The Institutional Character of Electronic Money Schemes: Redeemability and the Unit of Account

*Stefan W Schmitz**

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A number of commentators have argued that technological innovation is about to change the institutional structure of the retail payments system. Through the potential private issue of currency via new electronic payments systems – electronic money – individuals will create currencies based on units of account different from the dominant unit of account in the respective market. Thereby, the efficiency of the retail payments system would be enhanced. The following paper, however, denies the desirability of the parallel use of multiple units of account and the feasibility of competition in fiat-type currencies. The recent literature and Menger's views on the subject are surveyed. Furthermore, the question is analyzed from an evolutionary point of view based on the interpretation of new electronic payments systems as networks The strategic incentives for issuers and users of currency to switch from the existing dominant unit of account to an alternative one are discussed. It is concluded that new electronic payments systems will provide redeemability on demand and that they will not diminish the role the national currencies as the dominant unit of account without specific regulation interfering in the their evolution.

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While the idea that currency competition[1] would result in the provision of preferable (e.g. more stable) units of account is neither recent nor tied to the emergence of new electronic payments systems it became quite popular among commentators on e-cash. The reasons for

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[1] See i.a. Hayek 1990, Klein 1974, Vaubel 1984, 1985, 1990, 2000 and for a discussion i.a. Bomhoff 1990, Hellwig 1985, Issing 2000, Kessler 1990, Selgin, White 1994, and White 1984, 1990, 1999, 2000. Currency competition has to be distinguished from systems that theorize about the consequences of "pure accounting systems of exchange" and a single unit of account (e.g. the BFH system proposed by Greenfield, Yeager 1983) and focus their attention on the stabilization of the latter (for a discussion of the differences between the two approaches see Yeager 1983). For a discussion of electronic money and the BFH system see Krueger 1999.

the revival are mostly to be found in new technology:[2] (*i*) Due to advances in encryption technology and the diffusion of internet usage issuance and circulation of newly introduced media of exchange are cheaper than the production and distribution of physical cash and coins. (*ii*) Current legal restrictions prohibiting the private issue of banknotes do not apply to electronic money.[3] (*iii*) Transaction costs of calculating relative prices of different units of account are lower due to continuous trading of an increasing number of assets on financial markets and inexpensive online price information. (*iv*) The transaction costs of exchanging different units of account on online markets are lower than on traditional retail markets for foreign exchange. The following citation serves an illustration for this point of view:

> *"For the first time ever, each individual has the power to create a new value standard with an immediate worldwide audience." (Matonis 1995, p. 1)*

Within the economics profession, the consequences of the dispersion of electronic money on the role of national currencies as units of account are not fully understood:

> *"Whether the declining demand for central bank money might influence the role of national currencies as primary standards of value is not yet known. We are encouraged, however, that theoretical and empirical economic research are focusing energies on this topic. The possibility of a stable, privately issued currency that is not convertible into a national currency is subject of a growing literature." (Jordan, Stevens 1996, p. 2)*

While assets that dominate money in their rate of return are available they are (in most circumstances in retail payments) less liquid than cash and coins. The emergence of new electronic payments systems – it is argued – would enable private entities (banks, online shopping sites etc.) to issue media of exchange that are at least as liquid as cash and coins

[2] See Crede 1995, Matonis 1995, England 1996, Browne, Cronin 1996, and Kobrin 1997, Cohen 2001.

[3] See Issing 2000. For details concerning the legal restrictions in the USA and Canada see Hance, Balz 2000, pp. 353.

while dominating them in their rate of return.[4] A competitive environment would guarantee the emergence of units of account that exhibit a higher degree of price stability (or even deflation) than current units of account administered by national central banks, i.e. they would appreciate vis-à-vis high powered money (or in its absence a basket of goods) and, thereby, yield a positive return.

According to this point of view, issuers of electronic money would compete on the basis of three core functions: (*i*) the management of the portfolio of assets backing the issue of electronic money (if the electronic money is redeemable), (*ii*) the management of the payments system (incl. marketing, non-pecuniary benefits, and security), and (*iii*) with respect to the regulatory regime they are subject to (if there is any prudential supervision at all).[5]

Although new electronic payments systems are not widely accepted and used in the EURO zone at the moment[6] the ECB also expressed worries about the potential threat of the unit of account function of the national currencies (and the later on the EURO) due to the emergence of electronic money.[7] Therefore, the ECB proposed an amendment to the Council directive on the taking up, the pursuit and the prudential supervision of the business of electronic money institutions.[8] In particular the ECB demands that electronic money institutions should be obliged to redeem their electronic money liabilities in central bank money at par value.

[4] Concerning a subset of transactions (e.g. B-2-C eCommerce transactions involving very small amounts) the transaction costs of new electronic payments systems may be lower than the transaction costs of cash. Consequently, the liquidity of the former may even be higher than that of the latter.

[5] See Matonis 1995.

[6] See ECB 2000.

[7] See ECB 1998 and 1999.

[8] Directive 2000/46/EC. The proposed amendment to the original proposal (COM/98/56/EC) lead to the inclusion of a right to redeem electronic money and the obligation of the issuer to include the conditions of redemption explicitly in the contract with the user (Article 3).

Similarly, Rolnick (1999) argues – based on historical evidence concerning the Free Banking Area[9] - that bank issued e-cash may not exchange at par without public intervention.

In the following paper it is argued that such a requirement is not necessary. The dynamics of institutional change within the payments system would lead to a preservation of the unit of account function without explicit regulatory intervention requiring redeemability in central bank money (or a cash balance on a deposit account).

The following section will review the literature on currency competition in order to show that the competitive, parallel use of multiple units of account is not desirable[10] and, due to the time inconsistency problem, indeed not feasible. In the second section, the potential emergence of new electronic payments systems based on alternative units of accounts is analyzed from an evolutionary point of view. As institutional change is path dependent the decisions of individuals have to be analyzed within the current institutional structure of the payments system – the dominance of a single unit of account in a relevant market. The final section concludes and summarizes the paper.

