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Electronic Cash and the Innovation Process: A User Paradigm

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Electronic Cash and the Innovation Process: A User Paradigm

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This paper looks at the innovation process in an emerging service product in the financial sector. The role of banks in the development and diffusion of electronic cash is addressed in the context of their role as 'lead users'. Since the introduction of Electronic Funds Transfer (EFT), banks have been learning how to manage large amounts of detailed information about money. Merchants, consumers and banks transact mainly through the use of various information and communication technology systems. One of the most important developments in this area has been the advent of the Internet and the opportunity for direct electronic ordering and delivery. Electronic commerce, however, has yet to overcome a major obstacle to its proliferation, that is, a suitable and instantaneous means of payment. This paper examines electronic cash and its generation, diffusion and take-up in the economy. Electronic cash is a store of monetary value, held in digital form, which is available for immediate exchange in transactions. The paper considers electronic cash in terms of its suitability to the Internet and as an off-line payment method and analyses the sources of investment in electronic cash and the willingness and capability of the financial services industry to pave the way for its deployment. The results show that banks have the know-how and the need to innovate in this field. They are user-initiators as well as suppliers of electronic cash and play the role of a need-forecasting laboratory. The obstacles they face in terms of the lock-in of traditional operations are not very significant.

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Executive Summary

Driven by the Internet phenomenon, electronic commerce presents enormous opportunities for consumers and businesses worldwide. Within the European Single Market, it is already stimulating competition and generating innovative businesses, markets and trading communities. Electronic commerce will certainly have a considerable impact on Europe's competitiveness in global markets. Not only does Europe stand to benefit from the development of electronic commerce, but it is also well positioned for its deployment[1], given the prospect it offers for cross-border commercial exchanges.

The introduction of a single currency also present significant opportunities. In fact, the relationship is a mutually beneficial one: the ability to trade in a single currency will stimulate electronic commerce, and electronic commerce could, in turn, facilitate the transition to the Euro. Given that electronic commerce will not develop without suitable and efficient electronic payment systems, the European Commission, the European Monetary Institute and the Member States are building a supervisory framework for the issuance of electronic money[2]. A proposal for a Directive on the issue is currently being drafted for discussion. In the light of the importance of this issue for Europe, this working paper studies the interrelationships between various players in the electronic cash market focusing on two European companies, Mondex and DigiCash.

[1] See Commission of the European Communities, *A European Initiative in Electronic Commerce*, COM(97) 157, 15 April 1997.

[2] The Commission has also recently set up the Financial Issues Working Group, which has advocated an electronic expression for the Euro, stating the Europe should continue its lead in the promotion of financial technologies, such as the smart card.

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Introduction *

We have become so familiar with the constant need for and use of money that we have all but forgotten that money is in reality a symbolic representation of value, rather than true value itself. It is not improbable that the invention of money led to as much convenience for human living as the invention of fire.

The physical representation of 'money' has moved from the barter system to the exchange of metal coins, to the use of paper currency and eventually to sophisticated electronic instruments. The replacement of bartering by coinage was driven by the difficulty in assigning equitable value to a diverse set of goods and services. The exchange of coins ensured perceived uniformity of transaction. The loss of value arising from the unequal and arbitrary barter system was thus obviated. The eventual shift from precious metals to ordinary metals and paper currency was based on the need to reduce costs of coin production and increase portability.[3]

Money thus became an institution for a transparent exchange of goods and services based upon a convenient unit of transaction which was universally accepted within a given societal group. As in the past, money is still in part a material commodity, that is to say physical notes and coins are exchanged for various goods and services. However, unlike the days before the 'information age', today not all money is tangible: increasingly, information about money is becoming more important than money itself.

For some time now, particularly since the introduction of Electronic Funds Transfer (EFT), banks have been learning how to effectively manage large amounts of detailed information about money. Advanced communication technologies and services have facilitated the transborder transfer of information and its extended geographical reach. In this respect, they have had the effect of blurring traditional boundaries between individuals, states, and private and public institutions. They form the basis for present-day commercial activities within and between these various groups. Merchants, consumers and banks transact mainly through the use of various information and communication technology (ICT) systems.[4]

In fact, banks have been continuously learning how to manage their information and financial networks more efficiently, and have, in certain areas, been significant users of ICT. Similarly, consumers and merchants are learning different ways of exchanging goods and services. Recently, one of the most important developments in this area has been the advent of the Internet and the opportunity for direct electronic ordering and delivery. Electronic commerce, however, has yet to

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* Data for this study were provided by interviewees from various organisations. The author acknowledges, in particular, David Everett, Chris Reeds, Andreas Credé and George Simpkins. The Social Sciences and Humanities Council of Canada supported this initial study and an earlier version was presented as a Master's Thesis by Lara Srivastava at the University of Sussex.. The author also wishes to thank Fred Bigham, Richard Hawkins and Robin Mansell for their contributions to the earlier version. This working paper has been edited substantially by Robin Mansell. The views expressed are those of the authors and not those of any organisation or institution.

3 It is interesting to note that in ancient Greece, Lycurgus, the head of the Spartan state, wished to achieve the opposite result, for it seems that he did not wish money to be encouraged as a value in society. Thus, he decreed that money should be struck in iron. As Plutarch explains, the purpose seems to have been to dissuade people from amassing wealth, as moving large amounts of metal from one place to another was cumbersome and inconvenient. See Plutarch's 'Lycurgus' in Plutarch (1928), p. 229.

4 Automated Teller Machines (ATMs), EFT (Electronic Funds Transfer), and EFTPOS (Electronic Funds Transfer at Point-of-Sale).

overcome the main obstacle to its proliferation, that is, a suitable and instantaneous means of payment.[5] This working paper examines one such innovation in payment systems, i.e. electronic cash, and particularly the aspects concerning its generation, diffusion and take-up in the economy.

Electronic cash is a store of monetary value, held in digital form, which is available for immediate exchange in transactions. This working paper explores electronic cash not only in terms of its suitability to the Internet, but also as a novel off-line payment method. The role of the different key players in the industry is analysed (banks, credit card schemes, telecommunications operators and technology suppliers) to determine the extent to which the market has been user-led and whether leading actors are emerging in the adoption and deployment of this innovative technology. Many studies on the role of the user have been conducted within the context of the manufacturing sector, but little attention has been paid to their role in the services sector. This working paper uses the notion of 'lead user', as described by Erik von Hippel, to examine an emerging service product: electronic cash.

Two main electronic cash systems are considered: Mondex and DigiCash. These two systems were chosen because they are similar in what they are trying to achieve, but they differ in the means they are choosing to achieve it. Mondex has been developed within a banking context and is now owned by various banking institutions, whereas DigiCash is an independent supplier of the technology. This focus allows for comparative analysis of user-producer linkages in the electronic cash industry. The main issue which is discussed is the extent to which such linkages are leading to a commercially successful design.

Electronic cash is a new technology but already there are many pilot schemes operating throughout the world. About 63% of all consumer payments are made in cash and the different systems now emerging attempt to target the cash payments market.[6] Electronic cash can be used for physical transactions but it is expected to play a major role in facilitating commerce over the Internet, which, until now, has not expanded as rapidly as some observers expected. There are many observers who argue that this is due to a lack of payment infrastructure.[7] A major element of Internet business is the trade in small packets of information which cost very little to transmit. Current forms of payment can be both costly and cumbersome for very small purchases and this makes electronic cash an attractive option. This follows an historical trend of reducing costs by introducing new forms of 'money'.

It is not claimed that electronic cash will eventually replace notes and coins completely. However, most electronic cash systems are aiming at universal accessibility. This will depend on the widespread public acceptance of electronic cash which, in turn, will require a considerable investment by the financial services industry and by merchants. It is expected that these costs eventually will be transferred to the end-user. This study looks at the nature and the source of this investment, as well as the willingness and capability of the financial services industry to pave the way for the deployment of electronic cash.

It must be noted that banks currently incur large costs for the handling of notes and coins. In this respect, as in the virtual world, electronic cash promises a future of reduced costs, but this will require substantial initial investment by the financial services industry. Is investment by banks, in their dual role as users and suppliers, necessary for the diffusion of the technology into the economy? Do banks need to 'lead' the innovation process? There may be other actors on the supply-side who can lead the market and whose participation will be crucial for the development of this technology.

It is well-known that the financial services industry has always been at the cutting edge of the development and deployment of ICTs. It was early on in the computerisation era that the financial services sector found widespread applications for mainframe computers. The processing and storage of vast amounts of data were required for handling large volumes of financial transaction data in a

5 See Credé (1995), p. 17.
6 See Brown and Capelli (1996), p. 20.
7 See Credé (1995), p. 2.

rapid, simple and inexpensive manner. It is not surprising, therefore, that the financial sector has been actively involved in designing this new application for ICT, an electronic alternative to notes and coins.

The implications that stem from the development of a novel and sophisticated technology for payments in the financial services sector, such as electronic cash, are manifold. Legal and regulatory implications include the effects on bank supervisory authorities, the proper discharge of contractual payment obligations, confidentiality and data protection issues, as well as the control of illegal money flows (i.e. tax evasion and money laundering).[8] Other interesting aspects include the effect of electronic cash on international monetary markets, as well as its effect on money supply and economic growth. This study focuses on the various players in the electronic cash market, their roles and their interrelationships within the context of the innovation process.

To explore this issue, company profiles, market surveys and relevant theoretical literature on the innovation process were consulted. In addition, the major players in the electronic cash market were identified and a set of interviews was conducted. Banks in the United Kingdom were targeted (such as NatWest and Barclays) as well as the major credit card schemes (such as Visa and American Express). Two independent suppliers based in Europe were chosen: Mondex and DigiCash.

The results of the study confirm the significant role played by banks in the innovation and diffusion of electronic cash. They demonstrate that, while analysis of 'lead user' characteristics is helpful, other factors are needed to explain the potential for widespread acceptance of a service innovation. For example, although banks can be considered 'lead users' in the sense that they serve as a need-forecasting mechanism in the market, their participation does not necessarily lead to the market success of payment innovations.

