competition, with bank j setting a price p_j for a bundle of bank transaction services. The number of customers selecting bank j for the their transaction services is denoted by n_j .

Marginal costs per customer of supplying banking transaction services are k_j while there are fixed costs of K_j. The profit of bank j is thus given by $\pi_j = n_j \ (p_j - k_j) - K_j$.

The number of customers n_j is assumed to be a linear function of the pricing (p_j) and service quality (θ_j) offered by bank j and also on the pricing and service quality offered by all other banks (p_i and θ_i for $i = 1 \ldots j-1, j+1, \ldots J$) according to

$$n_j \ = J^{-1} + m \left[\left(\theta_j - \bar{\theta}_j \right) - \left(p_j - \bar{p}_j \right) \right] \tag{4.1}$$

Here $\bar{\theta}_j = \sum_{i \neq j} \theta_j / \left(J - 1 \right)$ and $\bar{p}_j = \sum_{i \neq j} p_i / \left(J - 1 \right)$ are the average quality and price of all other competing banks ie demand only depends upon relative service quality and price. m represents the senstivity of demand to price and service quality.[18] This demand specification implies that the total number of customers across all banks is normalised to unity: $\sum_j n_j \ = 1$.

Bank j then makes profits of

$$\pi_j \ = n_j \ (p_j - k_j) - K_j \tag{4.2}$$

Rewriting demand (4.1) as $n_j \ = \frac{1}{J} + m \left[\left(\theta_j - \bar{\theta}_j \right) + (\bar{p}_j - k_j) + (p_j - k_j) \right]$, profit maximising Nash equilibrium pricing yields the first order condition[19]

$$\begin{aligned} \frac{\partial \pi_j}{\partial p_j} &= n_j + \frac{\partial n_j}{\partial p_j} \left(p_j - k_j \right) \\ &= \left(J^{-1} + m \left[\left(\theta_j - \bar{\theta}_j \right) + \left(\bar{p}_j - k_j \right) \right] \right) + 2m \left(p_j - k_j \right) = 0 \end{aligned} \tag{4.3}$$

leading to an equilibrium price margin of

[18] The own-price and cross-price elasticities of demand are mp_j/n_j and $-mp_i/n_j$ respectively.

[19] These first-order conditions for the J banks determine a unique profit-maximising equilibrium. since the second order condition for profit maximisation is always satisfied $\partial^2 \pi_j \ / \partial p_j^2 = -2m < 0$ and (with linear demand) only one set of prices satisfy the first-order conditions for all J banks.

$$p_j^* - k_j = \frac{1}{2m}\left(J^{-1} + m\left[\left(\theta_j - \bar{\theta}_j\right) + \left(\bar{p}_j - k_j\right)\right]\right) \tag{4.4}$$

and equilibrium market share and profits of[20]

$$n_j^* = \frac{1}{2}\left(J^{-1} + m\left[\left(\theta_j - \bar{\theta}_j\right) + \left(\bar{p}_j - k_j\right)\right]\right) \tag{4.5}$$

and

$$\pi_j^* = \frac{1}{4m}\left(J^{-1} + m\left[\left(\theta_j - \bar{\theta}_j\right) + \left(\bar{p}_j - k_j\right)\right]\right)^2 - K_j \tag{4.6}$$

4.2 Incentives for shared technology adoption

4.2.1 Reducing shared fixed costs

Consider now a joint adoption of new technology, improving the shared bank payments infrastructure. This requires a period 0 investment of I by each bank, and yielding a reduction for all banks in fixed costs of ΔK in period 1 (the project is assumed to have the same impact on the costs of all banks).

An example of such a co-ordinated cost-reducing technology adoption may be the current upgrading of debit and credit cards (across Europe) to the EMV (Europay-Mastercard-Visa) standard for 'chip and PIN' technology, where an embedded chip is used to prevent the duplication of cards (relative to a magnetic stripe card it is difficult to skim the information and use it to create a new card) and PIN numbers at point of sale are used to establish the identity of the card user.[21] This will reduce fraud costs to banks (both because EMV improves security and because where EMV procedures are not followed retailers will have to bear the costs of fraud).[22] Such an upgrade is being undertaken by all European issuing banks together, so as to ensure that all European retailers adopt the necessary technology.

Proposition 1. *All banks obtain increased in profits from investment in a shared cost reduction, provided that the investment costs for each bank are less than their individual fixed cost reduction:* $I < \Delta K$

Proof. The reduction in fixed costs does not affect the pricing of the individual bank transactions services so the gain to each bank is simply $\Delta K - I$

[20] Full symmetric equilibrium, in which all banks have the same cost structure and service quality, yields (k subscripts are dropped) $p^* - k = [mJ]^{-1}$, $n^* = J^{-1}$, and $\pi^* = \left[mJ^2\right]^{-1} - K$.