1. Currency Competition: The Literature

Klein (1974) lists a number of arguments for the current shape of monetary arrangements in industrial countries. These are characterized by a fractional reserve banking system providing inside money based on a government monopoly of the issue of fiat money (outside money).

[9] For different results concerning the Free Banking Area and related policy implications see Selgin, White 1994.

[10] The option to switch currency does, in practice, not lead to price stability. According to Dowd, Greenaway (1993) it is a stylized fact that currency substitution only occurs if a currency performs very poorly. Even during hyperinflations the demand for the traditional currency is significantly above zero. Legal restrictions might currently increase the costs of switching such that their abolition could reduce the level of inflation individuals are willing to accept before currency substitution occurs.

The banking system is usually subject to prudential supervision and, in many cases, minimum reserve requirements.

Based on the assumption that *monetary policy* can have stabilizing effects in the short-run government economic policy might call for the control of the necessary means of conducting monetary policy, i.e. the control over the supply of money or the money market (short term) interest rate.[11] However, Klein concludes that even if the government were only one of a number of suppliers of competing inside monies while the dominant outside money were issued by a private entity the government could still engage in short-run stabilization policy by inflating at a higher rate than the dominant money. The government would lose reserves of outside money due to the redeemability of the inside monies in the dominant outside money. Albeit, the government would incur additional costs by holding those reserves it could still conduct stabilization policy by manipulating the supply of its own inside money.

An alternative class of arguments mentioned by Klein, states that the supply of information and, thereby, the creation of consumer confidence might be interpreted as a *natural monopoly*. Due to positive real costs associated with the detection of and reaction to unanticipated changes in the quantity of money reputation is " ... of exceptional value relative to other inputs in the money industry." (Klein 1974, p. 447) In a competitive environment each issuer has to incur costs associated with establishing a reputation while in the case of a monopoly only one issuer would have to establish a reputation. Given declining costs of establishing a reputation, a single issuer would supply a correspondingly higher (nominal and real) quantity of money than each individual issuer in a competitive environment the costs of establishing a reputation would not increase proportionally, i.e. a 'non-rivalry in production' is associated

[11] See also Bomhoff 1990 and Kessler 1990.

with the input reputation.[12] Thus, " ... a single firm or private trade association would be efficient in producing confidence for a group of monies." (Klein 1974, p. 447) Nevertheless, the existence of a natural monopoly in the supply of money does not necessarily imply a governmental monopoly but might also be subject to publicly regulated private production.

Vaubel (1984, pp. 45) discusses further arguments in favor of the interpretation of the unit of account as a natural monopoly. As the number of different means of payment in an economy is usually larger than one, he concludes, that only the unit of account function might exhibit characteristics of a natural monopoly. In that case monopoly provision of the unique standard of value in the economy would be justified but, however, that does not necessarily imply government monopolization of the production of money and restrictions on free entry. Since the characteristics of the optimal unit of account are not known with certainty (e.g. deflation at the real rate of interest or stable purchasing power?) and government bureaucrats might face a non-optimal incentive structure relative to private entities Vaubel suggests that the restrictions of free entry should be abolished. "Only if a governmental producer of money can prevail in conditions of free entry and without discriminatory subsidies is he an efficient natural monopolist." (Vaubel 1984, p. 47) The optimal unit of account, its properties, and the most efficient mode of production should be the outcome of '*competition as a discovery procedure*'.

Issing (2000) criticizes this Hayekian argument on grounds of the uncertainty associated with the adjustment process itself and the regulatory issues once a single issuer has emerged from

[12] In Klein's own model of competitive fiat-type money issue (to be discussed below) the costs of establishing a reputation (the opportunity costs of unanticipated inflation, i.e. the fall of the rental price of brand-name capital in Klein's terminology) are exactly proportional to the real quantity of money supplied (see also White 1999, p. 236). Consequently, the natural monopoly argument does not hold in Klein's model.

the process.[13] Until all issuers of low quality currencies are driven out of the market individuals would have to bear *high transaction costs* (incl. information costs). Furthermore, the process itself would be characterized by different rates of inflation and fluctuating exchange rates of different currencies. Thus, the co-ordination of individual plans based on relative prices of goods as well as currencies would be inhibited by higher transaction costs (incl. information costs). The optimal choice of a store of value would be subject to uncertainty about the future unit(s) of account.

Hellwig (1985) denies the validity of a fundamental assumption in the Hayekian argument. Namely, that the banks issuing outside money could control the rate of inflation of their currencies (e.g. by manipulating supply or a short-term interest rate). His argument applies to currencies with a stable relative price that is expected to remain stable by all individuals or to currencies that cannot be distinguished from each other. Therefore, at the exchange rate x one unit of one currency would be considered a perfect substitute for x units of the other one. Under the assumption of a stable exchange rate the inflation of one currency might be interpreted as inflation of a composite currency. Thus, the price level is treated as a *public good*, i.e. the price level is subject to a negative not individually attributable externality. Since there is no market solution to this externality a decentralized decision process will produce too little of the good price level stability. At a stable exchange rate, a positive value of the aggregate money supply, and in the absence of production costs of money balances the profit maximizing rate of monetary expansion is infinite. Consequently, the value of the aggregate quantity of money is reduced to zero, i.e. the price level is infinite and outside money is no longer accepted in transactions. The treatment of the aggregate quantity of money as a composite good of the different outside monies is a presumption that Klein (1974) takes into

[13] For a similar position see Kessler 1990.

consideration explicitly. He assumes that currencies are distinguishable such that the term price level is unambiguous only with respect to each one currency but not with respect to the aggregate quantity of money.