2 What is Electronic Cash?

This section looks at the 'precursors' to electronic cash and describes the operation of electronic cash payments with particular attention to the Mondex and DigiCash systems.

2.1 Traditional Electronic Payment Systems

In order to understand the manner in which an electronic cash payment is made, it is useful to consider traditional forms of electronic payment systems.

Electronically based payment systems have been in existence since the 1960s and have been growing in number and sophistication. The most important development was the use of Electronic Funds Transfer (EFT); this method is still used today by banks to exchange 'money'. In essence, an EFT is a transfer of debt from one bank to another. Much of the money held by banks is in the form of debts owed by them or to them. The evidence for this debt is contained in the bank's computerised records. EFT systems are concerned mainly with the management of information concerning these monetary debts. They allow for a rapid and efficient transmission of information between banks and for the resulting adjustments to their computerised records. The effect of an EFT is a change in the indebtedness recorded by each bank. Bank records are adjusted according to their contractual relationship, itself determined by such organisations as CHAPS and SWIFT,[9] of which they are members.

[8] See Reed and Davies (1995).and C. Reed (1996).

[9] Clearing House Automated Payments System and Society for Worldwide Interbank Financial Telecommunications, respectively.

EFTPOS (Electronic Funds Transfer at Point-of-Sale) developed out of this initial structure. It brings together banks' EFT systems and the distribution industry's point of sales (POS) systems. EFTPOS operates in the following manner. The cost of goods and services purchased by the buyer is entered into a POS terminal using a plastic card. The data relating to this purchase are sent to the appropriate bank using a telecommunication link. This bank then deducts the funds from the buyer's account and effects a transfer to the seller's account. In other words, the buyer's bank credits the seller's account and in so doing, undertakes a debt to the seller. Generally, EFTPOS systems immediately change the information concerning indebtedness, and this is called a 'direct debit'. EFTPOS systems are usually used in connection with what are known as 'debit cards'[10].

EFT systems effect payment by substituting a third party's obligation (e.g. that of a bank) to pay for the debtor's obligation (e.g. the buyer of a service). Some electronic cash systems function in a similar manner: they try to create an equivalent to cash by substituting either their own debt or that of a third party.[11] Essentially, they work the same way as credit or EFTPOS 'direct debit' payments, and fall into these two categories. In these systems, some trusted financial institution has been connected with the payment, either directly or indirectly, in order to provide users with the assurance that the payment will be honoured.

There are also systems where the service provider acts as the customer's agent, such as First Virtual Holdings Inc.,[12] which operates an Internet Payment System. First Virtual (FV) issues clients with a Virtual PIN (an alias for individual credit card information). Funds can then be debited from that card in favour of First Virtual. When making a purchase, potential buyers send a properly authenticated Internet payment message to First Virtual which then immediately debits their credit card. The company keeps an account of sums received from buyers, and periodically deposits these amounts (less charges) in the seller's bank account. Merchants sign up with First Virtual on the basis that all transactions will result in collection from the customer and payment to the vendor. The effect of a First Virtual transaction is that the buyer's debt to the seller is transformed into a debt owed by the buyer to his credit card provider as well as a debt owed by First Virtual to the seller. First Virtual therefore acts as a third party repository for sensitive information,[13] and replaces the buyer's obligation to pay the merchant with its own obligation to pay. Essentially, it plays the same role as the buyer's bank in a traditional EFTPOS transaction. Systems like First Virtual do not exhibit characteristics akin to physical cash.

2.2 General Description of Electronic Cash

In essence, 'electronic cash' is a store of monetary value, held in digital form, which is available for immediate exchange in transactions. The functions it performs include the following:

- It stores value as digital information independent of a bank account;
- It enables that value to be transferred to another by a transfer of the digital information;
- It is well suited to remote transfers, especially across public networks (e.g. public telecommunications networks and the Internet);
- In many cases, no third party is necessary to monitor and verify the transaction;
- It is suitable for low value payments, as transaction costs are minimal.[14]

There are two main types of electronic cash: 'prepaid' and 'true' electronic cash. The former is float-based and the latter token-based.

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10 Systems in some countries allow the use of credit instead of direct debits, and some POS systems offer differed payments. See Institute of Advanced Business Systems (Hitachi) and Hitachi Research Institute (1993), p. 67.

11 Reed and Davies (1995), p. 4.

12 See http://www.fv.com.

13 Centre for the Study of Financial Innovation (1997), p. 149.

14 Reed and Davies (1995), p. 1.

In float-based systems, the claim to value is held elsewhere, such as in a bank account. The issuer of the electronic cash receives payment from the consumer (payer) and deposits it into a float account. For this payment, the consumer receives a store of value which can be spent later. In such systems, there is a third party which undertakes through contract to pay the payer's debt to the payee. This new payment system is similar to the traditional EFTPOS system. For this reason, it is not as novel a design as those electronic systems that mimic more closely the operation of physical notes and coins.

Token-based systems are closer to 'true' physical cash than their float-based counterparts, because they have the following characteristics:

- transfer of possession of the electronic cash transfers ownership of it, and
- transfer of possession (accepted by the transferee) discharges the debt owned by the transferor to the transferee.

In contrast to 'prepaid' systems, the liability of the issuer of 'true' electronic cash arises only when a token is presented to it for payment. Tokens may be exchanged or transferred an infinite number of times before the issuer's liability for payment arises.

This is precisely the case with physical cash. Because the first type of (float-based) system is akin to traditional debt transfer or EFT systems, the implications arising from its deployment are not as significant as in the case of 'true' electronic cash, given the latter's potential to act as a replacement for notes and coins. Two of the most important systems which exhibit characteristics analogous to physical cash are Mondex and Digicash.

2.2.1 Mondex

The initial concept of Mondex was developed in 1990 by Tim Jones and Graham Higgins of the National Westminster Bank (NatWest) in the UK.[15] It is controlled by Mondex International (MI). Many banks are now shareholders in MI.[16] NatWest made MI into a separate company in July 1996, allowing it to operate independently. This was seen to be the most effective way to launch the product and market it in its own right. The first pilot trial of Mondex commenced in Swindon (UK) in July 1995 and is still ongoing.[17] International trials have also been conducted, such as the joint venture between the Royal Bank of Canada, the Canadian Imperial Bank of Commerce, and Bell Canada in Guelph (Ontario). Mondex has targeted universities in the UK as important pilots: Midland has introduced the University Card with the University of York, while NatWest has introduced the NatWest University Card with the University of Exeter.[18]

Mondex was developed to replicate the main features of physical cash and thus to constitute an alternative to notes and coins: Mondex claims not to be a complete replacement for physical cash, but

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15 See the Mondex Web site at http://www.mondex.com. The first patents were applied for in April 1990.

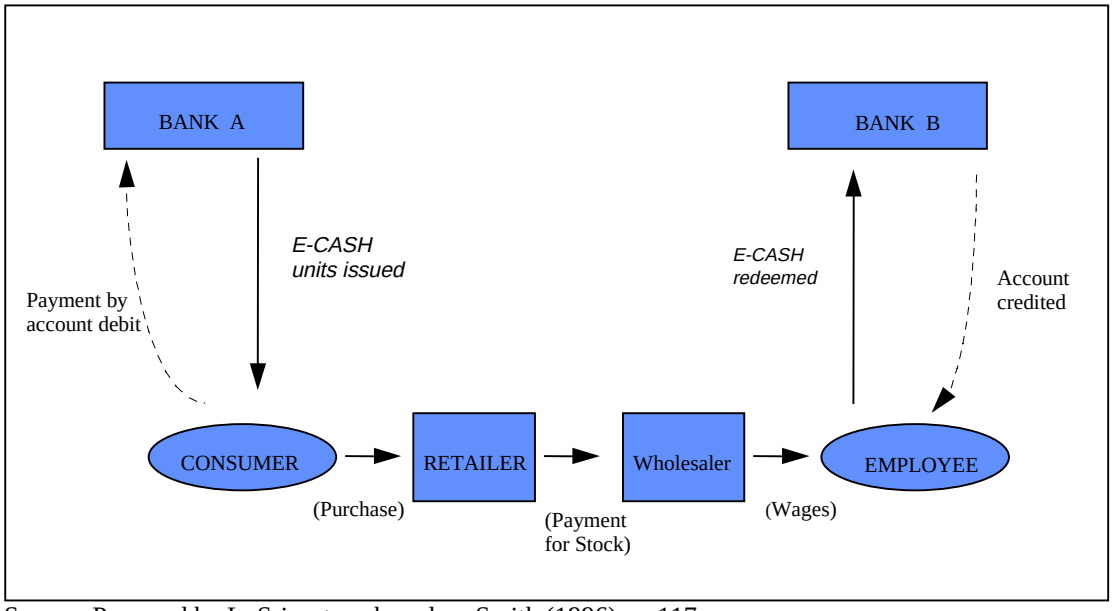
16 Shareholders (direct or indirect) include: National Westminster Bank (NatWest), Ulster Bank, Midland Bank, Scotiabank, Credit Union Central of Canada, The National Bank of Canada, Bank of Montreal, Canada Trust, Le Mouvement des caisses Desjardins, Toronto-Dominion Bank, Royal Bank of Canada, Canadian Imperial Bank of Commerce, The Hong Kong and Shanghai Banking Corporation, Wells Fargo, AT&T, Chase Manhattan, First Chicago NBD, Australia and New Zealand Banking Group, Commonwealth Bank of Australia, National Australia Bank, Westpac Banking Corporation (Australia); ANZ Banking Group (New Zealand), Bank of New Zealand, Countrywide Banking Corporation, The National Bank of New Zealand, ASB Bank and Westpac Banking Corporation (New Zealand).

17 The Swindon trial involved 700 retailers and a target consumer market of 40,000 (Swindon's total population being 190,000).

