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Abstract

The current discussion about the future of the financial system draws heavily on a set of theories known as the 'New Monetary Economics'. The New Monetary Economics predicts that deregulation and financial innovation will lead to a moneyless world. This paper uses a market microstructure approach to show that a common medium of exchange that serves as unit of account will remain a necessary instrument to reduce transaction costs. This finding is supported by empirical evidence from foreign exchange markets.

JEL-Classifikation: E42, E44, G20

Keywords: New monetary economics, monetary separation, market microstructure theory, monetary theory, moneyless world, financial innovation

1 Introduction

Ever since Fischer Black (1970/87) proposed that in efficient financial markets, indirect exchange via money is inefficient, doubts have been voiced regarding the efficiency of monetary exchange. Black as well as others, such as Fama (1980, 1983), argue from an efficient market stand point. If all assets are priced efficiently, a direct transfer of assets may serve as a substitute for payments with money. Related are papers by Cowen and Kroszner (1987, 1994), Greenfield and Yeager (1983, 1986) and Hall (1982a/b, 1983). The whole set of ideas has become known as the 'New Monetary Theory'.[1] With the advent of internet banking, new trading platforms and online trading etc the idea received renewed attention. Thus, Mervin King stated in 1999 *'Is it possible that advances in technology will mean that the arbitrary assumptions necessary to introduce money into rigorous theoretical models will become redundant, and that the world will come to resemble a pure exchange economy? Electronic settlements in real time hold out that possibility.'* (King 1999).[2]

In this paper, it is argued that the efficient markets theory is not well suited to tackle the question whether monetary or non-monetary exchange is efficient. Rather, a different strand of the theory of finance, market microstructure theory, should be used. Market micro structure theory provides explanations of the costs of using a market and allows for a comparison of the relative costs of different institutional set-ups.[3] Therefore, it makes it possible to compare the relative costs of monetary and non-monetary exchange. A market microstructure model of money has a lot in common with older approaches that explain the use of money with information costs (see Brunner and Meltzer 1971 and Alchian 1977).

Analytically, the question whether or not money[4] will prevail has to be separated form the question whether or not cash will survive. It may well be that the use of cash will be discontinued some time in the future but that money will survive in the form of deposits. Therefore, the following analysis will focus on the comparison of a monetary regime based on deposits with non-monetary exchange.

Focussing on deposits rather than cash, distinguishes the present analysis from papers such Capie, Tsomocos and Wood (2003) who focus on cash payments. Another important feature of the present analysis is the assumption that transactions involve the use of specialised traders. Thus, the basis for the analysis is the present real-world institutional set-up and not

[1] Critical reviews can be found, for instance, in Hoover (1988), McCallum (1985) and White (1984).

[2] See also Browne and Cronin (1995), (1997), Miller (1998) and Niehans (1982).

[3] See Madhavan (2000) or O'Hara (1997) for a survey.

[4] In the present study 'money' is defined as a good that serves as a common medium of exchange and that has a fixed price of 1 in terms of the unit of account.

some hypothetical state of the world with either no co-ordination mechanism at all (as in search-theoretic models) or a perfect co-ordination mechanism (as in Walrasian models). The problem of finding a suitable counter party has been solved by the existence of specialised traders who offer to buy or sell goods and asset at quoted prices. This sets the present analysis apart from search-theoretic models such Kiyotaki and Wright (1989) and puts it closer to trading post models such as Howitt (2005). It differs from these models, however, because the alternative that is analysed is not barter versus monetary exchange but 'financial barter' (see below) versus monetary exchange. Moreover, the perspective is reversed by starting from monetary exchange and asking whether the fall in technical costs may trigger a switch to financial barter.

The paper is organised as follows. In section 2 monetary and non-monetary exchange will be defined and the respective costs analysed. Section 3 provides a market microstructure model to tackle the question under what conditions non-monetary exchange could be efficient. Section 4 provides empirical evidence from foreign exchange markets to support the general findings of this paper.

2 Exchange With and Without Money

As the discussion above has demonstrated, there is a wide-spread belief that financial innovation will have a profound effect on the future of money and payments. But there is no agreement as to the precise nature of the future system of exchange. Excluding barter or 'e-barter' (see Capie, Tsomocos, Wood 2003), three different scenarios can be distinguished:

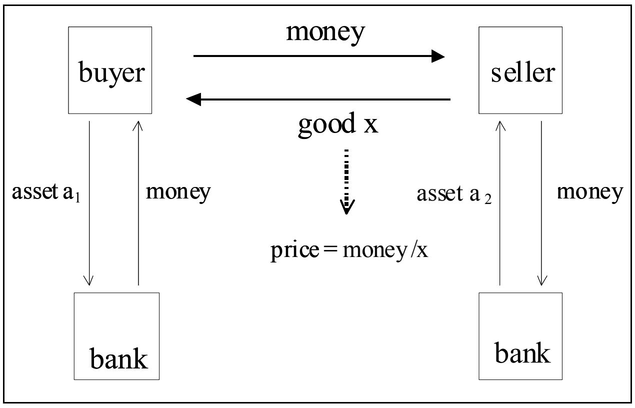
- Monetary separation (one unit of account, many media of exchange)
- Financial barter (many units of account, many media of exchange)
- Monetary exchange (one unit of account, one medium of exchange)[5]