[21] To the extent that fraud costs depend upon the number of customers and reflected in the pricing of transaction services, the EMV upgrade is better considered as a change in marginal cost k not fixed cost K.

[22] Note that US card issuers are not yet adopting the EMV standard, with the potential for aconsequent increase in fraud costs for US banks.

4.2.2 Shared marginal cost reduction or quality improvements

Another simple case is when banks consider a joint investment, resulting in *either* a reduction in marginal costs of providing transaction services for every bank of Δk or an improvement in service quality for every bank of $\Delta\theta$.

Examples of such investment would include changes in a central systems for credit transfer clearing and settlement, reducing clearing and settlement times, or increasing the information that accompanies a payment instruction (increase in θ) or reductions in the cost per customer of providing transactions services resulting, for example, from the introduction of new processing and messaging standards.

Proposition 2. *Banks obtain no increase in period 1 profits from investment in a shared marginal cost reduction or shared improvement in quality.*

Proof. Inspection of (4.4) shows that both the margin $p_j - k_j$ is unaffected by the industry wide changes Δk or $\Delta\theta$ since the relative prices and qualities do notchange. Hence there is no change in market shares n_j or in period 1 profits π_j^*.

The model thus predicts that there are no incentives for improvements in payment qualities or reduction in marginal payment costs associated with shared payments infrastructures (such as the ACH arrangements found in most countries.) Such innovations offer no competitive advantage to any individual bank.[23]

This is very similar to the standard insight on adoption of innovations from the industrial organisation literature, already discussed in the previous section, suggesting that monopoly firms have relatively little incentive to adopt new technologies because they can obtain as a result no increase in market share. In this model the mechanism is more pronounced than in the standard literature. Here there is no increased demand for payment services as a result of lower pricing or improved quality. Therefore a monopoly payments provider, or industry owned infrastructure, has no incentive at all to either improve quality or lower marginal costs.

4.3 Investment with account externalities

This sub-section considers investment in improving the quality or reducing the cost of individual bank payment services. This further analysis allows for variation in bank market shares to affect the quality of bank transactions services. This is another form of network externality. The higher the bank's share of the market for transactions accounts then the higher the average quality of its payment services, because a greater proportion of transactions are between its own customers directly across its own books. The phrase

[23] This absence of a business case for investment in payment services is clearly voiced in interview studies of payments industry participants, such as those of Ganguly and Milne (2002) or Federal Reserve Board (2003).

'account externality' can be usefully employed to refer to this particular network externality.

The account externality might appear on first consideration to be similar to that arising in mobile telephony and ATM networks, where network operators may seek to increase market share by offering lower charges for calls or ATM transactions made entirely on their own network and a dominant provider may raise costs for competitors by levying high interconnection fees for calls or ATM transactions from other (smaller) operators. But this is not an entirely accurate analogy. In the case of ATM and cellular phone networks operators are attempting to gain a competive advantage from their control over access to their own network. Moreover pricing of individual telephone calls or ATM transactions affects both usage volumes and choice of network.

In the present model of the 'ownership network' transaction volumes are exogenous and all customers make the same volume of transactions. The bank might choose to have a different pricing for inter-bank and intra-bank payment services but these component charges are economically irrelevant. All that concerns the customer is the overall price p_j charged for the entire package of transaction services.

4.3.1 Market share and equilibrium pricing

The modelling assumption is that bank customers send and receive the same number of payments to all other account holders, whether within the same bank or with competing banks. Normalising both payment volumes and customer numbers, the customers of bank j make n_j intrabank payments to customers of bank j and $1 - n_j$ interbank payments to customers of other banks. The average quality offered by bank j is an average of quality for intra-bank (θ_{jj}) and inter-bank payments (θ_{ji})

$$\theta_j = n_j\theta_{jj} + (1 - n_j)\,\theta_{ji}$$

Because they are unconstrained by shared clearing infrastructure or messaging conventions, pure intra-bank transactions can offer a higher service quality than inter-bank transactions (for example instanteneous funds transfer, immediate notification of payments failures, less constraint on accompanying information fields), implying the quality ranking $\theta_{jj} > \theta_j > \theta_{ji}$.