The presence of *network effects* and/or *switching costs* might lead to excess inertia[14], i.e. even if some competitors offer a preferable currency it might be hard to drive an incumbent issuer out of the market. Dowd and Greenaway (1993) show that for an individual switching – regardless of others to switch as well – only pays if the discounted network independent benefits[15] outweigh the foregone network dependent benefits of the old currency plus the switching costs (e.g. psychological costs of getting used to the new unit of account). Even if individuals are willing to switch to a new currency if others did so a co-ordination problem arises; i.e. the individual's expectations concerning the decisions of others are crucial. Switching is only welfare improving if the aggregated discounted network independent and network dependent benefits of switching outweigh the aggregated switching costs. Furthermore, Dowd and Greenaway (1993, p. 1184) cite a 'stylized fact' that even limited currency substitution occurs only during episodes of hyperinflation and conclude " ... that monetary authorities can 'get away' with a great deal of monetary 'misbehaviour' before loss of market share to competing currencies poses any significant problem." [16]

If the adjustment process leads to the emergence of a single monopoly issuer the familiar issue of a *non-optimal incentive structure* arises anew.[17] The threat of entry would serve to

[14] See Economides 1996.

[15] Examples of network independent benefits of a currency are the value of a unit of the redemption good if the currency is redeemable.

[16] Though, one has to bear in mind that legal restrictions usually increase the costs of switching to an alternative currency and may account partly for the 'stylized fact'.

[17] See e.g. Issing 2000.

discipline the issuer if the assumptions of the contestable markets theory were met:[18] (*i*) All costs associated with market entry are reversible, i.e. there are no sunk costs. (*ii*) An entrant can build capacity and gain access to distribution networks before the incumbent is able to react. (*iii*) The incumbent does not have a comparative advantage due to his own experience in the market. The financial services industry, it might be argued, has already built capacity and established or gained access to distribution networks in order to market a large variety of financial products. Furthermore, some private financial institutions do already operate payments systems such that they should not suffer a competitive disadvantage in providing the specific payments system 'currency'. But it has been mentioned earlier, that reputation and consumer confidence are of critical importance in the market for fiat-type money. Since costs associated with their production are sunk costs and their production might take considerable time some of the major assumptions of contestable markets theory might not be met.

Government monopoly provision of currency might also be justified by the existence of 'economies of scale' in consumption, i.e. a payments system might never reach *critical mass* due to high network effects as long as the network is still in its infancy. Vaubel (1984) discusses the role of government in the context of network effects in detail and concludes that it might be necessary that early adopters subsidize late adopters until the network reaches critical mass. The subsidy reflects the positive externality conveyed by the marginal late adopter in equilibrium (Pareto-efficient network size) on early adopters. However, the existence of network effects does not imply government subsidies let alone government monopoly provision of currency.

[18] See George, Joll, Lynk 1992, pp. 276.

A government monopoly would be efficient if the government had a *comparative advantage* in producing confidence.[19] That could be based either on the ability of the government to declare its own money legal tender or on the existence of economies of scope between the production of confidence and other goods supplied by the government (e.g. national defense). However, the government is also faced with comparative disadvantages. Government officials do not own the reputation they are supposed to establish or conserve and, thus, are subject to a non-optimal incentive structure. Finally, Klein (1974) concludes that the arguments based on a comparative advantage are at least ambiguous and do not justify governmental monopoly production of outside money.

Vaubel (1984, pp. 28) discusses several arguments for governmental monopoly provision of money based on *public good* characteristics associated with money. An individual holding money balances is less likely to become illiquid. Thus, potential trading partners are more likely to be able to trade with the individual. Vaubel argues that money balances posses neither of the public good characteristics of non-rivalry in and non-excludability from consumption. But the increased likelihood of an exchange to occur satisfies both criteria. However, the positive externality might be compensated for by a negative externality, i.e. the decreased likelihood of an exchange to occur with someone else who holds money balances. More importantly, the existence of a unit of account facilitates co-ordination of individual plans based on relative prices. Neither can individuals who do not hold money balances be excluded from basing their plans on information conveyed by relative prices (non-excludability) nor will this reduce the benefits of a unit of account for money holders (non-rivalry). Vaubel concludes that this might be a rationale for the government to define a unit of account and publish a price index for it. Since the government does not know what the

[19] See Klein 1974.

optimal unit of account and its characteristics are it should not impose but merely propose a specific unit of account. However, it would not necessarily imply the governmental monopoly production of money. White (2000), on the other hand, argues that a standard such as the unit of account, once established, does not require any further policy intervention – it is self-sustaining.

The use of different currencies by parties to a transaction implies that costs of conversion and, possibly, of hedging against currency mismatches between actual and desired holding have to be incurred. Who actually bears these transaction costs depends on the market structure, elasticities of supply and demand, and may be the result of a negotiation process. If, both, the seller and buyer share the costs of conversion their choices of currencies might cause *external effects*. Vaubel (1984, pp. 42) distinguishes three limiting cases: (*i*) The seller faces the same (weighted) price elasticities of demand and the same conversion costs in each currency domain such that he will choose the currency in which his sales reach the highest volume. Due to the fact that the elasticities of demand are the same in all currency domains the seller's private costs of conversion are proportional to the social costs of conversion. Thus, by minimizing his own share he also minimizes the social costs. The decentralized solution does not lead to an allocation that is different from the one chosen by a central planer. (*ii*) Again, the seller faces the same (weighted) price elasticities of demand in all currency domains. But it is assumed that he would conduct the same number of transactions with the same volume in all domains if there were no currency conversion costs. In this case, the seller chooses the currency with the lowest fixed and variable conversion costs such that his total currency conversion costs are minimized. Again, his conversion costs are proportional to the social conversion costs. Thus, the decentralized solution does not deviate from the allocation chosen by a central planer. (*iii*) In the third case, it is assumed that all currencies have the same fixed and variable conversion costs and – in the absence of conversion costs – the seller would

conduct the same number and volume of transactions in all domains. But the (weighted) price elasticities of demand are different in different domains. In this case, the seller will choose the currency that is associated with the highest price elasticity of demand. In a partial equilibrium analysis, the buyers having a perfectly price inelastic demand will also have to bear the seller's share of the conversion costs and the seller's currency choice indeed deviates from the allocation chosen by a central planer. If, however, the demand is perfectly elastic in all currency domains the seller has to bear the entire conversion costs and minimizes social costs by minimizing his private conversion costs. The decentralized allocation is, again, identical to the one chosen by a central planer. Vaubel (1984, p. 44) concludes that " ... if perfect or imperfect competition prevails, transaction cost externalities do not lead to suboptimal currency choices." However, the use of a common currency enables the trading partners to avoid these costs in the first place, though, at the cost of disregarding effects on individual portfolio balance and preference concerning the unit of account.