18 ' Mondex Launches UK University Pilots', *Press Release* 2 October 1996, Mondex International Newsroom. See http://www.mondex.com.

a complementary system.[19] Smart card technology forms the basis for the Mondex system. A smart card is a small device which contains a tiny integrated chip between layers of plastic. Its main advantage is that it can provide portability and ease of access. It is programmable and can store frequently changing data, which makes it quite different from current magnetic-strip cards. Smart card chips are also more resistant to tampering than are magnetic stripes. With smart cards, merchants do not have to access centralised databases on-line. They rely on personal identification numbers which verify the ownership of the card.[20] Value is stored on smart cards until it is used as payment for goods or services. Alternatively, value can be transferred to another consumer's card. Smart cards can be reloaded with value and this differentiates them from currently operating services such as prepaid phone cards. Transactions are not centrally recorded, as is the case with traditional non-cash payment systems. Data relating to the last ten transactions are stored on the chip of each individual card. The configuration of the Mondex system may be better explained in a diagram (see Figure 2.1):

Figure 2.1: Example of the Mondex System



Source: Prepared by L. Srivastava based on Smith (1996), p. 117.

In this example, the consumer is a customer of Bank A and makes a purchase from a retailer by transferring the necessary electronic value (acquired from Bank A) to the retailer's Mondex terminal. The retailer does not need to immediately redeem the electronic cash at the originating Bank A. For example, the e-cash can be used by the retailer to pay its wholesaler for stock. The wholesaler can then pay the wages of one of its employees. Technically, this chain could continue indefinitely, with the employee consuming goods and services from retailers who transfer the e-cash to various parties, and so on. Alternatively, as in this particular example, the employee can simply deposit the Mondex funds in exchange for credit to an account at Bank B. Mondex value can only be destroyed when it returns to what has been termed the 'originator' of the electronic cash.

19 One of the technical founders of Mondex argued it is not realistic to assume that electronic cash will lead to the disappearance of paper money. Physical cash will always be a fall-back system, and users will continue to carry physical currency world-wide.

20 See Fancher (1996) p. 25. The transfer of units of value between chips takes place as follows: 1. The chips identify themselves to each other, 2. The value of the transfer is deducted from the sending chip, encrypted together with the receiving chip's identifier, and transmitted to the receiving chip, 3. The receiving chip decrypts the transmission, adds value to its store and acknowledges the transfer. (If the transfer fails, the value is re-credited to the sending chip).

Mondex differentiates itself from other systems by its claim that it has no requirement for clearing. It does not need a third party to settle and clear transactions between its users. This has the advantage of increasing the speed and adding to the simplicity of the transaction. In order to keep up with other emerging technologies, Mondex is in the process of rendering its smart card technology suitable for Internet use. Presently, Mondex can be operated via the telephone network. In conjunction with British Telecom, the Swindon pilot allows users to load value onto their Mondex chip card using the public telephone network. Mondex has also envisaged a smart-card reader attached to a personal computer which would enable a customer to download electronic cash from the Internet. It has not yet piloted a system which would allow purchases to be made over the Internet, where cash can be downloaded and also transmitted over the network. However, Mondex and AT&T announced in March of 1997 that they plan to launch a solution to make micro-payments commercially viable on the Internet, using the Mondex electronic cash platform.[21] Mondex's strategy was to target the off-line market first because of the perceived limited scope of Internet commerce at the present time.

2.2.2 Digicash

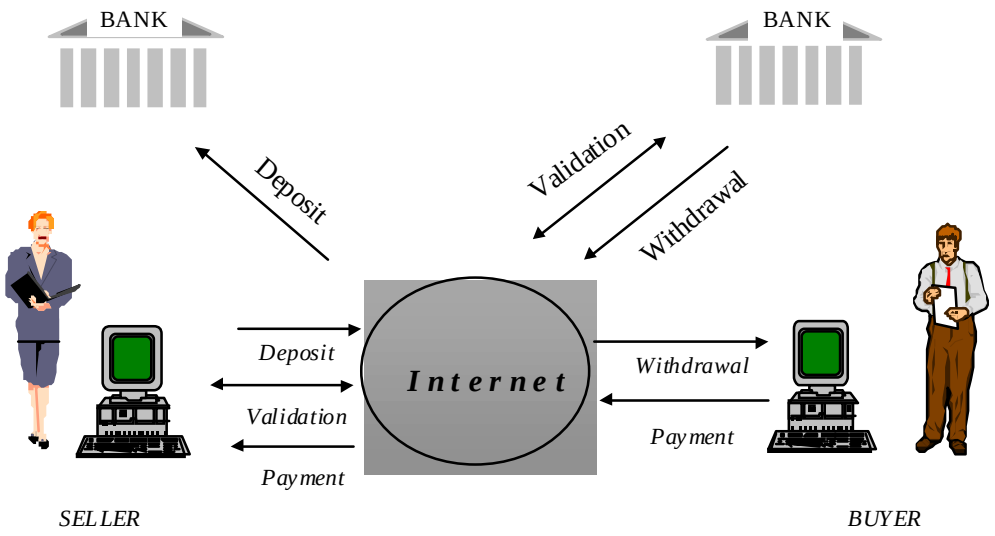
DigiCash[22] is a private company founded in 1989 by Dr David Chaum and is based in Amsterdam in The Netherlands. It has created an Internet money product, now patented, called 'ecash' and also has had experience in the development of smart card technology. 'Ecash' is designed to effect secure payments from any personal computer (PC) to another workstation, via e-mail or the Internet. It is intended to work in the same manner as physical cash and has the configuration indicated in Figure 2.2. As this diagram indicates, customers connect to their bank and withdraw 'ecash' tokens or coins, differing in denominational value (as dictated by software and user requirements). The value of the coins is then stored digitally on the hard disk of the customer's PC.[23] Each coin is encrypted with the identity of the issuing bank, a unique serial number, and its value. Payments for good and services are initiated by the customer who selects the value of the payment. This payment value is transmitted across a network to the payee merchant's workstation. The payee then checks the validity of the coins used for payment with the issuing bank and then deposits them at his or her bank. The bank receiving the 'ecash' value validates each coin deposited against its own digital signature.

21 'AT&T and Mondex Announce Electronic Cash for the Internet', *Press Release* 12 March 1997, Mondex International Newsroom. See http://www.mondex.com.

22 See DigiCash Web site at http://www.digicash.com.

23 See 'An Introduction to Ecash' at http://www.digicash.com.

Figure 2.2: The Digicash System



Source: C.Reed (1996)

Once validated, the bank stores the serial numbers in a database containing the serial numbers of the coins already spent. It uses the database to verify whether coins are being fraudulently used. In this system there is a requirement for some clearing of funds. Although the issuing bank is aware of the value of each coin issued to the payee, the coins are issued using a 'blind signature process'.[24] This means that the issuing bank cannot connect the customer with the serial number of the deposited coins and, in this respect, the customer's transactions remain private.

DigiCash has developed a complete technological system to run their 'ecash' on the Internet, including terminals, PIN pads, host computers and all the related software. It is now configuring its present system for compatibility not only with the Internet but also with off-line commerce. Some observers have indicated that this is due to the realisation by DigiCash of the limited scope of its focus on Internet commerce.

DigiCash's main concept trial started in October 1994. It was based on an artificial currency called the 'cyberbuck'. DigiCash made the cyberbuck available over the Internet to 30,000 individuals and 150 retailers. Consumers participating in the trial were given a certain amount of cyberbuck 'tokens' which were deposited in the First Digital Bank (a dummy bank run by DigiCash for the purposes of the trial). These tokens could be withdrawn and deposited into these accounts. In the cyberbuck trial and in live pilot projects, DigiCash's 'ecash' has been used for many different types of transactions, such as the purchase of mail order goods and information, stock quotations and on-line versions of magazines.[25] DigiCash is now seeking more and more partners in the financial sector. Its first partner was Mark Twain Bank (St. Louis, US) who started to accept applications for accounts holding 'ecash' in October of 1995. DigiCash has now gone live with its system in the US (through Mark Twain Bank), in Finland and in Australia. However, the applications of DigiCash in each of these countries

24 See Chaum (1992).
25 Brown and Capelli (1996), p. 184.

vary. In Australia, for example, the system is used only in the context of home banking schemes. In the US, it is limited to holders of a Mark Twain account.

2.2.3 Other Visa Cash

There is another electronic cash initiative which is worth mentioning as a major competitor to Mondex and DigiCash, particularly in the UK. This scheme is run by Visa International and is known as Visa Cash.[26] Visa Cash also uses chip card technology and aims at small-value payments. Essentially, it is a financial institution that is a member of Visa and issues Visa Cash cards (which are pre-loaded with value) to consumers who may then make low-value purchases at registered merchants. To make a purchase, the consumer inserts the Visa Cash card into the merchant's terminal, which reads the information stored on the chip and effects the transaction. The transactions are collected and sent to Visa, which then clears them and performs the necessary settlement among the participants. This is similar to the way Visa operates its credit and debit cards. The main difference is the increased speed of transaction and the use of chip technology which allows for disposable or re-loadable cards. However, this payment system is substantially different from Mondex in that it involves a centralised settlement and clearing procedure and is based upon credit and debit card operations. It is closer to EFTPOS-type systems than Mondex or Digicash and is not akin to physical cash. A trial of Visa Cash was run at the 1994 Olympic Games in Atlanta.

2.3 The Supply of Electronic Cash

Who can issue electronic cash? It is clear that state-regulated banks have the authority to do so. Banks have the necessary government support and legal jurisdiction to issue stores of monetary value. However, it must be noted that the opportunities for supplying electronic cash services are not only available to banks. Let us briefly consider the legal framework within which banks operate.