In monetary exchange, one special asset is used as unit of account (uoa) and at the same time as medium of exchange (moe). From the point of view of the money-holder, the chief disadvantage of money is the fact that it is non-interest-bearing or - if it pays interest – that the interest rate is lower than the interest on alternative investments. Thus, there is an opportunity cost of holding money. In a monetary economy, the inclusion of t-costs leads to the well-known phenomenon of cash management. Both, buyer and seller periodically exchange money against assets and vice versa. Such transactions are commonly referred to as 'trips to the bank'.

[5] Strictly speaking, in a monetary world, there are a number of assets that fulfil the criteria of footnote 1; for instance, bank notes, deposits with the central bank, commercial bank deposits or e-money.

As has been shown in standard money demand theory, an agent can minimise costs by optimising the number of 'trips to the bank'. Thus, for each purchase, there will be, on average, ω ($\omega \leq 1$) trips to the bank of the buyer and β trips to the bank of the seller.

Figure 1: Transaction Costs in a System with Monetary Exchange

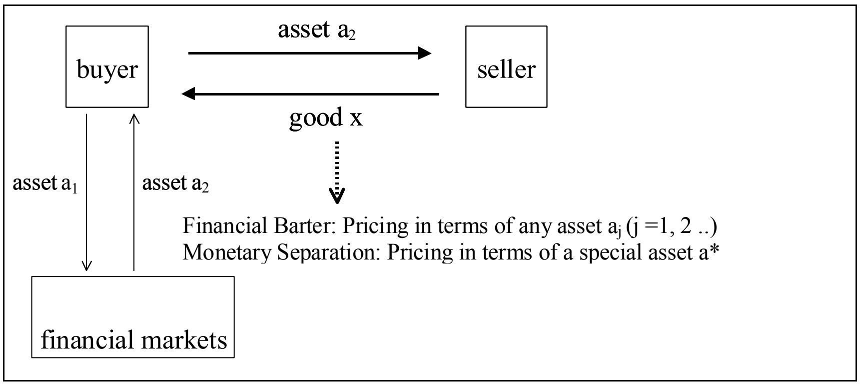


In a system of monetary separation, the role of the state is confined to defining the common unit of account. This unit is used to express prices of goods and services and value debits. Actual exchange, however, takes place using a wide array of goods and of assets. [6] A more radical vision is that of a completely moneyless world in which neither a common medium of exchange nor a common unit of account is used (Cowen and Kroszner 1994). Such a system will be referred to as 'financial barter'. As will become more evident below, monetary separation has more in common with financial barter then with the current system of monetary exchange. Therefore, both, monetary separation and financial barter, will be jointly labelled 'non-monetary exchange'.

In a moneyless world, less effort seems to be required to make a payment. After all, in principle, all liquid assets can be used in order to make a payment. Thus, the buyer of good x can simply transfer asset a_1 in order to pay for good x. However, there are two potential problems that may arise: first, the determination of the payment asset and, second, the determination of the relative price of the payment asset in terms of the unit of account. If the buyer determines the payment asset the seller may end up with an asset he does not wish to hold and which he therefore has to sell. If the seller determines the payment asset, the buyer may have to acquire the asset chosen by the seller before he is able to make the payment. Moreover, in order to determine the amount of the payment asset that needs to be transferred buyers and sellers need to agree on the relative price between the 'pricing asset' and the payment asset.

[6] One of the assets could be 'barter credit' (an IOY of the buyer).

Figure 2: Transaction Costs in a System with Non-Monetary Exchange



Consequently, the typical purchase transaction in a moneyless world looks as depicted in Figure 2 (assuming the seller determines the payment asset). Alternatively, the financial market transaction would have to be carried out the by seller (assuming the buyer determines the payment asset).

In the case of monetary separation, the pricing of goods and assets will be in terms of a common unit of account. In a system of financial barter, good x can be priced in terms of any good (or goods' basket) or asset (or portfolio of assets) that is used as unit of account.

A shift from monetary to non-monetary exchange would be efficient if the costs of non-monetary exchange are lower than the costs of monetary exchange.

The costs to be considered are:

- Brokerage fees
- Opportunity costs
- 'Technical costs'
- Costs of negotiating the payment medium
- 'Computational costs' (of determining the price in terms of a uoa and moe)
- (Net) Costs of issuing money

Each of these costs will be discussed below.

- Computational and negotiation costs

If there is no common medium of exchange the two parties involved in a transaction need to negotiate which medium of exchange shall be used. As a consequence, negotiations are more complex than in a monetary world and transparency is reduced. This argument applies to monetary separation as well as financial barter.