Hellwig (1985) argues that the displacement of outside (fiat) money by redeemable inside money might lead to the *over accumulation of real assets*, i.e. the real rate of return on capital would be less than the rate of time preference in the society.[20] Abstracting from default risk of issuers and fraud (counterfeit) the inside money will have a return structure equivalent to that of the underlying asset(s). In an economy with collective and individual risk individuals want to insure against endowment fluctuations. One way to do so is to adjust money balances to changes in subjective expectations concerning the marginal utility of endowments in future periods. If the marginal utility of future endowments are sufficiently volatile and inventory costs of the underlying real asset(s) are low relative to the real rate of return – and abstracting from network effects and excess inertia - inside money will displace non-interest bearing

[20] For a similar argument see Smith 1776 and Wallace 1988.

outside money. The portfolio choice between inside and outside money is biased against the latter due to the assumption of non- interest bearing outside money. The government could raise taxes in order to ensure a real rate of return sufficient to prevent inside money from displacing outside money. The stock of real capital held permanently as reserves to back the inside money could then be invested or consumed without decreasing the level of insurance as outside money - according to Hellwig - provides the same insurance service as inside money, albeit without incurring the opportunity costs associated with reserve holdings of real capital. However, the fact that an outside (fiat) money is preferable to inside money is not necessarily an argument in favor of governmental monopoly provision of the former.

The overview of the literature shows that the parallel use of multiple units of account is generally not considered to be desirable due to natural monopoly and public good considerations regarding the unit of account. The efficiency enhancing effects of the existence of a unit of account rest upon its uniformity as it minimizes the transaction and information costs associated with price comparisons.[21] Competition in the unit of account would lead to the emergence of a single issuer who would face a similar incentive structure to a government monopoly. Furthermore, the adjustment process would lead to fluctuations in the exchange rates between different currencies and make the co-ordination of individual plans based on relative prices more difficult. However, the arguments do not provide a clear rationale against free entrance. The presence of network effects and switching costs might make it very hard to drive an incumbent issuer of a dominant currency out of the market.

[21] See also Menger. "Imagine the condition of the monetary system of a country where coins of the same type are valued differently because of inevitable tiny differences in their minting and regularly occurring losses by wear in circulation, [or] a situation in which coins produced from different money materials (particularly fractional coins) function like parallel currencies because of fluctuations in the relative prices of money metals concerned, etc. In this way, obviously, the essential advantages of a uniform national money and coinage system, howsoever economically graduated and implemented, would partly cancel out." (Menger 1909, p. 24)

Time Inconsistency and Redeemability

The importance of the problem of time inconsistency in the provision of fiat-type or outside money has been discussed by a number of authors and is not constrained to the competitive supply of fiat-type money.[22] Individuals choose to accept outside money on the basis of its expected future value in exchange. That value, though, is not independent of the issuer's future actions, i.e. the future supply of outside money. Initially, the issuer has to commit to some future path of money supply (e.g. one that will keep the purchasing power of the currency constant) in order to create demand for money balances in his currency. At a certain point of time this commitment is profit maximizing, i.e. it is a part of an optimal plan. Once the public decided to hold and accept the currency keeping the commitment might no longer be optimal. Assuming that the marginal costs of producing an additional unit of the currency is zero it will be optimal for the issuer to increase the supply of money until his marginal revenue will be zero, too. If it remains impossible for the same issuer to rebuild his reputation afterwards he will go out of business. The expected cost of inflating the currency is the discounted expected value of foregone future profits from the provision of outside money. The related (discounted) expected profit is equal to the sum of revenues from the issuance of additional outside money over time until the marginal revenue of an additional unit of outside money is indeed zero.[23] Whether keeping the commitment in later periods is profit maximizing depends on the relation between the expected cost and revenue of inflating in each period.

[22] See e.g. Calvo 1978, Hellwig 1985, Issing 2000, Klein 1974, Vaubel 1985, White 1999 and Blanchard, Fischer 1990 Ch. 11, as well as the literature cited in these papers.

[23] If hyperinflation occurs instantaneously this time interval is zero. Furthermore, if hyperinflation is anticipated instantaneously (e.g. under a variant of rational expectations), too, the demand for real and nominal balances is zero immediately and the (discounted) expected profit from inflating is also zero.

The lower the discounted expected value of foregone future profits from the provision of outside money the higher is the incentive for the issuer to inflate. It depends on his subjective discount rate, the real demand for the currency in each period, as well as the time the issuer plans to stay in business. The more heavily the issuer discounts future profits and the lower the real demand for money in each period the lower his discounted expected value of foregone profits will be.

The higher the related (discounted) expected profit of inflating the higher is the issuer's incentive to inflate. It depends on the real demand for the currency in each period, as well as the time that elapses between the issuer's decision to inflate and the public's refusal to accept the currency any longer, i.e. real demand reduces to zero.[24] The faster the public learns about the issuer's reluctance to keep his commitment and, therefore, adjusts the real demand for the currency the lower the profits of inflating.