In most countries, banks must be licensed or authorised by a regulatory body, usually the Central Bank. They are subject to the rules and regulations set out by the Central Bank and by the enabling legislation. Whether or not an institution offering financial services falls under the jurisdiction of the supervisory authority is dependent on whether it falls within the ambit of the definition of 'bank' in the relevant banking law.[27] In most cases, this relates principally to whether or not the institution accepts 'deposits'. Section 5(1) of the UK *Banking Act 1987*, for example, defines 'deposit' in a manner similar to other national legislation in Europe as well as internationally:

> 'deposit' means a sum of money... paid on terms -
> (a) under which it will be repaid, with or without interest or a premium, and either on demand or at a time or in circumstances agreed by or on behalf of the person making the payment and the person receiving it: and
> (b) which are not referable to the provision of property or services or the giving of security
>
> *UK Banking Act 1987*

It would seem that the payment services considered in this study, float-based and token-based electronic cash, do not fall within the ambit of this legislation. Systems which function through the manipulation of traditional bank accounts or credit accounts, accept payment from users simply in return (as consideration) for providing a service. They do not have the obligation to return the payment unless the service is not provided.[28] Token-based e-cash systems operate by assuming that the electronic cash is a withdrawal from the user's deposit. The issuer will normally accept the e-cash for 're-deposit'. This is a question of 'repayment', and in order that it qualifies as a deposit, the funds

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26 See Visa's home page at http://www.visa.com. More specifically, information about Visa Cash can be found at http://www.visa.com/cgi-bin/vce/sf./cashmain.html

27 See Reed (1996).

28 See s. 5(2) of the UK *Banking Act, 1987*, which precludes this type of payment from being a deposit.

must be in the custody and control of the deposit-taking institution.[29] With true electronic cash, custody and control is in the hands of the user, as is the case with physical cash. Therefore, organisations wishing to issue electronic cash of this type would fall outside the definition of 'banks' for the purposes of state regulation.[30]

Thus, it appears that the new payment systems do not necessarily require the involvement of a bank for the issue or transfer of electronic cash.[31] The role of banks may be limited to that of guarantors, to ensure convertibility into other forms of value. However, even this may not always be necessary. For example, a user who is depositing large sums of money may look for the security that a bank offers, but a user who is purchasing US$25 worth of electronic cash may feel comfortable choosing an established non-bank institution, one which is not likely to fold before the $25 has been spent. Possible non-bank players in the electronic cash market include telecommunication companies, micro-electronics companies (such as IBM and Microsoft), transport authorities, and merchants. This means that there is likely to be increased competition between banks and non-banks for these types of financial services. This competition derives its strength from the steady blurring of traditional boundaries within the financial sector. Many financial services, such as personal loans, already are being offered by car manufacturers, insurance companies and merchant retailers. It has become clear that banking is necessary but that banks are not.

3 Towards a User Paradigm in Financial Services

There are three main kinds of players in the electronic money market: independent issuers of electronic cash, banks and credit card schemes (or payment associations).[32] These cannot necessarily and definitively be placed on either the supply-side or the demand-side of the market. In fact, most of the players can play the role of suppliers of the technology as well as users of it. Issuers, such as Digicash and Mondex, are suppliers but also producers of the technology. They are the generators of the innovative technology but they also supply the innovation (electronic cash systems) to various users. These users may be either final users of the technology, such as individual consumers, or 'intermediate users', who need the technology in order to enhance the services they provide to their own customers. However, these intermediaries can also be suppliers of the technology, when they themselves are generators of the innovation; this has been the case with the Mondex initiative which was first invented by National Westminster Bank in 1990.

In this respect, banks such as NatWest represent the entire supply chain: producer-supplier-user. In other words, they participate on all levels of the innovation process. Like banks, the payment association can be considered as a potential intermediate user. It equally can be a supplier of the technology when it joins hands with the issuer for instance, as did MasterCard in its purchase of Mondex in November 1996. The company thus extended its reach over the supply chain, as it became a supplier of the technology in addition to being a mere user of it.

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29 Reed (1996), p. 4.

30 This remains a contentious issue as the Courts have yet to be faced with the question. For a different perspective on the applicability of the UK banking legislation to issuers of electronic cash, refer to Smith (1996), p. 123.

31 Note that a report issued in 1994 by the EMI (European Monetary Institute) recommended that electronic purse services should only be issued by credit institutions. Some observers have indicated that the EMI will most likely change its stand on the involvement of non-banking institutions in electronic cash schemes, given the continuous pressure they are facing to be open and the developments in the industry over the last three years. The *Report to the Council of the European Monetary Institute on Prepaid Cards by the Working Group on EU Payment Systems* can be found through EMI's web site at http://www.emi.org/

32 Other players include telecommunication operators and, in the case of electronic commerce, Internet Service Providers (ISPs).

The literature on the nature of the innovation process, has focused on supply chains and the unique relationships between the user and producer segments of the market, where complex supply chains are involved. According to neo-classical economic theory, markets are perfect and players are anonymous.[33] If markets, which involve large numbers of users and producers, are characterised by anonymous relationships, it would be difficult for producers to identify new user needs and, similarly, users would lack the qualitative information on new products. Product innovation would be an extremely uncertain venture and best avoided.

This perspective does not coincide accurately with the behaviour of organisations that is observed in the marketplace. The majority of firms rely on technological product innovation as the core of their strategy. Since product innovation does occur, this means that there is a certain 'organisation' to the market in that users and producers of innovations do manage to exchange information. In many cases, the players are not anonymous, and the exchange of information is not 'perfect' in the sense intended by the neo-classical theory of the 'pure' market. Firms exploit the differences between them, through competition. It is this competition which stimulates the innovation process. Innovation is not the exclusive domain of supply-side players. Users, be they firms or individuals, can be equally the sources of innovations.[34] This perspective diverges substantially from the neo-classical model of user anonymity, and represents an advance on the linear technology-push and demand-pull models prevalent during the 1950s and 1960s.[35] It supports the notion that a more balanced, iterative and interactive process takes place between the supply of technology and its demand.[36]

Early innovation models focused on the causal relationship between scientific and technological development and the innovation process. Under the traditional 'technology-push' model, basic scientific discoveries eventually lead to industrial technological developments, and these developments lead to the launch of new products and processes into the market.[37] In this model, the user is essentially passive and the market simply receives the results of the firms' technological and scientific ventures. According to this model, not only do firms need to be constantly aware of basic scientific developments, but they also need to maintain their own capabilities for technological development. The more research and development is sustained, the more likely it is that innovations will occur.

This analysis largely ignores market factors. Another view emerged in the 1960s and is represented by the 'demand-pull' theories.[38] This model is based upon the notion that innovations occur as the result of perceived needs, which are often clearly articulated and flow freely from the marketplace into firms. This, of course, can lead to many short-sighted misconceptions about the need for research and development. Firms run the risk of being trapped in a cycle of incremental innovations, only responding to the needs they perceive in the market. In this model, the role of the user is 'reactive' and the role of the firm is to scan the market to find emerging patterns of needs. Like the 'push' model, it is a rather simplistic view of the innovation process.

The more recent *interactive* model,[39] depicts the innovation process as the result of the dynamic combination of technological capabilities and market needs within the firm and its relationship to other firms and users in the market. The important factor in this model is not whether the new product concept stems from an analysis of market demand or the emergence of a new technological capability. The main principle is that the innovating firm should link its technological capability to market needs. Even though market needs play an important role in this analysis, an active role for the user in the generation or diffusion of the technology does not seem to be implied. The user is involved in the

33 Gibbons and Weijers (1992).
34 von Hippel (1976, 1977, 1978).
35 Such as Schmookler (1962).
36 See Mowery and Rosenberg (1979).
37 See Casey (1976).
38 Schmookler (1962)/
39 See Mowery and Rosenberg (1979) and Rothwell and Zegveld (1985).

innovation process only via the identification of his or her need by an innovating firm. It is not the user who actively targets a need and seeks to fill it by the invention of a new design.

Eric von Hippel is recognised for having demonstrated that users (in certain sectors) play a principal role in the innovation process, particularly in the invention and early innovation phases. In his early work he found that the manufacturers of scientific instruments and process machinery for the manufacture of semiconductors were not configured*** to accurately perceive need as such, rather they possessed a solution to a need perceived by the users.[40] Von Hippel's key finding was that in approximately 80% of all major improvement [41] innovations in scientific instruments, it was the user who perceived that an advance in instrumentation was required and the user who completed the first stages of the innovation. Von Hippel classified the innovation process in this case as being user-dominated where the user perceives the need for the good, conceives a solution, builds a prototype and proves the value of the prototype by its use. This is an example of what he terms the customer-active paradigm (CAP), as opposed to the MAP or manufacturer-active paradigm, where it is the manufacturer who takes all of these steps.

Whereas von Hippel sees the customer as active only in the initiation of the innovative process in the customer-active paradigm, Gordon Foxall proposes a model where the user plays an active part in the ensuing development of the innovation for commercial exploitation.[42] In this manner, the user appropriates the benefits that would otherwise be obtained by the manufacturer in von Hippel's CAP model. It is the user who builds, tests and launches a prototype, thus gaining experience in manufacture and distribution to allow it to compete with rival firms.

Foxall describes a much fuller range of user involvement in new product development than does von Hippel.[43] He sets out four modes of user-initiated innovation: user-initiated process innovation (UII1), passive user-initiated product innovation (UII2), active user-initiated product innovation (UII3) and vertically integrated user-initiated product innovation (UII4). The last two are of most interest as they offer a different perspective from the one represented by the CAP. In UII3, the user actually exploits his/her process innovation. The user does not produce or directly market the item but strengthens his or her negotiating position with respect to the external manufacturer with whom that user becomes in part vertically integrated. The UII4 mode suggests that the user-initiator undertakes all stages of the development sequence, from deployment to manufacturing and marketing. It seems that there is no role for the traditional 'manufacturer' or 'producer' in this last model. The user has, in fact, become the manufacturer.[44]

The success of many technological innovations depends on the accurate assessment of user needs. However, the notion of 'user need' is somewhat nebulous. The notion of 'lead user' provides a basis for exploring the role of users in a complex supply chain such as the emerging and rapidly-changing electronic cash industry. Von Hippel defines lead users as having two principal characteristics:[45]

- They face needs that will be general in a marketplace, but they face them months or years before the majority of those in the marketplace encounter them.
- Their position allows them to benefit substantially from obtaining a solution to their needs.