Bank j market share is now given by[24]

$$n_j = \frac{J^{-1} + m\left[\left(\theta_{ji} - \bar{\theta}_j\right) - (p_j - \bar{p}_j)\right]}{1 - m\,(\theta_{jj} - \theta_{ji})} \tag{4.7}$$

implying a new lower equilibrium price margin (compared to (4.4), the difference is the term θ_{ji} replacing θ_j so the price margin is lower than before) given by

[24] Obtained by substituting for θ_j into (4.1) and solving for n_j,

$$p_j^* - k_j = \frac{1}{2m}\left(J^{-1} + \left[\left(\theta_{ji} - \bar{\theta}_j\right) + \left(\bar{p}_j - k_j\right)\right]\right) \tag{4.8}$$

and equilibrium market share and profits of

$$n_j^* = \frac{1}{2}\frac{\left(J^{-1} + m\left[\left(\theta_{ji} - \bar{\theta}_j\right) + \left(\bar{p}_j - k_j\right)\right]\right)}{1 - m\left(\theta_{jj} - \theta_{ji}\right)} \tag{4.9}$$

and

$$\pi_j^* = \frac{1}{4m}\frac{\left(J^{-1} + m\left[\left(\theta_{ji} - \bar{\theta}_j\right) + \left(\bar{p}_j - k_j\right)\right]\right)^2}{1 - m\left(\theta_{jj} - \theta_{ji}\right)} - K_j \tag{4.10}$$

Now the additional incentive to compete for market share leads to a reduction in equilibrium price margins and, since in aggregate banks cannot increase their market share ($\sum n_j = 1$), aggregate bank profits are lowered by the reduction in margins.

4.3.2 Incentives for investment

This amended model can be used to analyse the benefits to a bank of $t = 0$ investment by bank j of I that either:

1. Lowers the $t = 1$ marginal cost of bank services by Δk_j
2. Increases the $t = 1$ marginal quality of intra-bank services by $\Delta\theta_{jj}$.

Proposition 3(a). *Bank j obtains a positive return from investment of I to achieve a reduction in marginal costs per customer of Δk_j provided that*

$$\frac{\Delta k_j}{4}\frac{\Delta k_j + 2\left(J^{-1} + m\left[\left(\theta_{ji} - \bar{\theta}_j\right) + \left(\bar{p}_j - k_j\right)\right]\right)}{1 - m\left(\theta_{jj} - \theta_{ji}\right)} > I \tag{4.11}$$

Proof. The left hand side of this expression is the change in profits evaluated using the 'difference of two squares'.

Note that the 'account externality' (the attraction of new customers raising average quality and attracting further customers again) leads to a heightened impact of Δk_j on market share and profitability. This can be seen by examination of the equilibrium price margin (4.8) and market share (4.9). The account externality, while it has no effect on the sensitivity of the price margin to Δk_j, increases the change in market share from $\frac{1}{2}\Delta k_j$ to $\frac{1}{2}\Delta k_j / \left[1 - m\left(\theta_{jj} - \theta_{ji}\right)\right]$.

Proposition 3(b). *Bank j obtains a positive return from investment of I to achieve a improvement in intrabank quality θ_{jj} of $\Delta\theta_{jj}$ provided that*

$$\frac{1}{4}\frac{\left(J^{-1}+m\left[\left(\theta_{ji}-\bar{\theta}_j\right)+\left(\bar{p}_j-k_j\right)\right]\right)^2}{\left(1-m\left(\theta_{jj}-\theta_{ji}\right)\right)^2}\Delta\theta_{jj}>I \tag{4.12}$$

Proof. Differentiation of (4.10) with respect to θ_{jj}.

The benefit to the bank of the investment comes entirely from the resulting increase in market share, since from (4.8) the price margin is unaffected by the increase in θ_{jj}.

These two propositions, 3a and 3b, suggest that banks will have strong incentives to reduce their own costs and, where possible, raise the quality of payments services provided to their own customers. This conforms to observed behaviour, banks make considerable use of information technology in order to facilitate customer transactions, supporting a variety of banking channels (telephone, internet, etc). They also invest substantial sums in upgrading their own money transmission systems and reducing the costs of providing transaction services.

This extended model with the 'accounting externality' also suggests that larger banks are likely to have a greater commercial incentives to adopt new techology. To see this formally, note that (for a small improvment, so that we can neglect terms in Δk_j^2) the inequalities in these two propositions can be written respectively as $n_j\Delta k_j > I$ (Proposition 3a, reduced marginal costs) and $n_j^2\Delta\theta_{jj} > I$ (Proposition 3b, improved intrabank quality). In both cases, benefits are increasing in the number of customers, so incentives for adoption are greater for larger banks.

The model therefore predicts that relatively concentrated (but not monopoly) banking systems will achieve the greatest reductions in the marginal costs of providing bank payment services and the largest improvements in the quality of within bank payment services; where such investments can be made on an standalone basis.