Klein (1974) models the maximization problem of the issuer of fiat-type money explicitly and argues that it is not wealth maximizing for an issuer of fiat-type money to inflate infinitely. He assumes that currencies of different issuers can be identified costlessly and that all issuers are price takers and are confronted with an infinitely elastic demand for monetary services curve. The real demand for money is modeled as a decreasing function of the opportunity costs associated with real money balances (the difference between nominal interest paid on bonds denominated in that currency and nominal interest paid on money holdings) and an increasing function of consumer confidence (embodied in 'brand name capital'). An

[24] Assuming that this interval is relatively short with respect to the time over that expected foregone future profits from the provision of outside money are discounted one can neglect the discount rate as a determinant of the expected profit of inflating. The speed of public learning becomes irrelevant in the extreme case of a hyperinflation occurring instantaneously. Inflating yields a positive expected profit only if individuals do not fully anticipate the hyperinflation.

unanticipated increase in the nominal quantity of money affects real profits in three ways: (*i*) As the marginal costs of producing nominal balances are assumed to be zero the issuer accrues the real revenue equal to the additional quantity of nominal money issued. (*ii*) The unanticipated increase of the nominal quantity of money will change the inflation expectations of the individuals holding balances in the currency under consideration. In order to compensate them for this increase in anticipated inflation the issuer has to redistribute a portion of his proceeds to them. Otherwise their demand for real balances would shrink. Assuming that individuals cannot perfectly observe the contemporaneous increase in the quantity of nominal balances their share of real revenues of unanticipated inflation is smaller than 100 percent. Therefore, the share accruing to the issuer is always positive. The real revenue from inflating increases in the growth of the nominal quantity of money without bound. Consequently, the issuer would have an incentive to inflate infinitely, i.e. until the marginal revenue from inflating is zero. "The only constraint on the extent of the firm's profit rate is the existence of some rising costs of increasing [the nominal quantity of money] which places a limit on the rate at which a firm can profitably increase the supply of its money in circulation." (Klein 1974, p. 436)

Klein, then, argues that (*iii*) brand name capital is the constraint that solves the time inconsistency problem. The holders of the currency are compensated for the decreased *stability* of the future price level due to an unanticipated increase in its nominal quantity by the share of profits redistributed to them. In order to keep real money demand constant the issuer has to compensate the holders of money also for the reduced *predictability* of the price level. The deviation of the actual from the anticipated increase reduces the real market value of the firm's brand name capital (i.e. consumer confidence). The larger the deviation is the higher the nominal interest the holders of the currency demand in order to be compensated for

the reduced *predictability* of the future price level.[25] Thus, the real value of brand name capital decreases. Klein concludes that assuming consumers and producers have the same expectations concerning the short term gains from unanticipated increases in the nominal quantity of money an equilibrium exists in which a wealth maximizing firm will not inflate infinitely. In equilibrium the firm's share of the real revenues from unanticipated increases in the nominal quantity of money (after compensation for changes in anticipated inflation) equals the firm's real loss in terms of increased nominal interest payments to money holders in order to compensate them for the reduced *predictability* of the future price level.

White (1999) discusses Klein's in model in detail and denies that it presents a satisfactory solution for the time inconsistency problem.[26] As mentioned above, under Klein's assumptions the share of the real revenue from an unanticipated increase in the nominal quantity of money accrued by the issuer increases in the growth of the nominal quantity of money without bound (even after compensating the holders of money for the decrease in the *stability* of the price level). Consequently, the compensation demanded by holders of money for the decreased *predictability* of the future price level (i.e. the increased nominal interest rate paid on nominal balances) has to increase in the growth rate of the nominal quantity of money without bound as well relative to the nominal interest rate on bonds denominated in the currency. This would imply that the real value of brand name capital would have to become infinitely negative. Otherwise, it would pay for the issuer to inflate infinitely. If the

[25] Due to the assumption that consumers and issuer have the same expectations concerning the short term gain from unanticipated increases in the nominal quantity of money individuals know about the exact amount they need to raise their demanded nominal interest rate on money holdings in order to off-set the issuer's revenue from an unanticipated increase in the nominal quantity of money. This, however, implies that consumers can observe the contemporaneous increase in the quantity of money in order to adjust their demanded nominal interest rate on money holdings accordingly and is contradictory to Klein's implicit assumption that individuals cannot observe the contemporaneous increase in the supply of money. See White 1999.

[26] See also Selgin, White 1994.

nominal interest rate on money holdings is bound above the first-order condition for profit maximization derived by Klein will not suffice to prohibit infinite inflation. White, then, argues that the difference between the nominal interest rate paid on money holdings and the nominal interest rate paid on bonds denominated in the currency is bound below by zero. In terms of Klein's formulation that implies that the real value of brand name capital is bound below by zero, too. At this point, individuals would demand a nominal interest rate for money holdings equal to that paid on bonds. Any further increase in the nominal interest rate paid on money holdings implies that the yield on money increases above that of bonds. The issuer would have to resort to further inflationary over-issue in order to be able to meet his obligation vis-à-vis the holders of money. As long as individuals cannot perfectly foresee the future amount of unanticipated inflation they cannot adjust their ex-ante demanded interest receipts to prevent the issuer from over-issue. Instead of assuming that the public would be able to foresee the future deviations of the currency from *stability* (i.e. correctly perceive the actual increase in the nominal quantity of money) Klein assumes perfect foresight with respect to future deviations from the *predictability* of the future price level. Otherwise, holders of money are not able to adjust their demanded ex-ante interest rate in a manner to prevent the issuer from inflating further. In order to correctly anticipate the deviations from *predictability* individuals would have to be able to observe the contemporaneous change in the nominal quantity of money and, consequently, also the deviations from the *stability* of the price level. "Solving the problem of cheating, in this way, amounts to re-introducing perfect foresight through the back door." (White 1999, p. 238)

Taub (1985) analyzes the time inconsistency problem in an overlapping generations framework. Money demand is endogenous and individuals have rational expectations. Currencies can be distinguished costlessly and optimal supply by firms is determined in a Nash equilibrium. Taub distinguishes two dynamic structures – open loop control and

feedback control. In the first, firms can commit to an infinite sequence of future money growth rates while in the latter the enforcement mechanism is weaker and firms can optimize their decisions concerning current and future money growth rates anew each period. If commitment is possible time inconsistency problems do not arise and the competitive outcome implies that the rate of return on money holdings is equal to the inverse of the discount factor. The solution is efficient.