40 von Hippel (1976, 1977).

41 von Hippel divides the sample of innovations into three: 'basic', 'minor improvement' and 'major improvement'.

42 Foxall and Murphy (1985), Foxall (1988, 1989).

43 Foxall (1988).

44 The dual role of the user has been pointed out by other theorists, including Gibbons and Weijers (1992) and Rothwell (1994).

45 von Hippel (1985, 1986, 1988) and von Hippel and Herstatt (1992).

The activities of lead users can serve as a need-forecasting mechanism since these users are familiar with conditions that lie in the future for most other players in the market.

Lead users encounter needs early and expect a high benefit from a responsive solution. Von Hippel suggests that firms which could today obtain significant benefit from a certain type of office automation, before the market perceives the need for it, are lead users of office automation. Similarly, a semiconductor producer with a current strong need for a process innovation which many semiconductor producers will need a few years later is a lead user with respect to that process innovation.

Analysis of lead users typically emphasise the manufacturing sector. The insights arising from the analysis of these 'lead users' have not been applied to the services sector. Electronic cash was in its pre-launch phase at the time of this study (1997) and was being run in various pilot schemes. The study therefore focuses on lead users of a novel product and on very early adopters.

The 'lead user' concept has been developed in the innovation literature by several authors. For instance, Roy Rothwell has pointed to the need for strong linkages between what he terms 'leading-edge customers' and other firms in the supply chain.[46] A useful way of depicting the innovation process is 'know-how accumulation', both internal and external: learning from external agencies (via customer complaints) and learning with external agencies (where users, particularly leading-edge users, are employed as collaborators in the innovation process). While user-producer relations are clearly an important factor in the innovation process, not all users are equal in value with respect to the success of innovations. Certain characteristics of leading-edge users, that is users who, through the early and profitable use of a new product, can assist in propelling the product along the diffusion curve can be identified:[47]

- They are early adopters on the diffusion curve
- They have a proven track record in the successful use of innovative products
- They establish forward-looking, innovation-demanding specifications
- They become actively involved in suppliers/developments, such as prototype testing (where appropriate)
- They are a primary source of post-launch improvements.

It is not sufficient for a manufacturer to assess the needs of users in general; rather, the firm must ensure that it is plugged into a representative sample of customers.[48] It should strive to plug into 'innovative customers', demanding high-quality, high reliability products that provide a stringent design stimulus. Involved users accumulate know-how that better enables them to use a novel product: in this way, they are able to maintain it and derive maximum benefit from it, which, in turn, has a strong effect on other potential customers and accelerates the acceptance process for the new product design.

Von Hippel argues for the integration of market research methods with the 'lead user' concept. He sets out a step-by-step process for the identification of lead users. The preliminary steps are the specification of the underlying trend where users have a leading position and the definition of the measures of potential benefit.[49]

A modified concept of 'lead user' is applied to the emerging electronic money markets. Because of the number of different players involved, and the rapid pace of technological change, the 'lead user' concept is suited to the analysis of the innovation process in the electronic cash industry. Looking at

46 Rothwell (1992).
47 Rothwell (1994).
48 Rothwell and Gardiner (1985).
49 von Hippel (1988).

the innovation process from the perspective of user-producer interactions can provide insights into the perceived successes or deficiencies of the various players involved.

It is important to highlight some of the peculiarities of the services sector with special reference to financial services. Services are playing an increasingly large role in the economy to the point of overtaking many other sectors. Jonathan Gershuny pointed to the shift from a manufacturing-based economy to an essentially service-oriented economy.[50] Electronic cash is a good example of a service innovation based on the manufacture of chip card technology - an application of a manufacturing innovation.

The financial and business services sector has been described as a 'vanguard' or leading sector in the emerging service-based economy.[51] Service innovations may follow a reverse product cycle: a first stage in which the applications of new technology increase the efficiency of delivery of existing services, a second stage in which the technology is applied to improve the quality of existing services, and a third stage in which the technology assists in generating entirely new services. Within the financial services industry, the computerisation of bank records falls within the first stage whereas EFT and EFTPOS forms part of the second stage. The third stage is clearly user-dominated rather than supplier-dominated. The full realisation of this stage was expected to lie sometime in the future. It would be initiated once interactive banking occurred. Perhaps what we are now witnessing with present-day home banking schemes and, more particularly, with the newly emerging electronic cash systems is the inception of this third stage.

As the requirement for widespread acceptability of service innovations can only be gained through co-operation between otherwise competing institutions, the emergence of payment system innovations may be determined more and more by the tensions of co-operative institutional relationships. It may be that in order to be successful in their management of innovation, banks must rely on a combination of internal and external learning processes, and on the linkages between technical decisions about advanced communication technologies and services and overall corporate strategy. Banks which are both users and suppliers of a technology could have the opportunity to exploit these linkages to their full potential.

The question for the electronic cash industry is whether such linkages are leading to a commercially successful product. Who will be the leaders, i.e., those most enthusiastic about adopting the technology? How necessary is their involvement for the widespread diffusion of the product or service - does it necessarily take a leading user to innovate? What are the incentives for lead users to innovate?

4 Lead Users, Linkages and Innovation

This section looks at the role of the various players in the electronic cash market, particularly the banking industry, and the obstacles they face.

Company profiles and annual reports as well as marketing literature were the primary documentary sources for this study including published material on the Internet, press releases, and video material provided by organisations. Only a few comprehensive surveys on the subject of electronic cash have been carried out.[52] A common assumption has been that electronic cash will be successful in diffusing into the economy. The trade literature takes several positions on electronic cash. These range from the view that it will be widely used within the next decade to the view that it will create business opportunities for many players.

50 Gershuny (1978).
51 Barras (1986, 1990).
52 Brown and Capelli (1996) and Credé (1995).

To explore developments in the electronic cash industry interviews were conducted with five different categories of players: the banking industry, credit card schemes, technology providers, telecommunication companies and academics/consultants. The interviews focused on the interactions between players and the perceived leaders of the industry. The banks were all located in the United Kingdom and other representatives were located in continental Europe. A structured set of questions was used to elicit information about:

- the benefits of electronic cash and possible alternatives
- the perceived leaders in the market
- the incentives and obstacles faced by these leaders
- the necessity of bank involvement
- the forms of interaction between the various players
- the stimulus required for a more rapid diffusion of the innovation into the economy.

Other questions included the relative suitability of electronic cash to physical versus electronic commerce, as well as the need for regulation of the industry. A total of fourteen interviews was conducted. Interviewees were selected for their knowledge of the industry and an attempt was made to balance viewpoints by seeking the technology provider perspective, the financial services perspective, and the independent consultant perspective.

4.1 The Nature of Electronic Cash as a Service Innovation

Electronic cash systems, such as Mondex and Visa Cash, are based on smart card technology. However, the Internet segment of payment systems such as DigiCash are software-only solutions. It is interesting to note that, in this respect, Mondex and Visa Cash are service innovations based on a manufacturing innovation (chip technology) whereas DigiCash is mainly a service innovation. In all three systems, however, the service side of the innovation is dominant. It seems that these payment systems fall within a third, 'user-dominated' stage. The initial investment in new technology for the purposes of improving the efficiency of delivery (the first stage) is represented by the banks' need for and use of information technology in the early development of computerised records. Emphasis on the improvement of quality of delivery (the second stage) led to the possibility of transferring funds electronically between banks (EFT) and then between banks and retailers (EFTPOS).

The new emerging electronic cash systems go much beyond traditional EFT or EFTPOS operations. They are not merely improved versions of existing services, but constitute entirely new service products, giving rise to competitive product differentiation and the generation of new employment. In this third stage far-reaching demands are likely to be placed upon institutional structures. This is the case with ongoing discussions over the regulatory implications of electronic cash systems. But is this stage in financial services user-dominated supplier-dominated where technology is acquired externally?[53]

4.2 The Benefits of Electronic Cash

For the end-user, the main benefits as seen by the banks are convenience, simplicity and check-out speed. Interviewees pointed to the need for a more suitable payment method for vending environments and remote applications. One interviewee referred to transport applications, as did a representative from the credit card scheme. The main marketing platform for DigiCash is the benefit Ecash offers in terms of privacy protection. On the other hand, Mondex does not consider privacy as being an important concern for the consumer. Representatives of Mondex reported having conducted

[53] Barras (1986), Cassiolato (1990), Pavitt (1984).

various market surveys in major European countries in which they found that the majority consumers are not preoccupied with keeping their transactions private.[54]

Although the benefits of electronic cash for the consumer seem quite evident to banks and to technology providers, this is not the case with organisations outside the banking sector. For instance, representatives in the telecommunication industry pointed to the uncertainty and nebulous nature of benefits for the consumer. In their view, it is difficult for the consumer to understand the need for this new service product and to perceive its advantages. This, in fact, is the main obstacle to its market acceptance. The consultant and academic viewpoints were not dissimilar. The interviewees suggested that the benefits for the consumer have yet to become clear. The market is not ripe and ready for the introduction of electronic cash. There is no distinct and clearly articulated need or demand on the part of the consumer for such a product. Rather, it is a case of technology being ahead of consumer demand. It does not follow, however, that user-need does not play a part in the innovation process, or that the traditional 'technology-push' model is a more accurate description of the process. This is an illustration of the dialogue between the demand side and the supply side of the market, facilitated by the role of a particular type of user.

