Cyber money as a medium of exchange

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Summary

Electronic money constitutes (for the time being) the most recent innovation in payment instruments. The extent to which the further spread of electronic money might have consequences for monetary policy depends not least on the actual demand for electronic money. Numerous studies have sought to answer this question. However, those studies deal for the most part with the expected spread of electronic money in over-the-counter (OTC) transactions. As far as further developments in network money are concerned, though, it has not been possible to gain anywhere near as much in the way of insights. This is particularly amazing since from a monetary policy perspective network money, in particular, threatens the central bank's monopoly on money creation.

Against this background, this paper attempts to shed more light on the future spread of network money. It departs from the question as to the possible use of network money for transaction purposes. To answer this question, the paper studies a simple model which incorporates the demand for different payment media as well as their supply. In earlier studies, the influence of the supply side has in many cases only been partially included.

On balance, the study shows that cyber money will most likely not completely substitute other forms of money. Rather, a specialisation of different payment media for different transaction values is probable. Specialisation here means that only one payment medium is employed to buy a good. Here, analogously to the use of electronic money in OTC trade, network money is likely to assume the role of a medium of exchange used for small-value transactions.

Zusammenfassung

Elektronisches Geld stellt die (vorerst) neueste Innovation im Bereich des Zahlungsverkehrs dar. Inwieweit sich aus seiner Verbreitung Konsequenzen für die Geldpolitik ergeben, hängt nicht zuletzt davon ab, in welchem Umfang elektronisches Geld vom Publikum tatsächlich zu Zahlungszwecken eingesetzt werden wird. Zur Beantwortung dieser Frage liegt mittlerweile eine Reihe von Arbeiten vor. Die weit überwiegende Anzahl sowohl der empirischen als auch der theoretischen Untersuchungen bezieht sich jedoch auf den Einsatz elektronischen Geldes im stationären Handel. Weniger intensiv wurden bislang Fragen des Netzgeldes untersucht. Dies ist um so erstaunlicher, als aus geldpolitischer Sicht insbesondere Netzgeld das Geldschöpfungsmonopol der Notenbanken bedroht.

Vor diesem Hintergrund soll mit der vorliegenden Arbeit der Versuch unternommen werden, die voraussichtliche weitere Entwicklung des Netzgeldes näher zu beleuchten. Ansatzpunkt ist dabei die Frage nach seiner möglichen Verwendung zu Transaktionszwecken. Diese wird im Rahmen eines einfachen Modells untersucht, das sowohl die Nachfrage nach Zahlungsverkehrsdienstleistungen als auch ihr Angebot einbezieht, dessen Einfluß in der bisherigen Literatur oft nur partiell berücksichtigt wurde.

Im Ergebnis zeigt sich, daß Netzgeld andere Geldformen wahrscheinlich nicht vollständig verdrängen wird. Vielmehr dürfte sich eine Spezialisierung unterschiedlicher Zahlungsverkehrsmittel für bestimmte Preisbereiche ergeben. Unter dem Begriff der Spezialisierung ist dabei die Tatsache zu verstehen, daß für den Kauf eines Gutes nur ein Zahlungsverkehrsmittel eingesetzt wird. Dabei dürfte dem Netzgeld analog zum Einsatz elektronischen Geldes im stationären Handel die Rolle eines Zahlungsmittels im Bereich der Kleinbetragszahlungen zukommen.

Contents

List of tables and charts

Tables

Charts

Cyber money as a medium of exchange*

I. Introduction

The history of money has been characterised by evolution towards more efficient forms of money in terms of (transaction) costs. Electronic money (e-money) is so far the latest innovation. Up to now this new type of money has not made very deep inroads into Germany. At the end of 1998, there were 52 million *Geldkarten*, onto which electronic money can be stored, in the hands of the public. However, it must be borne in mind that the vast majority of those cards are eurocheque cards that have additionally been outfitted with a *Geldkarte* function. At the same time the value loaded onto all cards totalled merely DM 113 million. By contrast, the amount of cash in circulation excluding credit institutions' cash balances was slightly more than DM 242 billion at the end of last year. At that same time, software-based electronic money on the Internet issued in Germany, though, had not left the pilot project phase.

However, it would appear premature for monetary policy makers to conclude that there is no need to take action. In a report published last year, the European Central Bank tackled the issue of the possible consequences which the further spread of electronic money might have for monetary policy.[1] The extent to which they actually will appear depends not least on the extent of actual demand for electronic money. Numerous studies have sought to answer this question. However, those studies deal for the most part with the expected spread of electronic money in over-the-counter (OTC) transactions. Regarding further developments in network money which can be used on the Internet, though, it has not been possible to gain anywhere near as much in the way of insights.

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* This is an abridged version of Discussion paper 5/99 "Netzgeld als Transaktionsmedium" of the Economic Research Group of the Deutsche Bundesbank. This paper benefited from discussions that took place in workshops with colleagues from the Deutsche Bundesbank and the Oesterreichische Nationalbank, at the 47th International Atlantic Economic Conference in Vienna, and at the 74th Annual Conference of the Western Economic Association International in San Diego. Special thanks go to Frank Browne, Harald Nitsch, Aloys Prinz, Franz Seitz and Juha Tarkka for their comments. I also wish to thank my colleagues Hans Bauer, Johannes Clemens, Peter Schmid, Caroline Willeke and particularly Heinz Herrmann, Head of the Economic Research Group of the Deutsche Bundesbank, for many ideas and numerous comments on earlier versions of this paper. I am indebted to Frank Bickenbach for valuable suggestions, particularly for Section IV of this paper. Of course, all remaining errors are mine alone.

1 European Central Bank (1998).

This is particularly amazing since the question as to what role this form of money will play in the future has been answered nearly euphorically by followers of certain economic schools of thought. Those particularly deserving of mention here are proponents of increased competition in the monetary sector, known as the "free banking" school.[2] They especially hope that electronic money on the Internet will become a medium of exchange that can be brought into circulation independently of the prevailing central bank monopoly and that will exhibit desirable quality features in the sense of a stable and efficient monetary system. Titles like "The Internet and the End of Monetary Sovereignty" serve to show where the expected evolution will end.[3]

But even if no completely independent flows of money are generated with the help of network money, its widespread circulation is capable of having a considerable impact on monetary policy. The debate on what is called "New Monetary Economics" has recently been stimulated by the technical possibilities of innovations in payment systems.[4] Based on the assumption of a largely deregulated monetary sector, followers of this school of thought believe there will be a separation of different functions of money: in this system of separated monetary functions, transactions will be settled by marketable assets of variable value. In that scenario central bank money may take on the role of a unit of account, if at all.[5]

Against this background, this paper attempts to shed more light on the future spread of network money. It departs from the question as to the possible use of network money for transaction purposes.

This paper is structured as follows: Section II starts with a definition of the concept of network money followed by a brief description of the payment system on the Internet. The special features described in this section have an impact on the method of analysis. In

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[2] See, for instance, England (1997) and the literature on monetary competition quoted therein, based on Hayek (1977). See Pool (1998) for a critique of Hayek's proposal and for the empirical assessment for Germany of the conditions necessary for the proposal to succeed.

[3] Frezza (1997).