Under feedback control, the assumption of complete impossibility of commitment reduces real money demand to zero. If firms can manipulate contemporaneous money growth after individuals have decided how much real balances to hold for the period it is optimal for the issuers in the model to inflate infinitely within the current period. As individuals anticipate this solution they will decide not hold real balances in the first place. Therefore, Taub considers a structure that allows firms to commit for exactly one period, i.e. firms take the contemporaneous growth rate of money as given. The analysis is restricted to stationary equilibria in which the relative shares of real balances for each firm remain constant over time. In equilibrium the demand for real balances is below the efficient level since – even under competitive supply of fiat-type money – inflation is always positive in the model. However, the stationary equilibrium is not consistent with free entry. A firm entering the market cannot take its contemporaneous growth rate of money supply as given since it did not exist in the previous period. Taub shows that – for large numbers of issuers - firms initially choose to deflate their currencies. As this is inconsistent with stationary equilibrium the competitive solution with inflation has to be reached asymptotically. Due to the fact that the stationary equilibrium is dynamically unstable the economy will reach the only dynamically consistent long-run equilibrium in which money demand is zero. Thus, Taub concludes that competitive issue of fiat-type currency is not possible.

In Klein's model, the wealth of the issuer of the currency increases without bound in the growth of the nominal quantity of money. Thus, individuals could be compensated ex-post for unanticipated increases in the nominal quantity of money. Klein draws conclusions from U.S. monetary history where convertibility of privately issued bank notes into dominant outside money emerged under conditions of a competitive market structure.[27] Selgin (1997) argues that institutional change within the monetary system was historically the driving force behind the emergence of convertible money replacing commodity money. Fiat money, on the other hand, was the result of government intervention (e.g. nationalization of the note-issuing banks).[28] Also Vaubel concedes that " ... if there is a danger of 'profit snatching', money holders will prefer currencies that offer value guarantees." (Vaubel 1985, p. 554) Concluding the discussion of Klein's model White (1999) argues that the problem of time inconsistency has traditionally been approached by offering such value guarantees, i.e. redemption contracts. In a competitive environment different inside monies, redeemable in the dominant currency, would emerge but competition in fiat currencies is widely considered to be infeasible.

2. Institutional Change, Network Effects, and Currency Competition

An evolutionary analysis of new electronic payments systems has to start from the current institutional setting, i.e. the institutional change within the monetary system is path dependent. Therefore, the question one has to address is whether individuals (e.g. sponsors of

[27] As mentioned above, the issuer of dominant outside money faces a similar time inconsistency problem. A large literature has been devoted to the discussion of institutional arrangements to deal with inconsistency (e.g. constitutional arrangements, bonds that penalize the issuer for not complying with his initial commitment). For an overview see inter alia Blanchard, Fischer 1990.

[28] For an overview of the "free banking" literature see Selgin, White 1994.

new electronic payments systems, users etc.) are likely to switch to a new unit of account given the dominance of an established unit of account in the respective market.

Network Effects, Compatibility and the Redeemability of Electronic Money

An electronic money scheme can be interpreted as a network exhibiting network effects.[29] The willingness to pay for joining depends on the expected number of future participants (i.e. merchants who accept a specific currency or electronic money and consumers in schemes that permit peer to peer transfers). An additional individual joining a certain new electronic payments system affects those already using it in two ways: First, the number of potential partners in exchange increases (direct network effect). Secondly, the more market participants accept the specific currency or electronic money the more competitive and liquid the market becomes. If there is price discovery in the market the market price becomes more accurate (indirect network effect). Menger stresses the effect of the emergence of a generally accepted medium of exchange on price formation:

> *"[Before the emergence of a generally accepted medium of exchange] haphazard prices and other kinds of uneconomic price formations were easily the rule, but from now on price formation takes place with all those participating who offer a commodity on the market in question and at the same time all those who seek to acquire this commodity. Price formation will become more concentrated on and be adapted to the general market situation or, at least, will correspond to it far better than could be the case on barter markets. Current market prices are formed; and from now on the valuation of goods in money terms is incomparably more exact and economic than on barter markets, with their fragmented trading in goods and with price formation influenced by chance occurrences of all kinds*

[29] Currencies have frequently been interpreted as networks (see inter alia Hellwig 1985, Selgin 1997, Weinberg 1997, Issing 2000). Gowrisankaran and Stavins (1999) find empirical evidence of the presence of network effects in the automated clearinghouse electronic payments system.

or by rigid customary exchange ratios and statutory prices." (Menger 1909, p. 11)

Streissler (in his contribution to this volume, p. 10; original emphasis) interprets Menger's view of the emergence of a general medium of exchange on price formation as creating an "*information network* between all participants in the market".

However, not all markets engage in price discovery. Non-participants can often observe the equilibrium market price established in a particular market. This information can be used in another market in which exchange takes place at the equilibrium market price established in the former (price matching). The opportunity to free ride could provide incentives for the market engaged in price discovery to reduce the availability of information on prices (e.g. through proprietary information systems) or the value of the information contained in the observable equilibrium market prices (e.g. by reporting large bid-ask spreads).[30]

A supplier of a new electronic payments system faces the strategic decision concerning the compatibility of his new network with the existing payments system. Payments that involve transactions via, both, the new electronic payments system and the existing dominant payments system can be interpreted as composite goods. Its components are the transactions via the two different payments systems. Complete compatibility is reached when the two components are combined to a composite good without increasing the cost of the combined transaction – vis-à-vis the sum of the costs of each component such that the completely compatible networks can be treated as one single network.[31] This strategic decision has two dimensions. First, the technological dimension concerns the interoperability of the components of an electronic payments system (e.g. protocols, hard- and software). Secondly,

[30] See Economides 1993 and 1995.

[31] See Economides 1996.

an economic dimension concerning the unit of account underlying the new electronic payments system (e.g. a mutual fund index or the unit of account of the dominating payments system in the relevant market – e.g. US$, ¥ or EURO). Furthermore, there are two different technologies through that compatibility can be reached: First, the adoption of a common standard and, second, the adoption of an adapter. While the former can only be based on a unanimous decision of all network operators (sponsors) concerned the latter can be enacted unilaterally.[32] So far no single technological standard has emerged out of the vast number of innovative solutions for new electronic payments systems (e.g. DigiCash, CyberCash, Netbill and Proton, Mondex). Most of the prevailing technologies are not compatible, i.e. a consumer cannot pay a merchant if they are subscribers of two different network based electronic payments systems. However, the focus of the paper rests upon the economic dimension of compatibility.