The benefits of electronic cash for the retailer were regarded as a less contentious matter. Most players agreed that electronic cash will allow retailers to increase the security of their operations by lowering the amount of cash they have to handle. It may also be a cost-saving measure, as it could greatly reduce leakage and errors in counting.[55] In addition, as observed by a representative of the telecommunication industry, the possibility of Internet payment systems brings the mass market to the retailer. The speed of check-out is also a benefit as it can lead to greater convenience and turn-over as well as increased customer satisfaction.[56]

4.3 The Role of Banks

Banks such as NatWest are in the unique position of being both innovators and users of the innovations. NatWest addresses the entire supply chain, from user to producer to supplier. The British banks which are now shareholders of Mondex International have placed themselves, similarly, in the role of suppliers as well as users. On the other hand, DigiCash is purely a supplier of its product innovation. Similarly, Visa International is not in the same position as banks. Although it runs its own payment system, Visa Cash, this system was not developed in-house. It is based on various payment technologies, acquired from other European countries. The two main technologies, which Visa adopted, are SIBS (Portugal) and Dancoins (Denmark). Visa is thus in the position of supplying these services to banks and end-users.

Banks supply new service products to their customers but equally, they are 'intermediate' users of the technology. To what extent is their participation in the electronic cash game necessary for the widespread diffusion of the technology? Banks may not necessarily be the only organisations that can issue electronic cash. As one interviewee pointed out, banks can be *disintermediated* very easily by any number of players, such as telecommunication companies, Internet Service Providers (ISPs), and

54 The only exception to this general rule was Germany, where most consumers did view private transactions as a benefit to them.

55 An interviewee pointed out that the perceived advantage of a decrease in cash-handling varies depending on the size and market presence of the retailer. For smaller retailers, the cash flow at the end of the day makes up a large part of their business incentive, whereas for the larger retailers, cash-handling is simply costly and cumbersome.

56 An interviewee argued that the whole payment services industry is moving to chip cards and that retailers will have to adopt this type of technology if they are not to be left behind. Electronic cash, such as Mondex, is simply one of the applications of smart card technology.

IT companies. The main obstacle to these players is the inertia of the market and the legislative protection accorded to the banking industry. On the issue of the necessity of bank involvement, perceptions differed slightly although most of the interviewees agreed that, at least in this pre-launch phase, prior to the product becoming commercially viable, the participation of the banking industry is crucial.

One of the banking representatives stated that innovations usually lead to commercial products because they have the essential industry backing. In other words, those players that can turn innovations into widely accepted products are those with the mass market appeal, such as banks and large retailers. On this point, an interviewee observed that retailers are not as threatened about their position in the market as banks are, and, for this reason, do not feel compelled to participate as actively in the electronic cash game. Banks, on the other hand, are starting to realise that the payments world is no longer their exclusive domain. For this reason, they are actively involved in the innovation and diffusion processes. Another reason for the necessity of banks, according to another interviewee, revolves around credibility and regulatory issues. At the moment, if a problem arises with the money supply, the Central Bank owns the notes and coins and guarantees their value. In the case of a broken multi-currency electronic cash system, it is not clear where the responsibility for patching the system would lie.

The representatives from the telecommunication industry also saw the need for banks to generate and guarantee the electronic value. Another interviewee felt that banks will be necessary both in the pre-launch and post-launch phases due to customer trust and the need for regulation. Others agreed that banks are crucial in this market due to the cash-like nature of the innovation; but this is not the case with Internet payment systems.[57] On the whole, most players were in agreement that the participation of the banking industry is essential to the diffusion of the technology. This does not mean, however, that banks will lead the electronic payments market. Moreover, the fact that they are necessary to the adequate diffusion of the technology does not place them automatically in the category of 'lead user'.

The innovation process is 'user-dominated' when the user perceives the need for the product, actively conceives a solution, builds a prototype and proves the value of the prototype by its use.[58] This is the 'customer-active paradigm' (CAP). The role of NatWest is akin to a CAP given that the bank perceived the need for an electronic payment system and subsequently tested it. However, the case of NatWest goes even further than Von Hippel's CAP model, and can be viewed in terms of a reverse innovation process.[59] With Mondex, NatWest, having invented a new payment product, acted in an entrepreneurial manner in an attempt to derive maximum benefit from its diffusion into the economy.

NatWest sold the design concept to a consortium of banks. An independent entity was then created (Mondex International), of which different organisations are shareholders. The main purpose of this step was for NatWest to recover development costs and secure ongoing revenue, while allowing the banking industry as a whole to take the innovation forward. This is a case of 'reverse innovation'. The evolution of the Mondex system is an illustration of the user playing an active part in the ensuing development of the innovation for commercial exploitation. More specifically, it is close to the 'U114' mode of user-initiated innovation, where the user-initiator undertakes all activities from manufacturing to marketing. In this manner, he/she receives the benefits, which the manufacturer would otherwise have obtained in models that focus only on the user's role in the initial stages of innovation. The user has in fact become the manufacturer.

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57 One interviewee argued that in the virtual world, it is the presence of the telecommunication operators and technology providers which is crucial to the development and diffusion of the payment technology.

58 von Hippel (1976, 1977).

59 Foxall (1989).

Can banks be classified as 'lead users' of electronic cash technology? To answer this question, it is important to define the particular needs that banks face and what they stand to gain by addressing those needs.

It costs the financial services industry over £4 million a year to handle notes and coins. Converting physical cash to an electronic form has the potential of being a significant cost-saving measure for the banking industry. Electronic cash gives banks the opportunity to offer new services to their consumers in this era of increased competition in financial services. Many of the interviewees pointed to the immediate need for banks to protect and strengthen their position in relation to other players entering the financial services sector. It is clear, therefore, that banks encounter certain needs, which the implementation of electronic cash serves to address. NatWest first developed Mondex in the early 1990s, when there were fewer players interested in the concept and the service product was not very well defined. It seems that banks fit the first of the two lead user criteria, i.e. banks face needs that will be general in a marketplace, but they face them months or years before the majority of the marketplace encounters them.

The second criterion revolves around the extent to which banks may benefit from addressing the needs outlined above. Because 'lead users' expect a high rent from the satisfaction (or 'solution') of a need they have identified, they often attempt to fill this need and this can be a valuable source for the development of potentially successful new products.[60] In the case of banks, many see that the principal problem they encounter is the need to secure their customer base and to thwart *disintermediation*. By developing electronic cash systems, they address this need while benefiting substantially in other areas, such as cash handling, fraud and security, and new markets. In addition, as pointed out by an interviewee, banks will have the ability to tie in their banking services with smart cards and therefore with their specific brand of service (which is not the case with generic physical cash presently being issued by banks). This has the potential of fostering customer allegiance and even 'lock-in', which can prove to be highly profitable for banks. On the surface, therefore, banks fulfil the 'lead user' criteria with respect to electronic cash as a service innovation.

The specific needs which banks face do not entirely place them in a different category from other users (for instance, credit card schemes, retailers, and end-users). While the cost of handling cash directly affects banks and large retailers, it does eventually trickle down to other levels of the money supply chain, including the end-user. Because banks own the notes and coins, they perceive the need to address their overall cost to the payment system much earlier and more accurately than the rest of the market.

On the whole, it seems that the banks have much to gain by the development of electronic cash systems and that the industry is willing to pave the way for its deployment.[61] There are certain caveats that are worth mentioning. Some banks are somewhat cautious in their attitude towards electronic cash, whereas others are more open to the possibilities offered by this new technology. There was a clear division between those banks, which are shareholders in Mondex, and those, which are not. The Mondex shareholders seemed more enthusiastic about adopting the technology and more optimistic as to the benefits it offers and its future prospects. The banks, which decided against joining Mondex, were more concerned about the negative effects electronic cash could have on their present core business and whether or not they would profit sufficiently from its introduction to the market.

Some of the interviewees from the banking sector affirmed that although banks are willing to get involved in this domain, there are certain obstacles they must overcome in order to succeed in the market. In high technology industries, the environment changes so rapidly that the real-world

60 von Hippel (1988).

61 There was one exception to this general rule. The representative from one of the UK banks (not a shareholder in Mondex) stated that banks are in the position of wishing to slow down the innovation and diffusion process in this area. The fear is that electronic cash would erode currently profitable business.

experience of typical users is often rendered obsolete by the time a product is developed or during its commercial lifetime.[62] Banks have been conducting their operations in a traditional manner and it could be argued that they will be slower to adapt and compete in the new electronic environment for cash. This 'cultural baggage' does not seem to play a significant a part in the ability of banks to keep up with the direction in which financial services are evolving. In the case of one interviewee, for example, a separate group (the 'Emerging Markets Group') was established in order to provide a greenhouse environment for the development of new payment technologies, one which is protected from the bank's traditional committee-based structure. NatWest made a similar decision when it decided to create an independent company, which would work towards developing a commercially viable product. Although the banks' 'cultural baggage' does not seem to be a significant obstacle for them, there are other hurdles, which must be overcome. These include the participation of merchants, the cost of running three channels simultaneously (Internet, phone, face-to-face banking) and ensuring widespread acceptance.

'Leading-edge' users are expected to have a number of characteristics.[63] For instance, these users are generally 'early adopters' on the diffusion curve. This study does suggest that banks are early adopters of electronic cash. They seem to be the most involved in the planning and running of pilots[64], and are not content with adopting a 'wait and see' attitude.[65] Banks also have a proven-track record in the successful use of innovative products and the establishment of forward-looking specifications. Banks have been significant and effective users of advanced communication technologies and services with the development of EFT and Automatic Teller Machines (ATMs). They have also been involved in prototype testing: NatWest first tested the Mondex chip-to-chip transfer in their offices in 1991.

As for post-launch improvements, it remains to be seen whether banks will play an active role in this area. The present situation indicates that with increased competition in financial services, banks will continue to offer enhanced services to customers in an attempt to generate new business and to protect their current customer base. Thus banks in the electronic cash market have the characteristics of early adopters and leading users. They also are a 'representative' sample of users who are demanding high-reliability products, that is to say 'tough customers'.[66] Because their concerns for security and fraud-prevention are high, and because they have always been in the business of dealing with cash, they are much more demanding of the technology than an ordinary user would be. Banks understand what cash is and how it behaves, and this is why they can create a product that is suited to the financial sector.