[4] For an overview of the most important theoretical contributions provided by New Monetary Economics, see Greenfield and Yeager (1983).

[5] See most recently Browne and Cronin (1996) and (1997).

particular, an empirical approach seems to have little chance of success at present. Therefore, the microeconomic explanation of the use of various payment instruments forms the centrepiece of this paper. Section III discusses, on the basis of Whitesell (1992), a theoretical explanation of the transaction-related demand for different media of exchange on the Internet. Section IV, the key chapter of this paper, extends the framework of Section III and analyses the interaction between the supply of and demand for cyber money. The resulting equilibrium will provide a tentative assessment of a plausible scenario for the spread of network money. Section V concludes.

II. Special features of network money

1. Definition

"Electronic money is broadly defined as an electronic store of monetary value on a technical device that may be widely used for making payments to undertakings other than the issuer without necessarily involving bank accounts in the transaction, but acting as a prepaid bearer instrument."[6]

Therefore, if the stored units of value can only be used to pay for certain goods or services and if the issuer and the acceptor are identical (single purpose schemes), this is not considered electronic money. Prepaid telephone cards are one example. A further distinction should be made between electronic money and products that provide electronic access to standard forms of money such as sight deposits. In this area, the use of eurocheque cards employed as debit cards has become particularly widespread in Germany.[7]

In the actual area of e-money, two different product forms have crystallised so far. One is prepaid cards. In this context the ECB uses the term "card-based products" and defines them as "(...) plastic card[s] which contain[s] real purchasing power, for which the

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[6] European Central Bank (1998), p. 6.

[7] Eurocheque cards can be employed as debit cards for EFTPOS payments (either with a PIN number in an electronic cash procedure or in the POZ method, i. e. point of sale without payment guarantee). For information on developments in these forms of payment in Germany see Deutsche Bundesbank (1997) and (1999).

customer has paid in advance (...).”[8] The other type is “software-based products” which serve typically to transfer electronically stored value units via telecommunications networks such as the Internet.

The term “network money” should not be regarded as synonymous with a certain type of electronic money product. Although it contains software-based products, card-based products must also be included insofar as they are also employed in telecommunications networks with the help of card readers to make payments.[9]

2. The payment system in different marketplaces

The use of network money as a payment instrument in (Internet) trade will also depend on what alternative payment instruments are available. This raises the question of the payment system on the Internet. For the sake of comparison, the payment system for OTC trade will be briefly outlined first, without going into further detail on the individual payment instruments.

2.1. The payment system for OTC trade

Payment instruments are usually classified according to the onset of the liquidity effect, from the point of view of the payer, i. e. the purchaser of a good or service. The “liquidity effect” is defined in this context as an interest waiver, since it is no longer possible to invest the funds in an interest-bearing way. To that extent, classifying different payment instruments reflects an important component of the transaction costs which accrue to the payer: in the event of liquidity effect prior to receipt of the good, the buyer incurs opportunity costs in the form of lost interest income. If the good is paid for after receipt, the cost calculation should take interest gains into account. In this sense, for instance, cash is a payment instrument which is categorised as “pay before”. From the moment cash is

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[8] European Central Bank (1998), ibid.

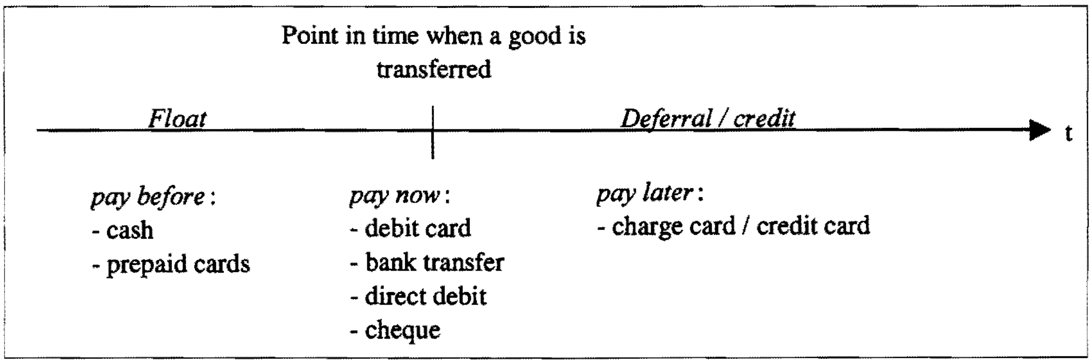
[9] Rojas (1996) makes a distinction in this context between off-line money (= card-based network money) and on-line money (= software-based network money). These terms, though, do not seem particularly well-chosen as they might lead to confusion in connection with the terminology of the OTC payment system. It is true that the term off-line transaction is used here, too, in connection with card-based electronic money. However, this term's counterpart referring to the on-line authorisation necessary to use a debit card does not describe an alternative form of electronic money but is an access product instead.

withdrawn, i. e. even before the time of the actual purchase, its holder relinquishes the opportunity of collecting interest.

By contrast, in the case of a prepaid instrument of payment, its issuers have what is known as the "float" at their disposal. The use of a payment instrument where the liquidity effect sets in after transfer of the good involves a deferral of payment or a credit to the buyer.

For OTC trade the following description of the main payment instruments can be derived:[10]

Chart 1: Payment system for OTC trade



The categories "pay before", "pay now" and "pay later" each contain different payment instruments the buyers have at their disposal. The classification of the various payment instruments shown in Chart 1, however, is merely a rough orientation. By no means should one conclude that payment instruments belonging to the same category will all take liquidity effect at the exact same time for the person making a payment. For example, owing to the required processing time, the liquidity effect of a eurocheque will probably be different from that of a payment by debit card authorised on-line. The same applies to the different liquidity effects of charge cards (where the payment is deferred until the amount is debited, usually monthly — with no credit option) and credit cards, provided the credit option is utilised. Nevertheless, the above classification illustrates the general nature of each payment instrument.

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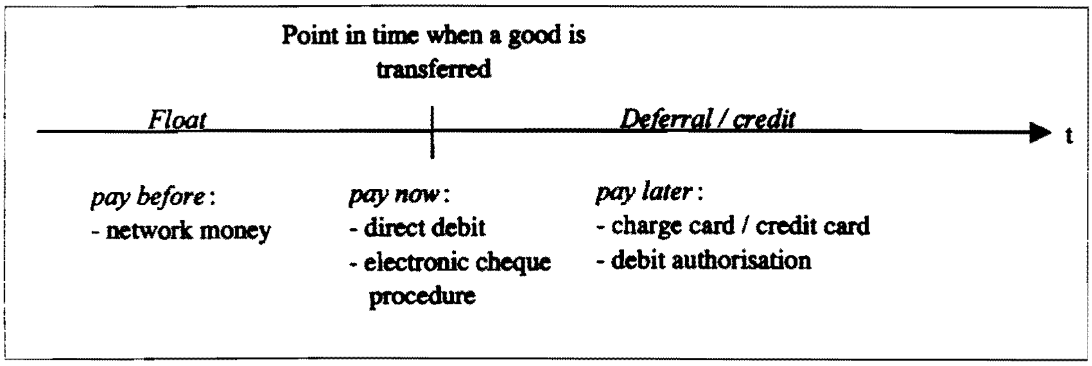
10 See, for instance, Dickertmann and Feucht (1997), p. 67; or Büschgen (1998a), p. 432.