Economides (1991) analyzes the strategic decision of network operators (sponsors) to achieve compatibility in a non-cooperative setting – for smaller networks it pays to be compatible, while for the large dominant network incompatibility is advantageous. Katz, Shapiro (1985) find that the joint incentives of the large and the small network operators are lower than the social incentives – but still, those of the small network operator are large. The potential inadequacy of the social incentives is a consequence of the fact that the incentives of the large network's sponsor are to small. The analysis suggests that the sponsors of the dominant payments system in retail transactions (the Central Banks) might rationally oppose compatibility with new electronic payments systems if they were profit maximizing entities since they cannot appropriate the entire benefits of compatibility. However, the CBs are non-for-profit public institutions that aim, ideally, to preserve the stability and enhance the

[32] See Katz, Shapiro 1985 and the examples cited therein.

efficiency of the economic payments system. However, for sponsors of new electronic payments systems the incentives to adopt the unit of account of the dominating retail payments system in the relevant market are strong. Operators of new electronic payments system can increase their demand by credibly committing to a one-for-one fixed exchange rate of electronic money vis-à-vis the dominant currency due to network effects. In order to ensure the stability of the exchange rate (and the related expectations) the operator of the new electronic payments system would have to offer redeemability on demand.

Switching Costs

The analysis of Dowd and Greenaway (1993) also offers strategic implications for providers of new electronic payment systems. They conclude that - if no-one else is expected to switch - switching to a new currency is only individually optimal if the discounted network independent benefits of switching outweigh the switching costs and the discounted foregone network dependent benefits of the abandoned currency. In the other extreme case – if every-one else is expected to switch – it would be individually optimal not to switch if the switching costs outweigh the discounted network independent and network dependent benefits of switching. Therefore, it can be optimal for a society to stick to an inferior (electronic) payments system if the switching costs are substantial. Switching costs include e.g. the psychological cost associated with the use (e.g. calculating and quoting prices) of a new unit of account and the necessary changes in accounts denominated in it. Therefore, fixing the exchange rate at one-to-one with respect to the existing unit of account once and for all can also increase the probability of adoption of a new electronic payments system by, at least partly, avoiding the switching costs associated with the adoption of new unit of account. Brunner, Meltzer (1971) also argue that it is optimal for issuers of private money to maintain a fixed exchange rate vis-à-vis a dominant money and to offer redeemability on demand as

this reduces the information costs (e.g. with regard to the quality of the privately issued currency) incurred by users of private money.

Sunk costs

Individuals joining a new electronic payments system invest in the new technology in various ways (including software, acquiring the necessary technology competence, and buy an initial balance of electronic funds). Some of these fixed costs are irreversible (i.e. sunk costs) such as the time and effort invested in learning how to operate the system. The decision to incur these sunk costs can be interpreted as an investment decision based on the expected value of joining the system for the consumer which in turn is based on expected number of users. Individuals who join a new electronic payments system have to acquire an initial balance through a transfer of wealth to its operator. Unless the operator offers redeemability on demand this initial balance is also, at least partly, lost if the payments system does not reach critical mass. By reducing the real value of the amount at risk for the consumer, e.g. through redeemability on demand, the operator can reduce the barriers to adoption.

Network Effects, Currency Competition and Market Prices

Two distinct approaches towards market prices in new electronic payments systems can be distinguished: Market prices are either assumed to be given by exchange in the dominant currency (price matching) or a new electronic payments system engages in price discovery.

Market exchange in the dominant currency determines market prices that are often public information. The price in a new electronic payments system - based on a unit of account different from the dominant one - is determined in two steps. The market price of a certain good quoted in the dominant unit of account is multiplied by the relative price of the unit of account of the new electronic payments system in terms of the dominant unit of account. That implies that the new unit of account must also be traded on a market denominated in the

dominant unit of account continuously. The necessary calculations used to be time consuming and timely information on market prices expensive. It is argued, that technological progress makes new electronic payments systems based on alternative units of account feasible.[33] Participants in the new electronic payments system, therefore, free ride on price information established in two different markets - for the good exchanged and for the unit of account - denominated in the dominant unit of account. Furthermore, the accuracy and information content of the prices established on the market denominated in the dominant unit of account might be reduced as trade shifts partly from that market towards one which follows a price matching strategy.[34]

Even if a price in the alternative unit of account can be calculated the alternative unit of account is only accepted at precisely that price if – at a relative price of the two currencies of $x - x$ units of the alternative unit of account are considered to be a perfect substitute for one unit of the dominant unit of account. That in turn implies that the expected future relative price must be expected to be x, too. The relative price of the two units of account is expected to remain perfectly stable in the future and, furthermore, these expectations have to be shared by all individuals.[35]

If the exchange rate between the alternative unit of account and the dominant one is subject to fluctuations and uncertainty the alternative unit of account will only be traded at a spread between bid- and ask-prices. The spread is determined by the degree of uncertainty, the risk preferences of individuals, resource costs of holding inventory positions in different risky assets and the related uncertainty, the market structure, potential asymmetries of information

[33] See Matonis 1995, Browne, Cronin 1996, England 1996, and Kobrin 1997.

[34] See the discussion below for details of the relationship between liquidity, random order arrival rates, and the information content of prices.