5 Policy implications and conclusions

This paper has analysed the economics of innovation adoption in bank payment services. The focus here is on the adoption of innovations (cost reductions or quality improvements) to existing payment arrangements, rather than the choice between payment instruments or the pricing of payment services. The main question addressed, and illustrated by the comparison in Section 2 of payments provision in the UK, the USA, and three Scandinavian countries, is why the quality and cost of payment services lags so much in some countries relative to others. Is there some failure of incentives to make these investments?

Section 3 has reviewed some of the principal determinants of incentives to adopt innovations. Standard models of industrial organisation suggest that incentives to adopt innovations are strongest in more competitive markets. But the international comparisons reported in Section 2 suggest the opposite applies in bank payments, that adoption of payments technologies has gone furthest in small countries with most concentrated banking systems.

In order to explore this question further, Section 4 of this paper offers a simple model of linear demand for choice of payment service supplier, capturing two network features which make banking different from other network industries. These are the importance of shared infrastructure and the existence of an 'account externality' ie the benefit to customers in terms of the quality of payment services for a bank capturing a relatively large share of the total market Because of this account externality, there are strong incentives to adopt innovations that reduce marginal costs or improve the quality of payment services for individual banks.

In contrast, this same model reveals a lack of private incentives to adopt innovations in shared payments infrastructure. The reason is that improvements in shared infrastructure offer no individual bank any competitive advantage. A board member of any bank, faced with an investment proposition of this kind, will naturally ask 'what's in it for us?' and the answer, from a business perspective, will almost always be 'very little.'

This model is highly stylised, leaving out some important aspects of reality. The assumption that overall payments demand are neither price nor quality sensitive is not unreasonable.[25] As already discussed payment services are consumed not for their own sake but in order to complete other transactions. Payment services are provided as a bundle, individual pricing is relatively unimportant to the consumption decision, so again the focus on overall charges per customer p_j is also plausible.

However, the assumption of a constant linear responsiveness of market share to changes price and quality (m in this model) is a strong one. This linear specification is a simple reduced form intended to capture the impact of switching costs, but this fails to capture a number of mechanisms that might affect the adoption of payments technologies: Switching costs may indeed remain constant in terms of labour and capital equipment devoted to changing a banking relationship; but switching costs can be expected to rise, and hence m to fall, as the economy grows and wage and capital costs increase.

This suggests that improved payments quality and lower payment costs can increase bank profits, through the indirect mechanism of raising overall economic activity. The importance of payments as a share of overall economic activity, summarised in Section 1, suggests that this impact will be quantitatively important; but typically it will not be internalised by banks when considering a prospective improvement in shared payments infrastructure. Internalisation of this social benefit, even though it leads indirectly to higher bank profits, is more likely in small countries where the banking system is dominated by a small number of relatively large banks. This

[25] The same assumption is made in the structural econometric model of Ackerberg, and Gowrisankaran (2004)

is one possible explanation of why adoption of advanced payment technologies has proceeded relatively far in Scandinavian countries. [26]

The model does not address the co-ordination of investment. While a joint venture by a group of banks might overcome some of the incentive problems highlighted here, the benefits would have to be sufficiently large to overcome the costs of bargaining and co-ordination. Co-ordination problems of the kind analysed by Farrell and Saloner (1985) are a further explanation of why more fragmented banking systems have slower rates of adoption of payments technologies.

Despite these limitations, this paper has suggested that commercial incentives to adopt innovations in payment systems may be weak. This in turn suggests the possibility of a welfare enhancing policy intervention in the operation of retail payment systems.

Firstly the analysis indicates that steps to reduce the role of shared infrascture, and encourage competition between payment providers, can increase incentives for adoption of innovation. This approach is observed both in the USA and in Finland. In the USA the authorities adopt the relatively unusual position of both encouraging competition between providers of payments infrastructure and also acting as major infrastructure providers themselves, the Federal Reserve being itself the most important operator of retail payments infrastructures, such as ACHs and cheque processing. Finland has gone especially far in this direction with no central clearing (all settlement of retail payments is done on a bilateral basis) and hence, at least according to the analysis of this paper, very strong incentives for banks to improve the quality of payment services.

The other principal policy conclusion is that where payments infrastructure remains a shared monopoly, then the authorities may need to take steps to encourage more rapid innovation that would be undertaken by the banks on a purely commercial basis. This is in fact the policy that has often been adopted. In the other Scandinavian countries, while they have centralised credit clearings, the central banks have paid close attention to retail payments and have encouraged the adoption of new technologies. In the UK retail payments arrangements have for many years been left to the banking industry, but failure to innovate and perceived poor standards of service have led to the creation of a joint public authority-user-industry regulatory oversight function, conducted by the UK Payments Taskforce.[27]

[26] m should also be related to the number of competing banks and ability to attract customers might be expected to depend upon existing market share n_j and the remaining market size $1 - n_j$.

[27] See Office of Fair Trading (2005).

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