Another main contender for a 'leading-edge' user position is the credit card business. Visa International has been active in the electronic cash industry, marketing various technologies under the Visa Cash platform. It has sought the participation of banks and has been involved in pilots. Similarly, MasterCard is now a major shareholder in Mondex International. It is interesting to look at the dynamics between the credit card schemes and the banking industry. The main difference is that the former is largely owned by the latter. Credit card organisations act according to their members' specifications. Most interviewees appeared to agree that of the two players, the banks are dominant. As observed by one of the interviewees from the banking industry, card schemes have a vested interest in their current business and, for this reason, may have blinkered vision with respect to novel service products such as electronic cash. Electronic cash has the potential of eroding their credit account business because consumers may be more likely to use a smart card for small to medium-value purchases rather than drawing the money on credit. This is the reason why Visa International

62 von Hippel (1988).

63 Rothwell (1994).

64 Lloyd's-TSB and Barclays are involved in Visa Cash trials in Leeds and Manchester, respectively.

65 On the other hand, an interviewee indicated that the telecommunication sector would be willing to adopt whichever technology becomes a commercially viable service product. In the meantime, that industry will wait and observe the market for developments.

66 Rothwell and Gardiner (1985).

will be running pilots of Visa Cash (in Leeds and Manchester) based on a system where electronic value is debited from a credit or debit card and then stored on a chip located on the same card or on a separate card. This does not constitute a true electronic cash system as it is markedly different from the operation of physical notes and coins.

MasterCard, on the other hand, did attempt to develop payment technologies in-house but did not succeed. Its decision to buy into Mondex is seen by many observers as an attempt to address the weakness of its competitive position in relation to Visa. In any event, its involvement with Mondex has now given the technology a global reach and secured a position for MasterCard in the payment systems market. When one compares the role of the credit card schemes with the role of banks, it seems clear that although the credit card schemes may be 'early adopters' on the diffusion curve, they are not 'lead users'. This is mainly because they are owned by the banking industry and also because they have not been as forward-looking as banks have been in this field. Their needs revolve more around preserving the economic rents they obtain from credit and debit card charges. For this reason, it is more likely that they would wish to slow the process down. In addition, their active involvement began at a later date than that of the UK banks and it was essentially in an effort to protect their current account base. In addition, the benefits they may reap from the introduction of the technology are not as significant as are those of banks. In the end, it is the banks that actually implement the payment systems.[67]

Other players in the market include the UK telecommunications operators and the technology providers. One of the technology providers was of the view that these firms are leading the market. Given the complexity of the technology involved, there are very few players who understand how it operates and those who hold this 'tacit' knowledge can drive the industry. Although the technology providers will have an impact on the rate and direction of the innovation process, they are not 'users' of the technology and for this reason do not constitute an adequate need-forecasting mechanism.

As for the telecommunication operators, their role has the potential of addressing both the user and supplier sides. Representatives of the telecommunication operators were clear about their position in the market. They were adopting a 'wait and see' attitude. Although they were involved in a Mondex trial, they had not committed to any future trials and they were open to adopting other technologies. Telecommunication operators in Britain are in a very unique situation. Because liberalisation occurred earlier than in the rest of Europe, they have to be much more cautious about new markets than their European counterparts. In addition, they share a mutually interdependent relationship with the banks. Because banks are one of their largest customers, they are not interested in developing in-house any competing payment systems at this time. On the whole, therefore, it seems that banks are the only players that have the know-how and the need be lead user-suppliers of electronic cash systems. They are also the ones who stand to benefit the most from the diffusion of the technology.

4.4 The Importance of Industry Linkages

To what extent are industry linkages important in the development of electronic cash? Conventional linear models of innovation do not apply to financial services.[68] This is mainly due to the fact that the widespread acceptance of financial innovations can only be gained through co-operation between otherwise competing institutions. Banking organisations are facing increasing competitive pressure and must become active in the provision of a large and varied range of financial services. In order to do so, they must rely on both internal and external learning activities. Innovation can be described as a process of 'know-how' accumulation. This learning derives not only from internal sources but also

67 One interviewee suggested that MasterCard and Visa are merely the brand leaders whereas banks are the product leaders.

68 Scarborough and Lannon (1989).

external sources through interaction with other agencies, where users (particularly leading-edge users) act as collaborators in the innovative process.

The 'fifth generation process' is marked by strong linkages between leading-edge users and suppliers. It seems that electronic cash is a child of Roy Rothwell's 'fifth generation'.[69] As many of the interviewees observed, banking institutions cannot succeed on their own. Not only will it be difficult for a single bank to introduce the technology, but also it will be equally difficult for banks to act independently. With the involvement of the credit card schemes, the telecommunication operators and the technology suppliers, it has become clear that the many players in the market may have become mutually interdependent. According to one interviewee, the survivors in the industry will be those who seek to integrate players of different kinds.

Past linkages are important too. When organisations have had profitable interactions in the past, they tend to be more likely to collaborate in the future. For example, it was partly due to Barclays' relationship with Visa that the bank decided to run a Visa Cash pilot. The same applies to Lloyd-TSB and its allegiance to Visa. British Telecom joined the Mondex Swindon pilot due to the significant business relationship they have with NatWest Bank. Some of the interviewees observed that collaboration is necessary in the electronic cash market, especially in the early stages before the service product becomes commercially viable. Initially standardisation and regulatory issues must be developed in a collaborative environment. Competition arises when the product has been successfully launched. In the case of electronic cash, this has yet to happen. The blurring of boundaries whereby the definition of banks, technology suppliers, credit card schemes and telecommunications operators will become more and more nebulous is beginning to occur as become increasingly horizontally integrated.

This has certainly been the case with Mondex International, as it has been involved with various players other than banks, including Sun Microsystems[70], British Telecom and AT&T. Mondex International has also been instrumental in creating the MAOSCO[71] consortium, which involves a group of players from the smart card industry. Their aim is to make what was initially developed by Mondex, MULTOS[72], an industry standard. The consortium also, includes companies such as Hitachi, MasterCard International and Motorola. This is an example of integrated parallel development and collaborative research groupings.

4.5 Mondex and Digicash

In contrast to Mondex, the technology provider DigiCash has not been as active in collaborative ventures, although its representatives believe that collaboration is on the rise. DigiCash did not have any bank involvement in its development of Ecash technology[73]. Over the last couple of years, the company has been seeking more bank participation, for instance from Mark Twain Bank in the United States and Deutsche Bank. DigiCash representatives indicated that this is due to the fact that their visibility to the banking industry has increased. Their technology had been in its developmental stages but is now ripe and can be marketed to banks and other players. The difference between DigiCash and Mondex is that NatWest did not wait until the Mondex product was fully developed to seek collaborative links. Whether Mondex as a product has benefited from these industry links remains to be seen. However, the company now has the backing of a number of key players.

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69 Rothwell (1992).

70 In the Spring of 1997, Mondex International agreed to work with Sun Microsystems in the development of the JavaCard.

71 MAOSCO stands for Multi-Application Operating System Consortium.

72 MULTOS is the multi-application operating system for smart cards. It has the potential to allow many different operating systems on one smart card.

73 Brown and Capelli (1996), p. 184.

It seems the future of electronic cash will rely heavily on collaboration. Many of the interviewees agreed that the industry is heading in that direction. According to one, competition will most likely arise in the future not with respect to infrastructure, but in value-added services markets. At this time, the infrastructure and the basic service are still being refined and, for this reason, collaborative ventures are on the rise. Fragmentation of the market could slow down the diffusion process. It remains to be seen to what extent this collaborative environment will give way to a competitive one if the product becomes commercially viable.

4.6 Ensuring Widespread Acceptance

The involvement of banks may be necessary for the further diffusion of electronic cash. They are 'lead users' of the technology and in this respect provide an effective 'need-forecasting' mechanism. However, this is not to say that their participation in the industry will guarantee the commercial success of the product. The main obstacle to the proliferation of electronic cash and its commercial viability is mass acceptance. The factors that may contribute to ensuring or speeding up the widespread acceptability of this payment technology are discussed below.

The technology providers pointed to a major catalyst for the diffusion of electronic cash: convergence. This concern is reflected in the recent activities of both Mondex and DigiCash. Although DigiCash has focused on Internet payment systems over the last five or six years, it is now looking to integrate its Ecash product with smart card technology.[74] Similarly, Mondex is essentially a smart card product, initially designed for the purpose of transactions in the physical world. Mondex and AT&T have announced that they will be launching a micro-payment solution for the Internet. The innovators of the technology at NatWest intended to address remote applications. The Internet is simply a type of remote application. The fact is that both Mondex and DigiCash are aiming at the same market, but from two different directions. This was a case of strategic planning for DigiCash. In the early 1990s, this forward-looking technology provider saw the Internet as a possible medium for large-scale commercial transactions. At that time, banks, such as NatWest, did not believe that the Internet would be a significant phenomenon but, rather one, which would be restricted to a small group of academics. In this respect, the technology provider had the advantage. However, due to the lack of banking involvement, it seems DigiCash did not create a product as attractive to banks as Visa Cash or Mondex. DigiCash now realises that in order to ensure widespread acceptance of Ecash, they have to assume that the consumers will retain many of their existing habits.

As the DigiCash representatives indicated, the solution is to provide consumers with the appropriate tools to maintain their payment habits. In other words, Ecash must be converged with smart cards and made available both in the physical and in the virtual worlds. Banks view the Internet as an application of smart card technology and a logical progression from this. Mondex value is now, for example, being loaded via telephones in Swindon, and the PC would simply provide a different delivery channel. Some still see the Internet network as a niche market and banks as mass market players. Others see the Internet as the main catalyst to the diffusion of electronic cash technologies. Still others believe that, in order to be commercially successful, payment systems on the Internet must be tangible and card-based rather than pure electronic products. Although views on the role of the Internet differ, the common thread is that technological convergence plays a significant role in ensuring the future acceptance of electronic cash as a payment medium.