[35] See Hellwig 1985 and Vaubel 1984.

amongst traders, and transaction and information costs.[36] According to Menger the dominant unit of account involves the smallest spread in trade – it is the most saleable, i.e. liquid good available.[37] Individuals holding a stock denominated in an alternative unit of account might have to exchange part of their holdings for the dominant currency. That again implies transaction costs. In order to complete a transaction in another unit of account individuals would have to exchange currencies on markets and bear the related costs (e.g. bid-ask spread, transaction and information costs).[38] This point was also emphasized by Menger (1909, p. 30): "Whoever hoards trade goods of another kind [than the generally accepted medium of exchange] must, when he has resort to the accumulated stock, commonly first exchange them for the general medium of exchange, while he who has hoarded the latter avoids (or is already past) the trouble, uncertainty, and economic sacrifices of this transaction." Therefore, individuals willing to minimize the transaction costs associated with trade prefer to trade in the dominant unit of account rather than in an alternative one.

The unit of account function of money (and all other functions such as the store of value function) is a consequence of its use as the general medium of exchange.[39] Only in a world where all goods are equally saleable and are expected to remain so in the future all goods (and

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[36] See O'Hara 1997 and Goodhart 1989.

[37] "In the age of barter, goods of these and similar kinds offer not only the advantage, to the person who brings them to the market to exchange them for goods he especially needs, that he is far more likely to achieve his purpose than if he goes to market with goods that are not or only to a lesser degree distinguished by their marketability; but he can also with greater probability count on being able to trade them away at a relatively more favorable barter price – since the demand for the goods he brings to market is more extensive, constant, and effective than the demand for other kinds of goods." (Menger 1909, p. 7) See also White 1984.

[38] The same argument applies to new electronic payments systems in which claims are settled by the transfer of securities of fluctuating value in terms of the unit of account (see e.g. Browne, Cronin 1996 and the literature cited therein).

[39] " ... the function of money as a "standard of exchange value" (and "measure of price") evolves by necessity from the original function of money as intermediary on the commodity market ..." (Menger 1909, p. 55)

combinations thereof) can be employed as the unit of account. Relative prices are not determined in exchange but by a Walrasian auctioneer without involving any transaction and information costs regardless of the existence of a generally accepted medium of exchange.[40] In a less perfect world, relative prices are determined in exchange of goods for the medium of exchange and assets providing a positive expected return vis-à-vis the dominant unit of account are not generally accepted without spread in exchange.

Alternatively to following a price matching strategy, a new electronic payments system can engage in price discovery. As the alternative unit of account is less marketable than the dominant one the market structure might not be as competitive as in the market denominated in the latter. The information network created by the new electronic payments system involves a smaller number of participants than the dominant unit of account. Exchange would take place less frequently and – in a market characterized by random order arrival rates - timely information on market prices would be less accurate and spreads between bid- and ask-prices would be higher to reflect the increased risks associated with larger fluctuations of the market price.[41] The larger fluctuations are a consequence of the lower frequency of trades as random fluctuations in order arrival rates and the related uncertainty increase with the time interval between subsequent trades. Consequently, individuals would prefer to exchange their goods on markets that provide the most precise pricing information available due to lower associated spreads and an increased frequency of trades.

The institutional analysis of the evolution of the structure of new electronic payments systems has to start from the existing structure of the payments system, i.e. the existence of a dominant unit of account in the relevant market. The discussion of the adoption of alternative units of

[40] See White 1984 and Wallace 1988.

[41] See Economides 1993 and O'Hara 1997.

account in new electronic payments systems is based on the incentive structure of their potential issuers, as well as, their potential users. Potential issuers can profit from the economic compatibility of their new electronic payments system with the existing dominant unit of account, i.e. by fixing the exchange rate of their privately issued electronic money one-to-one vis-à-vis the dominant currency by offering redeemability on demand. Furthermore, switching costs and sunk costs for potential users are reduced by this institutional set-up. If a new electronic payments system does not engage in price discovery it has to presuppose (and potentially free rides) on the existence of markets - for both, the goods traded and the alternative unit of account - denominated in the dominant unit of account. Even if prices can be calculated the alternative unit of account would not be accepted as perfect substitute for the dominant currency such that the alternative unit of account would only be accepted at a spread. Thus, offering another incentive for users to stick to the dominant unit of account. Assets promising an expected positive return vis-à-vis the dominant currency can, and indeed are sometimes preferred as stores of value but not as media of exchange. If a new electronic payments system engages in price discovery market prices are less accurate, the market is less transparent and the costs of the co-ordination of individual plans based on relative prices are increased.

3. Conclusion

The paper analyzed the prospects of the emergence of alternative units of account due to technological and institutional innovation in the payments system, i.e. due to the emergence of electronic money. Since the evolution of the retail payments system is path dependent the discussion is based on the existence of a dominant unit of account in the respective markets.

An overview of the existing literature shows that the competitive, parallel use of multiple units of account is not desirable. The transaction costs of the co-ordination of individual plans are reduced and the transparency of markets increased by the existence of a uniform unit of

account (in the respective market). However, competition of inside monies redeemable in the dominant currency can increase the efficiency of the payments system.

A discussion of the literature on the time inconsistency problem associated with the provision of fiat-type money points out that users of new electronic payments systems would prefer institutional arrangements that provide redeemability on demand in order to prevent the issuer from inflating infinitely.

Due to network effects and switching costs, both, the issuer and the user of new electronic payments systems face strong incentives to adhere to the dominant unit of account.

Finally, it can be concluded that the most likely institutional structure of new electronic payments system to emerge includes the redeemability of electronic money on demand and its denomination in the dominant unit of account. Therefore, the role of national currencies as units of account is not influenced by the emergence of electronic money. Ceteris paribus, public policy intervention in order to preserve the unit of account function of the dominant currency in the respective market is not necessary. Monetary policy will, in principle, be affected only to the extent that the balance sheet of central banks shortens (including a reduction of seignorage) - ceteris paribus – and that the relationship between the instruments of monetary policy and the primary objective of price stability might turn out to be less predictable (e.g. interest elasticities of money demand might change). The irrelevance of monetary policy and the failure of bank issued e-cash to exchange at par due to the displacement of the dominant unit of account by new electronic payments systems based on alternative units of account is unlikely, at current levels of inflation. Whether bank issued e-cash exchanges at par depends on the same determinants that govern the relative prices of other forms of inside money issued by different banks (e.g. checks) and the technological interoperability of new electronic payments systems.

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