2.2 The payment system on the Internet

Existing payment instruments are used to settle some of the payment transactions executed via the Internet. This is only establishing access using a new medium. Moreover, there are in some cases already electronic equivalents of the payment instruments shown in Chart 1; for some of them their (technical) implementation is just a matter of time.[11] Finally, there are also payment instruments specially devised for the Internet. Analogously to the chart for OTC trade, the payment system on the Internet can be roughly outlined as follows:[12]

Chart 2: Payment system on the Internet



When applying the standard classification of payment instruments to the Internet environment, a limiting factor must be noted: owing to the medium involved here, the intervals between the liquidity effects of different categories are often shortened considerably. This is less so in the area of pay later instruments, which only establish access via the Internet without changing the settlement periods of the issuer. By contrast, the time interval between the liquidity effects of payment instruments belonging to the other two categories is likely to decrease. However, the specified classification still maintains a certain justification in that it highlights the key features of the payment

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11 The payment system on the Internet will only be briefly sketched in this report. For a more detailed description see, for instance, Furche and Wrightson (1997), Schuster, Färber and Eberl (1997), Stolpmann (1997) or Weißhuhn (1998). In particular, the aforementioned literature contains explanations of the security strategies associated with each payment instrument.

12 Here, it should be noted that not all on-line purchases of goods or services are paid for within this medium. Actually, goods ordered over the Internet in Germany are paid for largely by invoicing or C.O.D. (Voss (1998)). In Chart 2, by contrast, only payment instruments which can be used to pay directly on-line are taken into consideration.

instruments being considered here. They, in turn, influence the costs associated with the payment instrument, which will be at the centre of the following theoretical analysis.

The payment systems environment on the Internet deviates from that of over-the-counter trade in that there is no anonymous, final, cash-like payment instrument which serves as an alternative to e-money. Pay before instruments are only available in the form of network money. This type of money can be employed two ways:

- Firstly, software-based systems have been tested in pilot projects for quite some time already (in Germany since 1997).[13] At the centre of the system whose features are probably most similar to those of cash is what is called an electronic purse, which is installed on the PC of the payer supported by a special type of software. It can be used to store electronic value units (tokens) for later use, which are loaded by the customer and certified by the issuing bank. The anonymity of the payment transaction is guaranteed by encryption methods which make it possible for the issuer to verify the authenticity of a token submitted by a third party without the identity of the consumer being revealed at the same time.[14] In addition, a further Internet payment system is being tested in Germany at present; however, it does not involve electronic money as defined by the ECB. For the consumer, though, it is similar to electronic money in terms of the need for special software as well as its use (electronic purse). This system centres on shadow accounts, "cash containers", held both by the payer and the traders receiving the payments. However, they are held not on the PC at home but centrally by the issuer.[15] Hence, this is not a bearer instrument.

- Secondly, there are card-based systems which allow electronic money saved on prepaid cards to be sent on the Internet with the help of a reading instrument linked to the consumer's PC.

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13 For the German pilot project see Blakowski, G, C. Blum and C.A. Gerlof (1997).

14 On the method of blind signature used in this context see Chaum (1997). On further details of the system, see DigiCash (1998).

15 See CyberCash (1999).

From today's perspective it is unclear whether one of the two types of e-money products will eventually prevail on the Internet and which one will do so. The card-based variant is supported, in particular, by the fact that it can also be used in OTC trade.[16] By contrast, the security technology presently available seems to favour the software-based type of network money.[17]

In the category of Internet payments that take place simultaneously with the transfer of the good, there are basically several electronic types of conventional payment instruments: they include not only the electronic (collection-only) cheque procedure[18], but also electronic direct debiting. However, the aforementioned systems are at different stages of development. Moreover, they are not available to all Internet purchasers — depending on the regulatory stance regarding contracts signed electronically. The problem these payment instruments generally share is the legally binding nature of electronic signatures. To use the procedures belonging to this group, generally both sides of the market need a special software with which the payment is automatically executed. The security of the instruments described depends on whatever encryption methods are used when transmitting the data.

As regards the pay later methods of payment on the Internet, in addition to the unsecure exchange of information necessary for payment transactions (such as credit card numbers) between the purchaser and the trader, there are mainly two basic models of a secure system:

- Firstly, there are systems where the data required for the transaction are encrypted before being sent. A special software installed on the participating computers is used for encryption.[19]

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16 See, for example, Pauli and Koponen (1997), p. 12; von Radetzky (1998), p. 59; and Rodewald (1998), p. 22.

17 Rojas (1996), p. 239.

18 See, for example, Netcheque (1999).

19 The development of SET (Secure Electronic Transaction) could set an open standard for the encrypted transmission of confidential information through open networks. It is true that this standard is suited to the secure transmission of information, very generally speaking. However, since this communication standard was developed at the urging of credit card companies, it is especially likely to be used for credit card transactions on the Internet. See, for instance, Judt, Bödenauer and Andlinger (1998), p. 774. However, it must be noted that SET by no means represents a complete payment system. See, for instance, Stolpmann

- The second model is a debiting system linked to different types of assets — analogous to the charge card principle. These are payment instruments where the operator has a binding contractual relationship with both consumers and traders. The trader receives payment from the operator of the system and the consumer receives a bulk invoice at regular intervals. Payment can then be made either by credit card or by directly debiting the amount from a sight-deposit account. If the payment is linked to a credit card, the settlement described here can be regarded as a secure procedure insofar as there is no need to pass on confidential card information over the Internet for individual transactions. Rather, this information only has to be transmitted once, such as in the application sent to the system operator along secure communication channels, i. e. by phone or mail. Besides being used for payments in closed systems, such as, and in particular, shopping malls, this method of making payments secure can be used in general for credit card transactions on the Internet, too.[20]

3. The analytic approach

Recent studies have tackled the issue of what consequences electronic money will entail for monetary policy. The vast majority of both the empirical and the theoretical studies, however, refer implicitly or explicitly to the use of electronic money in the form of prepaid cards for over-the-counter trade, whereas up to now the issue of network money has not been studied as intensively.

Most studies focus on the role that electronic money is likely to play as a payment instrument in the future. This approach will be followed here, too. As opposed to network money, though, the use of e-money in over-the-counter trade is foreseeable, not least because there is already experience with systems introduced on the market. There is not much dispute concerning the fact that primarily cash will be substituted as a payment

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(1997), p. 74. Instead, the SET protocol is to be integrated into the payment system software, which is then accessed during the payment transaction by the parties involved.

20 See, for instance, First Virtual (1999).

instrument for low-priced goods, even if there is less agreement about the expected extent of the substitution process and its importance to monetary policy.[21] [22]

By contrast, from today's perspective, the empirical evidence of the actual use of network money, such as for low-value payments, is insufficient. As mentioned earlier, the use of network money issued in Germany is still in the pilot project stage. To that extent, therefore, one cannot rule out the possibility that in future nearly the entire spectrum of Internet transactions will be paid with network money.