Other factors, which have the potential of speeding, up the diffusion process. For example, a catalyst application may be required as an impetus to usage. This could be anything from a transport application to the adoption of the technology by a mass market retailer. However, the perfect catalyst application does not exist and this is similar to related 'convergent' electronics services markets such as the entertainment services markets. The key to the market is finding the 'right' infrastructure, such as the telephone network or another suitable delivery channel. There also is a need for government to

[n] No formal plans had been announced.

set the ground rules. This, of course, would require organisations to co-operate in order to set standards and specifications. An increase in collaboration may be one of the main factors leading to the widespread acceptance of the electronic cash products. A multi-application product, one, which can only be created through collaborative ventures, may also be needed and market fragmentation will need to be avoided.

The government's role in stimulating the diffusion process was raised by several interviewees who stated that the government should take a decisive role in the standardisation of smart card technology. This could be achieved, for instance, by issuing smart cards for the purposes of social security or health insurance. Countries like France may be more likely to take the lead in this matter. The role of the European Union was also mentioned in the acceleration of the diffusion process. The introduction of the EURO currency may also prove to be a catalyst for the introduction of smart cards. This would address what some have indicated as one of the main obstacles to the diffusion of a multi-currency card, that is, the lack of a regulatory structure that could guarantee its electronic value.

5 Conclusion

This working paper has considered the extent to which banks can be considered lead users of electronic cash technology. Banks are early adopters of the technology, as well as lead or leading edge users. Among the various players involved in the market (such as telecommunication operators, technology providers and credit card schemes), banks have the requisite know-how and the strong need to innovate in this field. The benefits they stand to derive from innovative activity in payment systems place them in a unique position in the supply chain. They are user-initiators as well as suppliers of electronic cash and, in this regard, can play the role of a need-forecasting laboratory. The obstacles they face in terms of the lock-in of traditional operations are not as significant as they may seem at first glance. Moreover, their involvement in the development of electronic cash is crucial at this early stage. This is not to say that banks will continue to play a similar role in the further diffusion of electronic cash, nor does it imply that their participation guarantees the widespread acceptance of the innovation.

This examination of a financial services innovation has demonstrated the importance of industry linkages, both past and present, to the development and diffusion of new technologies. With electronic cash, we are witnessing a prime example of what Rothwell calls a 'fifth generation' innovation process. Electronic cash is being developed in a competitive and collaborative environment and collaborative ventures are on the rise. Linkages between players in the market are pivotal to the development of a successful service product. This will continue to be the case until such time as regulations and standards have been set or until a commercially viable product has emerged. Following this stage, value-added services are likely to be offered on an increasingly competitive basis.

Horizontal integration and increased collaboration may not provide all the answers to successful innovation despite the fact that it seems that this is the present strategy of banks. There is an argument in the diffusion of innovation literature which suggests that the setting of collaborative standards which occurs too early may either lead to a wide array of incompatible solutions, or alternatively to the adoption of a less than optimal solution.[75] This means that the timing of regulation and government intervention must be carefully considered. In a market which is not yet mature, premature regulation may have the undesired effect of stifling innovation.

Of the two systems, it seems that Mondex fits best Rothwell's 'fifth-generation' innovation model. Unlike DigiCash, it has benefited from industry linkages and seems to be bringing in as many players of different kinds as possible. Moreover, the product has been developed through the use of a 'lead

[75] See David and Steinmueller (1990), p. 45.

user' and has, in this respect, more accurately forecast unmet needs and opportunities in the marketplace. The fact that DigiCash has not had the involvement of a 'lead user' in the development of its technology may place it at a disadvantage. It remains to be seen to what extent this situation will evolve. The fact that Mondex was developed by a 'lead user' does not mean that it will necessarily lead the market and, similarly, the fact that banks are 'lead users' of electronic cash does not imply that they will develop a commercially successful product or succeed in post-launch improvements.

Electronic cash is yet another stage in the evolution of 'invisible' money, which has its origins in the debasement of coinage, where the actual value of the metal in the coin no longer represented its face value. This new stage seems a logical continuation of the process that has been going on for as long as human memory stretches, i.e., the development of money from coinage to paper currency to electronic instruments.

Electronic cash will not automatically become the successor of physical currency. However, the way that money currently operates may be subject to a radical change over the next few decades. This change will most likely derive from the blurring of distinctions between the various categories of players: IT companies, banks, credit card schemes, telecommunications operators and so on. The future of electronic cash is strongly influenced by developments in the surrounding institutional structures and the advanced communication technologies and services infrastructure. This working paper has been written early in the development of the technology. A post-launch analysis would elucidate further the role of the various players and the importance of industry linkages in the innovation process.

Bibliography

Barras, R. (1990), 'Interactive Innovation in Financial and Business Services: The Vanguards of the Service Revolution', *Research Policy*, Vol. 19, No. 3, pp 215-237.

Barras, R. (1986), 'Towards a theory of innovation in services', *Research Policy*, Vol. 15, pp 161-173.

Brown, D. and Capelli, W. (1996), *Electronic Cash: Opportunities for Banks and IT Suppliers*, London, Ovum Ltd.

Casey, J.P. (1976), 'High Fructose corn syrup - a case history of innovation', *Research Management*, September, pp. 27-33.

Cassiolato, J.E. (1990), *The User-Producer Connection in High Tech: A Case-study of Banking Automation in Brazil*, Paper prepared for H. Schmitz and J. Cassiolato (eds): *High-Tech for Industrial Development*, Institute of Development Studies, University of Sussex.

Centre for the Study of Financial Innovation (1997), *The Internet and Financial Services*, London, City and Financial Publishing.

Chaum, D. (1992), 'Achieving Electronic Privacy', *Scientific American*, August, pp. 96-101.

Credé, A.(1995), *Electronic Commerce and the Banking Industry: The requirement and opportunities for new payment systems using the Internet*, 45th Annual Conference of the International Communications Association.

David, P.A. and Steinmueller, W.E. (1990), 'The ISDN Bandwagon is coming, but who will be there to climb aboard?: Quandaries in the economics of data communication networks', *Econ. Innov. New Techn.*, Vol. 1, pp. 43-62.

Fancher, C.H. (1996), 'Smart Cards', *Scientific American*, August, pp. 24-29.

Foxall, G.R. (1988), 'The Theory and Practice of User-Initiated Innovation', *Journal of Marketing Management*, Vol. 4, No. 2, pp. 230-248.

Foxall, G.R. (1989) 'User Initiated Product Innovations', *Industrial Marketing Management*, Vol. 18, pp. 95-104.

Foxall, G.R. and Murphy, F.S. (1985) 'Market Development in Practice: A Case Study of User-Initiated Product Innovation', *Journal of Marketing Management*, Vol. 1, pp. 201-211.

Gershuny, J. (1978), *The Self-Service Economy*, Paper prepared for the Acton Society Conference 'Growth, No-Growth and Other Dilemnas', SPRU.

Gibbons, M. and Weijers, T (1992), *Some Policy Implications of New Developments in User-Producer Relations*, Paper prepared for the Six Countries Project Meeting on User-Producer Relations held in Helsinki.

Plutarch (1928), *Plutarch's Lives*, Vol. 1, London, William Heinemann.

Institute of Advanced Business Systems (Hitachi) and Hitachi Research Institute (1993), *Payment Systems: Strategic Choices for the Future*, F.I.A. Financial Publishing Co.

Mowery, D. and Rosenberg, N. (1979) 'The influence of market demand upon innovation: a critical review of some recent empirical studies', *Research Policy,* Vol. 8, pp. 102-153.

Pavitt, K. (1994) 'Sectoral Patterns of Technical Change: Towards a taxonomy and a theory', *Research Policy*, Vol. 13.

Reed, C. (1996), *The Legal Regulation of Internet Banking,* London, Internet Law Project.

Reed, C. and Davies, L. (1995), *Digital Cash- The Legal Implications*, London, The Internet Law Research Project.

Rothwell, R. (1992), 'Successful Industrial Innovation: critical factors for the 1990's', *R&D Management,* Vol 22, No. 3, pp. 221-239.

Rothwell, R. (1994), 'Issues in user-producer relations in the innovation process: the role of government', *International Journal of Technology Management*, Vol. 9, Nos 5/6/7, pp. 629 - 649.

Rothwell, R. and Gardiner, P. (1985), 'Tough Customers: good designs', *Design Studies,* Vol. 6, no. 1, pp. 7 -17.

Rothwell, R. and Zegveld, W. (1985), *Reindustrialization and Technology,* London, Longman.

Scarborough, H. and Lannon, R. (1989), 'The Management of Innovation in the Financial Services Sector: A Case Study', *Journal of Marketing Management,* Vol. 5, No. 1, pp. 51-62.

Schmookler, J. (1962), 'Economic Sources of Inventive Activity', *Journal of Economic History*, pp. 1-20.

Smith, G.J.H. (1996), *Internet Law and Regulation,* London, FT Law and Tax.

von Hippel, E. (1976) 'The dominant role of users in the scientific instrument innovation process', *Research Policy*, Vol. 5, pp. 212-239.

von Hippel, E. (1977) 'Industrial Innovation by Users: Evidence, Explanatory Hypotheses and Implications', Working Paper, Alfred P. Sloan School of Management, M.I.T.

von Hippel, E. (1978) 'Users as Innovators', *Technology Review*, Vol. 80, No. 3, January, pp. 31-39.

von Hippel, Eric (1985), 'Learning from Lead Users', in Robert Buzzell (ed.), *Marketing in an Electronic Age,* Cambridge (Mass), Harvard Business School Press, pp. 308-317.

von Hippel, E. (1986) 'Lead Users: A Source of Novel Product Concepts', *Management Science*, Vol. 32, No. 7, pp. 791-805.

von Hippel, E. (1988), *The Sources of Innovation,* Oxford University Press.

von Hippel, E. and Herstatt, C. (1992), 'From Experience: Developing New Product Concepts Via the Lead User Method: A Case Study in a 'Low-Tech' Field', *Journal of Product Innovation Management*, Vol. 9, pp. 213-221.

von Hippel, E. and Urban, G.L. (1988), 'Lead User Analyses for the Development of New Industrial Products', *Management Science*, Vol. 34, No. 5, pp. 569-582.

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