Furthermore, the payment system in which network money is taking up position is different from that of over-the-counter trade in that there is not necessarily a satisfactory solution applicable to all transactions, particularly to trade in low-priced goods. For example, there is no final payment medium that is comparable with cash. In that case, network money, however, would not just be a substitute but also a complement within the payment system once a new market is opened up by network money. In addition, a further dynamic development of trade on the Internet is expected, which means we would be ill-advised to base our analysis on the existing volume of transactions. Thus, the scope of a discussion dealing solely with the substitution of existing payment instruments by e-money would inevitably be too limited.

Therefore, a more fundamental approach has been chosen here: against the background of the theoretical discussion concerning the demand for and the supply of different media of

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[21] See, for instance, Alejano and Peñalosa (1998) for calculations of the cash substitution to be expected in Spain. Boeschoten and Hebbink (1996) calculate the expected spread of electronic money in over-the-counter trade in the G-10 countries. See also Jansson and Lange (1998) for similar calculations for Germany.
The aforementioned calculations are based, *inter alia*, on assumptions concerning the processes of substitution to be expected between prepaid cards and established payment instruments, particularly cash. If it may be assumed that electronic money in OTC trade will be in a well-defined ratio to the cash substituted, then the contraction of the demand for cash can be calculated based on a plausible average amount of e-money per prepaid card. For example, given an equal velocity of circulation of electronic money and cash, the former would substitute the latter to the same extent. However, the velocity of circulation of electronic money is likely to be higher than that of traditional forms of money. See Ruckriegel and Seitz (1999), p. 233. As an alternative, assumptions on the probable replacement of certain denominations of cash or a careful analysis of the frequency of certain payment amounts may serve as a basis for benchmark scenarios regarding the substitution of cash.

[22] See, for instance, Bank for International Settlements (1996), Berentsen (1998), European Central Bank (1998) or Söllner and Wilfert (1996) for an overview of possible monetary policy consequences of widespread cash substitution by electronic money.

exchange, the objective of this study is to ascertain which role network money can play in payments on the Internet of non-banks in future. Other authors take a similar approach by using microeconomic models grounded in the transactions motive of holding money as a basis for gaining further insights into the spread of electronic money to be expected. The two groundbreaking papers on this subject were written by Whitesell (1992) and Santomero and Seater (1996). The latter paper, though, analyses only the demand for various payment media. Based on an extension of Whitesell (1992), Folkertsma and Hebbink (1998) examine the behaviour of purchasers of a good or service when choosing which payment instrument to use as well as the consequences for the use of electronic money. Shy and Tarkka (1998), by contrast, study a model which takes into account the decision-making problems of all parties involved, including purchasers, issuers of prepaid cards and traders. The aforementioned papers, though, are all restricted to an analysis of payments in OTC trade. By contrast, Prinz (1999) explicitly studies the potential spread of network money by applying a Lancaster approach to the problem faced by the purchaser of a good or service in trying to decide which payment medium to use.

The model introduced in Section IV differs from the cited literature insofar as it, for one thing, explicitly tackles the problem of the future spread of electronic money on the Internet. For another, the analysis is not limited to the payer's decision between different payment media. Rather, the behaviour of payment services providers is also included.

III. Whitesell's model of the demand for different payment media

Only recently has the issue of using different forms of money for transaction purposes been studied more closely from a theoretical perspective. In addition to the inventory theoretic approach by Santomero and Seater (1996), which is based on Baumol (1952) and Tobin (1956), the model developed by Whitesell (1992) provides a theoretically substantiated explanation of the demand for different payment media.

One characteristic of Whitesell's model compared to that of Santomero and Seater is a more differentiated cost structure. To that extent it can be understood as a formalisation of the widespread assertion to be found in the literature on e-money that the costs entailed by cyber money are likely to have a decisive influence on its future. There are now a series of papers that analyse the costs and benefits of network money to those involved.[23] Another thing is that the underlying cash-in-advance condition as a determinant of money demand, which results in the individual decision-making problem being, relatively speaking, less complex than in the inventory theoretic approach, implies a clearer relationship between the costs and the use of the various payment media. Therefore, in the following the Whitesell model will form the basis for taking a closer look at the demand for different payment media on the Internet.

The framework of Whitesell's model is as follows:

- The individual's problem consists only in minimising the costs of predetermined purchases of goods. The individual receives a fixed income which is distributed evenly (Y for each value of transactions) across the range of goods, i.e. the same amount is spent on each type of good. The goods are distinguishable by their different prices (p_i). Instead of looking at different transaction volumes, the approach looks at varying transaction frequencies n_i. These are an inverse function of the transaction values: the higher the price of a given good, the less frequently it will be bought during the one period considered here.

- One period is being observed here. At the beginning of the period, similarly to other cash-in-advance models, the decision on assets has to be taken. The transactions are settled at the end of the period.[24]

- The original model examines three different payment media — cash, cheques and credit cards in OTC trade — specifying the costs they each entail. Basically a similar approach is possible for Internet trade and will be used in this section for the optimisation problem faced by the purchaser of a good or service. Thus, electronic cheque

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23 On the cost-benefit structure of e-money and its significance, see, for instance, Büschgen (1998b), Dickertmann and Feucht (1997) or Herreiner (1997).

24 As opposed to an inventory theoretic approach, in the Whitesell model transaction costs are minimised not by determining the withdrawals during the period but only by choosing the media of exchange once at the beginning of the period. Folkertsma and Hebbink (1998), however, have shown that incorporating the inventory approach into Whitesell's model is both possible and worthwhile. However, it does not alter the basic structure of the findings.

procedures, payment (in a secure or encrypted way) by credit card and cyber money will be examined here.[25]

Following Whitesell, the costs to the purchaser which each medium of exchange entails are specified as follows:

	Costs per transaction	Transaction costs per period per type of good n	Opportunity costs per period per type of good n
Cyber money	$(\beta_E)+kp$	$(\beta_E n)+kY$	$(r-r_E)Y$
Electronic cheque	β_S	$\beta_S n$	$(r-r_D)Y$
Credit card	1	n	-

Here β_i designates the fixed costs per transaction. Those of a credit card payment are normalised at unity; for those of a payment by cheque the following shall hold: $0<\beta_S<1$. In addition to transaction fees charged by the issuer of a payment medium, this cost component may also include the time required for a transaction using that particular payment medium. It could be argued here that the use of network money may be less time-consuming compared with the other payment media because the money has already been authorised prior to the purchase. In software-based systems there are tokens on the hard drive of the customer's home computer, whereas in card-based systems there is value stored on prepaid cards. It can only be estimated with difficulty to what extent this argument actually brings its weight to bear, in terms of network money transactions requiring less time, and it depends on future technological developments. For example, as part of the software-based e-money system currently being tested in Germany, merchants consult the network money issuer to settle each transaction, which means that at present the time required by each of the three payment media is likely to differ only fractionally. Anyway, on account of the speed of electronic communications, there will probably be no major differences, either. For simplicity, let us assume here that this cost component will not play a role.

That leaves a potential fee charged by the issuer for each transaction as the determinant of fixed costs entailed by paying with network money. It is certainly possible, given the

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25 See Section II.2.2 of this paper.

software-based systems existing today, to levy such a fee due to the participation of the issuer in the transactions.[26] However, the more it becomes possible in the future to transfer e-money from customer to customer without involving a central body, the less possible it will be to levy a fee. In other words, the more closely future network money systems resemble cash, the more apt it would seem to set up a model incorporating costs to the purchaser of using network money which do not contain a fixed cost component. In the following, therefore, we will assume the fixed costs of a network money transaction, β_E, to be zero. This assumption has no severe impact insofar as the results compared to the original Whitesell model are unchanged as long as the fixed costs of a network money transaction are lower than those of all other payment media, which is still the case.

However, for network money account will be taken of the fact that as the amount of money transacted rises, so do the risks involved. This is justified insofar as payment using cyber money as a bearer instrument is the only form of payment where purchasing power is transmitted via the Internet. The same risks of loss, theft and counterfeiting that apply to cash also apply to network money, in principle. The model parameter k represents these risks in proportion to the transaction volume.[27]

Whitesell's assumptions with respect to the opportunity costs entailed by each form of payment, are motivated not only by their varying liquidity effect but also and in particular by their linkage to different assets. Whereas cheques can be cashed on deposits, credit card purchases can be settled through (money market) fund shares. As already shown in section II.2, however, the non-coincidence of the liquidity effect of the payment media can also be regarded as an important determinant of the opportunity costs. This has consequences for the possible constellation of the model parameters. If one focuses on the different links, the return on the balances held for cheque payments and for credit card payments are the same

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26 With one exception, the electronic money systems available at present do not permit *purse-to-purse* payments, i.e. unlimited payments between individuals. This is true of most card-based systems. The same holds for the software-based system described in Section II.2.2 where the tokens are returned to the issuer after being used once.

27 It is true that such risks also exist for other payment media, such as credit cards. Unlike network money, which is a bearer instrument, theft of the credit card number does not automatically lead to the loss of real purchasing power. In the example cited here the owner of the credit card has the option of blocking the card. The key assumption concerning the model results is not so much that payment instruments on the Internet are risk-free, with the exception of network money. Rather, the decisive factor is that the risks of loss, theft and counterfeiting are the highest, relatively speaking, for cyber money.

if the interest earned on the underlying assets is the same. By contrast, focusing on the non-coincidental settlement of the payments will lead to the opportunity costs of paying by cheque being able to correspond to those of payment by credit card only if deposits bear a higher rate of interest than the asset used to settle a credit card payment. If, however — as is customary in Germany — both payment media are usually linked to deposits, this possibility does not apply. By contrast, it is technically quite possible to offset network money's liquidity effect preceding that of payment by cheque by allowing the stored value to bear interest, since this lead time — as opposed to a comparison between a cheque and a credit card — does not go hand in hand with transferring the assets to the seller of a good or service. Pay before payment media, rather, remain in the hands of the purchaser up to the point in time of the transaction, i.e. until the point in time of the liquidity effect of the pay now instruments. The model parameter r designates either solely the interest borne by the asset backing the credit card purchases or also additionally the time lag of the debiting, depending on the interpretation of opportunity costs chosen here. r_D denotes the interest on the deposits and r_E denotes the interest borne by the network money balances.

Finally, it should be remarked that installation costs, i.e. fixed costs that are not dependent on the transactions, are not included in Whitesell's model. In the case of Internet payments, this specification does not appear to be unproblematical at first glance. However, it could be argued that they are incurred by all payment instruments being examined here and therefore will most likely not differ all that greatly. All the same, the potentially high costs of installation could mean that only one form of money will be used.

The cost structure can easily be used to draw conclusions on how different payment media are used. For example, network money has, by assumption, the lowest fixed costs per transaction and will most likely be used for low-value transactions (having a high frequency).

Let m be the largest value of n up to which, starting from zero, the consumer uses credit cards, and let M be that value of n starting from which network money is used. Further, let N be the maximum frequency observed in this model. The assumption of an upper bound for n corresponds to that of a lower bound for the transaction value. In reality, there is certainly a minimum price at which goods are traded, which means that the assumption of a maximum transaction frequency included in the model seems plausible and necessary. If $0 \leq m \leq M \leq N$ holds, this leads to the following optimisation problem for the customer:

$$\underset{m,M}{Min} \int_0^m n dn + \int_m^M ((r - r_D)Y + \beta_S n) dn + \int_M^N ((r - r_E)Y + kY) dn \tag{1}$$

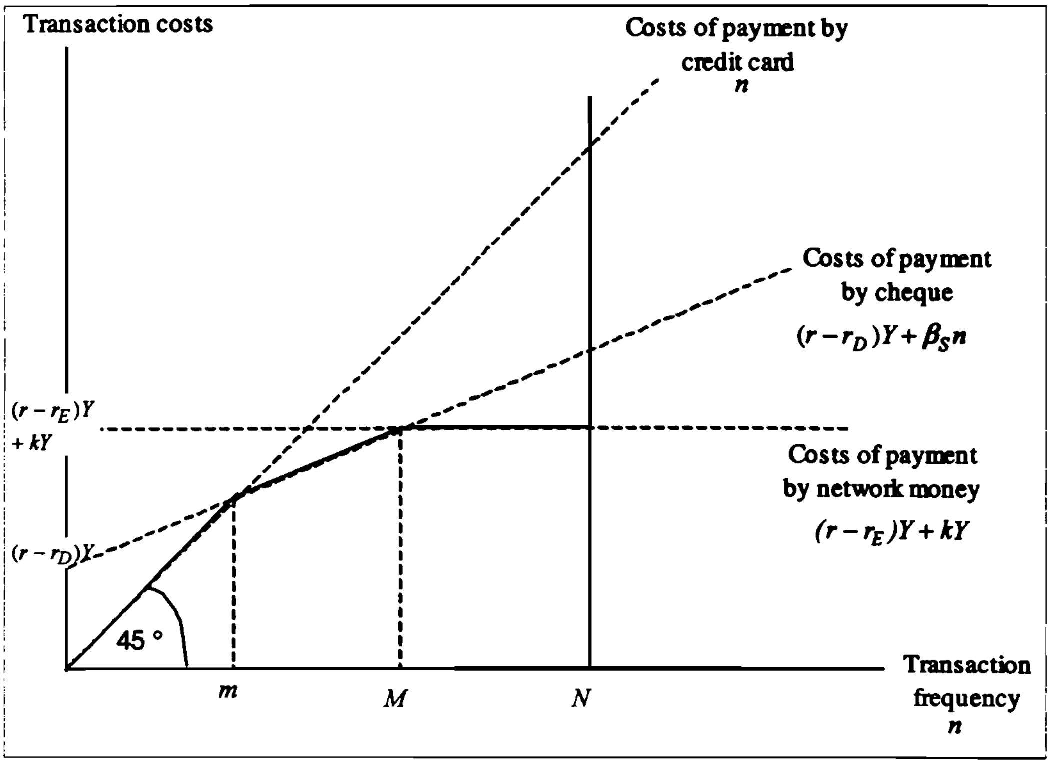
The first-order conditions lead to those values of *m* and *M* which minimise transaction costs (The second-order conditions are fulfilled.):

$$m = \frac{(r - r_D)Y}{1 - \beta_S} \tag{2}$$

$$M = \frac{((r_D - r_E) + k)Y}{\beta_S} \tag{3}$$

The graphic representation of the different transaction segments illustrates the findings:

Chart 3: Distribution of payment media according to Whitesell



In the area from zero to *m* (high-priced goods) payment is made by credit card; in the zone between *m* and *M* by electronic cheque; and from *M* (low-priced goods) by network money. In Whitesell's model, in an optimum a relationship is established between the bounds of the segments within which transactions are uniformly made with one specific payment medium and the model parameters (income and cost structure). If, for instance, the fixed costs of a cheque payment β_S fall, the curve of the costs of a cheque payment shown on the chart flattens, m shifts to the left, and M shifts to the right. The cheque payment zone is extended at the expense of the other two zones. The following table sums up the relationships.

Table 1: Causality in Whitesell's model

		Endogenous variables		
		$m-0$ Credit card payment zone	$M-m$ Cheque payment zone	$N-M$ Cyber money payment zone
Exogenous variables	k Risk parameter	No effect	+	-
	Y Expenses per type of good	+	+	-
	N Maximum transaction frequency	No effect	No effect	+
	r Market interest rate	+	-	No effect
	r_D Interest rate on deposits	-	+	-
	r_E Interest rate on cyber money balances	No effect	-	+
	β_S Fixed costs per cheque payment	+	-	+

Here it must be noted that the reactions of the endogenous parameters in Table 1 to changes in the model parameters have been derived under the assumption that both in the old optimum and in the new optimum all three payment media are used.[28] Otherwise some effects might vanish. For example, assuming a situation where $M = N$, a further rise in the risk k associated with a network money payment can neither lead to an extension of the transaction segment for cheque payments, nor does it reduce the segment taken up by network money. In fact, network money was not even employed in the starting situation,

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[28] This corresponds to the assumptions that $M > m$ or $k > \frac{r - r_D}{1 - \beta_S} - (r - r_E)$ and $N > M$.

since the low-value payments where there would be a cost advantage in using cyber money were lower than the lowest-value transaction actually made.

In Whitesell's model, the focus of this section, the main feature of the optimum state is the general fact that the use of payment media becomes specialised depending on the costs of using each respective payment medium. They can be classified under certain transaction segments by the frequencies of a transaction or by the price of the goods purchased. Here, network money assumes the role of a medium of exchange for low-value payments.

In the light of the key role played by the costs of using each medium of exchange, it would be desirable not to incorporate them exogenously in the determination of optimal payment patterns. Rather, it would be preferable to derive them from plausible assumptions concerning the behaviour of the issuers. This will be done in the next section.

IV. Interaction between supply and demand

In his model, Whitesell (1992) looks at the decision problem of a (monopolistic) credit institution that accepts deposits upon which cheques can be drawn. By setting the costs of payment by cheque $r - r_D$ and β_S, the bank can ultimately determine the segment within n where payments are made by cheque. Whitesell assumes here that the decisions taken by the other issuers of payment media are exogenously given. The credit card industry has set its costs per transaction (normalised at unity), and the transaction costs of cash issued by central banks are also given. Under these assumptions (and if N is defined suitably), the transaction segment for cheques that maximises the credit institutions' profits can be derived. It turns out that this segment — apart from marginal solutions — makes up half of the overall transaction space.[29]

The optimisation problem faced by an issuer of network money, however, differs from that considered by Whitesell in important respects. For one thing, the transaction segment covered by cheques is potentially threatened from both sides by other payment media. By contrast, the transaction segment covered by network money — as shown in Section III —is at the right-

29 See Whitesell (1992), p. 488ff.

hand side of the spectrum of frequencies being considered here. This makes the assumption of a maximum transaction frequency or a minimum price at which a good is still traded a decisively important one, since it places restrictions on the possible transaction segment of the issuer of network money, thus "forcing" the issuer to compete with other payment media. For another thing, in Whitesell's model, the issuer of cheques basically has two decision parameters: interest borne by deposits and the fee associated with a transaction. The extent to which a transaction fee can be charged for network money, however, depends on the extent to which network money takes on the character of cash in future — as was discussed in Section III. Since network money should in principle be able to be passed through the Internet in independent flows of circulation in the model being discussed here, we will continue not to incorporate a transaction fee for this medium of exchange. Therefore, it remains for the issuer to decide on the potential rate of interest on cyber money balances. In the case of independent circular flows of network money, this would be interpreted as interest reaped by the initial holder, who during this one model period under consideration holds cyber money in order to make transactions at the end of this period.

Besides these modifications of the Whitesell model, which are more of a technical nature, it would seem desirable also to make a fundamental extension to the decision problem faced by an issuer of payment media. It can hardly be assumed that the issuers of competing payment instruments will not react to decisions taken by the others. For that reason, an approach should be chosen which includes all suppliers in the analysis. In the following, therefore, a simple model will be introduced which serves to illustrate the interplay between the demand and the total supply.

For simplicity, only two payment media will be analysed here: credit cards and cyber money. The cost structure is specified analogously to Section III as follows:

	Costs per transaction	Transaction costs per period	Opportunity costs per period
Cyber money	kp	kY	$(r-r_E)Y$
Credit card	β_K	$\beta_K n$	-

Thus, those two payment media which differ the most from one another in terms of their cost to the consumer are included, as their competition is particularly interesting for analytical purposes.

Let μ be the smallest value of n for which cyber money is used. $0 \leq \mu \leq N$ then leads to the following optimisation problem faced by the customer:

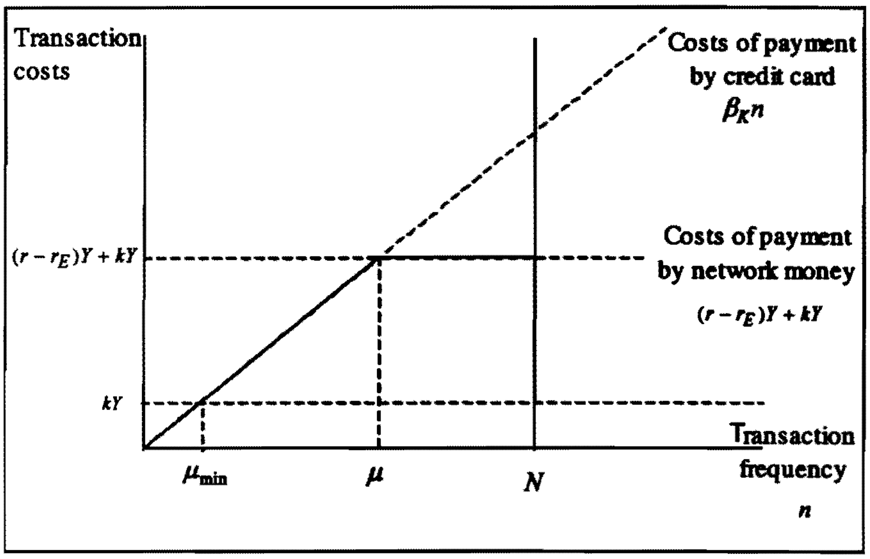
$$\underset{\mu}{Min} \int_{0}^{\mu} (\beta_K n) dn + \int_{\mu}^{N} (k + (r - r_E)) Y dn \tag{4}$$

The first-order condition leads to the following bound between the segments of the two payment instruments, μ:

$$\mu = \frac{kY + (r - r_E)Y}{\beta_K} \tag{5}$$

The optimisation problem faced by individuals can be illustrated by a graph as follows:

Chart 4: Distribution of payment media in a simple model with two payment instruments



Here, $\mu_{\min}$ denotes the lowest possible bound of the segment of transactions settled using network money, which the issuer of network money cannot undershoot, given a positive risk of loss, theft and counterfeiting k. For $r_E = r$, depending on the transaction fee levied by the credit card issuer, this bound turns out to be:

$$\mu_{\min} = \frac{kY}{\beta_K} \tag{6}$$

Thus, it is only possible for the issuer of network money to cover the whole transaction segment if a) she takes on the loss risk of those holding her payment medium and b) offers a sufficiently high interest rate on the network money balances. The extent to which the possibility for the issuer to take on the risk should be additionally integrated into the model depends again on the type of network money system under consideration. For example, a system that provides for the participation of the network money issuer in every transaction will tend to allow the issuer to control the costs she will incur resulting from malfunctioning and to prevent moral hazard. By contrast, this seems hardly possible in a system of independent circular flows of network money, since the issuer is unlikely to be able to verify a case of loss, thus giving the public an incentive to commit fraud. Therefore, it will be assumed in the following that the issuer of network money cannot take on the risk involved with her payment instrument. In the light of progress in the field of secure transmission technology on the Web, however, it should be assumed that the potential segment of network money transactions will tend to spread out over time. Hence, the parameter k corresponds to an exogenously given technology on the Internet.[30]

In the following, a credit card issuer and a network money issuer on the supply side will be considered, both of whom have a monopoly in their respective markets. Theoretical arguments and trends in Internet payments which can actually be observed both justify modelling the supply side in this manner. In the literature, in connection with the further spread of electronic money, it is often pointed out that, owing to network externalities, a logistical pattern in its spread is likely to occur.[31] This corresponds to the idea that in the early stages of the spread of this innovative payment instrument in the market, the benefits of network money are relatively modest. The number of traders who accept this form of money is still relatively small. However, once a critical level of market penetration is achieved, this innovation can then spread much more quickly. This, however, means that if a network money system reaches the point where exponential growth sets in, this makes it much more difficult for competing systems to take root.[32] In fact, trends in the Internet payment system

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[30] See the literature on Internet payment systems cited in Section II.2.2.

[31] See, for instance, Wehinger (1997), p. 66.

[32] In a dynamic model, the development of a competitive market into a monopoly due to network externalities could be integrated. One could also study to what extent the existence of network externalities provides an incentive for each individual issuer to offer a (temporarily higher) rate of interest on the loaded values, i.e. for those issuers who are striving to be the first to achieve exponential growth with their product.

seem to confirm this theory. For one thing, it can be observed that up to now, for the software-based cyber money system described, in each case only one credit institution has issued this form of money at a national level.[33] For another thing, the cooperation of various credit card companies in developing the SET standard indicates that the enterprises are aware of the risks involved in interfering with one another in an early stage of this innovation, or that they are aware of the possibility of a bad investment in view of a competing system that is conquering the market, and thus wish to avoid this occurring.

As far as the issuers' optimisation problem is concerned, the simplest cost structure possible is assumed. The credit card issuer produces her services at constant marginal costs of $c_K > 0$. No further costs exist. By contrast, the costs of issuing network money are negligible ($c_E = 0$).

Hence, the credit card issuer's profit, depending on the value of μ, is as follows:

$$\Pi_K = \int_0^{\mu} ((\beta_K - c_K)n)dn = \frac{1}{2}(\beta_K - c_K)\mu^2 \tag{7}$$

For the issuer of network money, the profit equation is specified as follows:

$$\Pi_E = \int_{\mu}^{N} ((r - r_E)Y)dn = (r - r_E)Y(N - \mu) \tag{8}$$

The credit card issuer maximises her profit by choosing a value for β_K. The network money issuer maximises her profit by choosing a value for r_E or $r - r_E$. A (Nash) equilibrium is reached in the model if neither of the two has an incentive for varying her decision parameter, given the choice of the other issuer. The equilibrium fee per credit card transaction maximises the credit card issuer's profit provided the network money issuer chooses the equilibrium rate of interest, and vice versa. Therefore, the next step is to derive the best response in terms of her decision parameter that a monopolist can provide, given the other's decision parameter.

In the simple model framework being studied here, this is not possible. Besides, one could argue that the long-term equilibrium in both models is likely to be the same.

33 See Digicash (1998).

Substituting μ from (5) into the profit functions gives the respective profit that takes account of the impact of the cost parameters on the bound between the segments of the two payment media. Differentiating these functions with respect to the respective decision parameters results in the following response functions of the two monopolists:

$$\beta_K = 2c_K \tag{9}$$

$$r - r_E = \frac{1}{2}\left(\frac{\beta_K N}{Y} - k\right) \tag{10}$$

It turns out that the credit card issuer selects the fee to be charged regardless of the behaviour of the network money issuer. By contrast, the lower the fee per credit card transaction, the higher the rate of interest on network money holdings or the lower the spread $r - r_E$ selected by the network money issuer will be. Furthermore, the interest on e-money holdings will rise with an increasing transaction volume per type of good Y, a declining transaction segment N and a rising risk parameter k. This means an indirect compensation for a rising loss risk. Furthermore, it proves to be worthwhile for the issuer of cyber money to strive for a greater market share given rising expenditure per type of good, despite the fact that she will have to hand over a larger percentage of the (rising) interest income from the float to the holders of e-money. Finally, the issuer reacts to a reduction in the transaction segment being analysed here by making her medium of payment more attractive to the public so as not to let the remaining market share become too small.

The equilibrium cost parameters follow as:

$$\beta_K = 2c_K \quad \text{and} \quad r - r_E = \frac{c_K N}{Y} - \frac{1}{2}k \tag{11}$$

In equilibrium the following bound μ shows up between the segments of the two payment instruments:

$$\mu = \frac{1}{2}\left(N + \frac{1}{2}\frac{kY}{c_K}\right) = \frac{1}{2}(N + \mu_{\min}) \tag{12}$$

The second-order conditions for a profit maximum are fulfilled.

Thus, in equilibrium, a division of the market occurs such that both issuers each serve exactly half of the market for payment media when the loss risk of network money is negligible. Otherwise, this risk then leads to the market share taken up by network money being less than half of the market. However, it is half of the remaining market when taking into account the fact that the zone up to μ_{min} is left for the credit card issuer anyway. The credit card issuer determines this zone by choosing a transaction fee; therefore, it is by no means exogenous.[35]

The following table sums up the relationships in equilibrium:

Table 2: Causality in a simple model with two payment instruments

		Endogenous variables			
		β_K Fee for payment by cheque	$r-r_E$ Spread	$\mu-0$ Credit card payment zone	$N-\mu$ Cyber money payment zone
Exogenous variables	k Risk parameter	No effect	-	+	-
	Y Expenses per type of good	No effect	-	+	-
	N Maximum transaction frequency	No effect	+	+	+
	r Market interest rate	No effect	No effect	No effect	No effect
	c_K Production costs per credit card payment	+	+	-	+

Taking the supply of payment media into account here (as opposed to Table 1) means that some of the parameters which are exogenously given when only the demand side is considered now become endogenous. Their chosen values can be explained. This affects the variables β_K (normalised at unity in the Whitesell model) and r_E. The result is sometimes diverging relationships. For example, one result is that — unlike the result obtained when looking only at the demand side — the market interest rate has no effect

[35] See equation (6).

whatsoever on the division of the segments among the payment instruments. The reason is that whenever the market rate of interest changes, the network money issuer makes the same adjustment to the interest she offers on e-money holdings.

What seems more important when looking at both sides of the market, though, is the possibility of analysing the conditions under which network money may come into use for all transactions. Whereas the model in Section III enables us to state only that as the interest rate on network money balances goes up, so does the volume of transactions made using this form of money, additionally taking the supply into account enables us to provide an answer to the question of whether the level of interest required to supplant payment by credit card will possibly be set by the issuer. Even though the costs of issuing network money are nil, in equilibrium there will still be transactions using credit cards. One reason — as already discussed — is the loss risk associated with network money, which assures the credit card issuer a positive market share. Another reason illustrated by the model is that even if the loss risk is negligible, the network money issuer has no incentive to cover the entire market through the choice of her cost parameter. To this end she would have to offer the public an interest rate that does not maximise her profit. Thus, when taking the supply side into account, the result remains a segmentation of the payment system such that network money assumes the role of a medium of exchange for low-value payments.

V. Concluding remarks

An analysis of the microeconomic foundations of the choice the payer must make between different payment instruments allows a tentative assessment of the future spread of network money to be expected. Thus, a cash-in-advance model based on Whitesell (1992) asserts that specialisation of different payment instruments is a characteristic of the consumer's optimal payment pattern. Specialisation here means that only one payment medium is employed to buy a good. Furthermore, payment instruments can be classified according to certain price zones. This applies to the payment pattern in OTC trade, where such behaviour can actually be observed.[36] This also applies to trade on the Internet. Here, analogously to the use of electronic money in OTC trade, network money is likely to assume the role of a medium of exchange used for low-value transactions.

This result is confirmed by a simple model with two payment instruments which additionally includes the supply side. Here, it turns out that the use of network money for the entire range of e-commerce is not only hampered by the loss risk resulting from the fact that cyber money is a bearer instrument but is also at odds with the issuer's profit-maximising behaviour.

However, that makes the scenarios where all other media of exchange are substituted completely by cyber money, potentially ending up in the existence of a monetary flow independent of the central bank monopoly (as described in the introduction to this paper), seem rather unlikely.[37] Instead, the impact of the further spread of network money on monetary policy — much like that of e-money in over-the-counter trade — is likely to be limited.

However, the simple model discussed in Section IV leaves out numerous aspects, especially the role of e-commerce traders in the spread of certain payment media. In particular, a detailed modelling of the idea that certain markets might potentially be opened up by electronic money on the Internet would enable us to make more detailed statements about the development towards the steady state examined in Section IV. It must also be remarked that the model examined here only deals with e-commerce on the Internet, thus necessarily leaving unresolved the issue of substitution between OTC trade and e-commerce. Ultimately this paper seeks to provide an initial impetus towards a genuine "microfoundation" of the role electronic money is expected to play in payments. On this basis, in a second step it would be possible to draw conclusions on the resulting implications for monetary policy.

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[36] See Deutsche Bundesbank (1999).

[37] Besides, it becomes clear from the description in Section II.2 of the existing e-money systems that no system which is technically capable of creating an independent circular flow of money has been implemented yet. If the tokens created by the software-based system are used several times, this affects the security of that payment medium against counterfeiting. A further hindrance is also to be seen in purse-to-purse payments not being possible in all systems. Payments between individuals are currently possible only in the aforementioned software-based system and in one of the established card-based systems. See Mondex (1999). In addition, the very nature of the pilot projects in the field of software-based systems leads to the problem of insufficient inter-operationality between different issuers. Neither multi-currency capability nor multi-bank capability exists so far.

List of acronyms

C.O.D.	Collect on delivery
EFTPOS	Electronic Fund Transfer at Point of Sale
E-money	Electronic money
EMU	European Monetary Union
ECB	European Central Bank
OTC	Over-the-counter
PC	Personal computer
PIN	Personal identification number
POZ	Point of sale without guarantee of payment (*Point of Sale ohne Zahlungs-garantie*)
SET	Secure Electronic Transaction

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May	1995	The Circulation of Deutsche Mark Abroad	Franz Seitz
June	1995	Methodology and technique for determining structural budget deficits	Gerhard Ziebarth
July	1995	The information content of derivatives for monetary policy – Implied volatilities and probabilities	Holger Neuhaus
August	1995	Das Produktionspotential in Ostdeutschland *	Thomas Westermann
January	1996	Sectoral Disaggregation of German M3	Vicky Read
March	1996	Monetary aggregates with special reference to structural changes in the financial markets	Michael Scharnagl
March	1996	The impact of interest rates on private consumption in Germany	Hermann-Josef Hansen
May	1996	Market Reaction to Changes in German Official Interest Rates	Daniel C. Hardy
May	1996	The role of wealth in money demand	Dieter Gerdesmeier

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August	1996	Intergenerational redistribution through the public sector – Methodology of generational accounting and its empirical application to Germany	Stephan Boll
August	1996	The impact of the exchange rate on Germany's balance of trade	Jörg Clostermann
October	1996	Alternative specifications of the German term structure and its information content regarding inflation	Sebastian T. Schich
November	1996	Enterprises' financing structure and their response to monetary policy stimuli An analysis based on the Deutsche Bundesbank's corporate balance sheet statistics	Elmar Stöss
January	1997	Reserve Requirements and Economic Stabilization	Ulrich Bindseil
June	1997	Direct investment and Germany as a business location	Thomas Jost
July	1997	Price Stability versus Low Inflation in Germany An Analysis of Costs and Benefits	Karl-Heinz Tödter Gerhard Ziebarth
October	1997	Estimating the German term structure	Sebastian T. Schich
October	1997	Inflation and Output in Germany: The Role of Inflation Expectations	Jürgen Reckwerth

February	1998	Problems of Inflation Measurement in Germany	Johannes Hoffmann
March	1998	Intertemporal Effects of Fiscal Policy in an RBC-Model	Günter Coenen
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February	1999	Die Kapitalmarktzinsen in Deutschland und den USA: Wie eng ist der Zinsverbund? Eine Anwendung der multivariaten Kointegrationsanalyse *	Manfred Kremer
April	1999	Zur Diskussion über den Verbraucherpreisindex als Inflationsindikator – Beiträge zu einem Workshop in der Deutschen Bundesbank *	
July	1999	Monitoring Fiscal Adjustments in the European Union and EMU	Rolf Strauch
October	1999	Cyber money as a medium of exchange	Gabriele Kabelac

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December 1999	Implicit Government Guarantees and Bank Herding Behavior	Rasmus Rüffer
December 1999	Implications of the new sesonal adjustment method Census X-12-ARIMA for current economic analysis in Germany	Robert Kirchner