Table 1: Computational costs per transaction

Monetary exchange	**Financial barter**	**Monetary separation**
	C_{C1}	C_{C2}

$C_{C1/2}$ are the costs of determining the price of the good in terms of the payment medium

If there is no common unit of account, it becomes more complex to assess the price of a good and the amount of the agreed settlement asset that has to be offered (accepted) in payment. In other words, it becomes more difficult to 'compute' values and quantities. Because of these difficulties, price transparency is reduced and accounting becomes more complex (see also Niehans 1978, ch.7).

- Technical costs

All of the three types of exchange involve digital information that travels over electronic networks. In all cases, an account has to be kept with a financial institution. In the case of monetary transactions, financial institutions need to hold an account with the central bank for settlement purposes. In the case of non-monetary exchange, financial institutions need to employ the services of custodians to store electronic assets. There is no reason to assume that the technical costs of one particular mechanism should be significantly higher than for the other mechanisms.

Table 2: Technical costs per transaction

Monetary exchange	Financial barter	Monetary separation
C_T^m	C_T^{nm}	C_T^{nm}

C_T^m and C_T^{nm} are t-costs of transferring an asset between buyer and seller, of keeping an account, of clearing & settlement and of custody

- Costs of issuing money

Under current conditions, issuing deposits involves the costs of providing convertibility between bank notes and deposits. However, in a pure deposit regime, these costs would be non-existent. In such a system, there would be very few extra costs for a money issuer over and above what has been summarized under the heading 'technical costs'. What remains are the costs of complying with specific regulations for deposit issuing institutions (incl. minimum reserves and capital).

Table 3: (Net) Costs of issuing money per transaction

Monetary exchange	Financial barter	Monetary separation
$(C_D^m - r^m)(t_b + t_s) P_x$		

$t_{a/s}$ is the average time money is held (by a buyer 'b' or seller 's') before it is spent or deposited, P_x is the size of the transaction, r^m corresponds to the opportunity cost variable known from cash management models (here as income of the money issuer), and C_D^m are the costs of producing one unit of deposits. (Since money can be used more than once per period, costs per transaction depend on the average holding period).

- Opportunity costs

Opportunity costs may be important from the point of view of individual agents. However, from a social point of view, opportunity costs of the money holders are off-set by seigniorage gains of money issuers.[7] Never-the-less, opportunity costs matter, even from a social point of view, because they give rise to brokerage costs (see below). In this context, it is important to note that, to some extent, opportunity costs also arise in a moneyless world. Whenever buyers and sellers do not wish to transact with the same medium of exchange, one of them has to accept a temporary deviation from his optimal portfolio. If the seller gets to choose the payment asset, for a short period of time, the buyer has to hold an asset which he does not wish to hold. If the buyer gets to choose the payment asset, the seller receives an asset he does not want to hold and which he will have to sell. Thus, the shift from monetary exchange to non-monetary exchange transforms opportunity costs but does not reduce them to zero: instead of **permanently** holding an exchange asset with low or zero interest people have to **temporarily** hold an asset that they do not wish to hold. This entails costs in terms of a departure from the optimal risk-return position.

Table 4: Opportunity costs per transaction

Monetary exchange	Financial barter	Monetary separation
$(t_b + t_s) P_x \cdot r^m$	$(T_b + T_s) P_x \cdot r^{nm}$	$(T_b + T_s) P_x \cdot r^{nm}$

r^m corresponds to the opportunity cost variable known from cash management models, $t_{b/s}$ ($T_{b/s}$) is the average time money (a payment asset) is held by a buyer (subscript b) or seller (subscript s) before it is spent or deposited[8], P_x is the size of the transaction, r^{nm} are opportunity costs of temporarily holding an unwanted asset (of a temporarily sub-optimal asset structure)

- Brokerage costs

In a monetary world, brokerage costs are the costs of buying and selling assets. Since not every purchase or sale of a good will trigger an asset sale or purchase, brokerage costs b^m have to be multiplied with the probability of an asset sale or purchase. If, for instance, a retailer deposits payments received at the end of the day and if he carried out 100 transactions during that day, brokerage costs for each transaction are 1/100th of b^m.

In a non-monetary world, brokerage costs are the costs of exchanging one asset against another. Given the huge number of existing assets, the probability that a payer and a payee wish to transact using the same asset as medium of exchange is fairly small. Thus, the probability that a payment transaction makes a subsequent financial market transaction necessary (δ) should be fairly close to one.[9]

[7] The opportunity costs of holding money can be reduced via payment of interest on money.
[8] It corresponds to (1/2 *k*) in standard cash management models (where k is the number of trips to the bank).
[9] The cash management calculus cannot be applied to the non-monetary world because aggregation is usually not

Table 5: Brokerage fee per transaction

Monetary exchange	Financial barter	Monetary separation
$(\omega + \beta)\, b^m$	$\delta\, b^{nm}$	$\delta\, b^{nm}$

b^m corresponds to the brokerage fee in the well-known cash management model, for each purchase, there will be an average of ω ($\omega \leq 1$) 'trips to the bank' of the buyer and β (β <1) trips to the bank of the seller, b^{nm} are the brokerage costs of buying/selling assets in a non-monetary world, δ corresponds to the probability that buyer and seller do not wish to transact with the same asset[10]

- Trade-off between brokerage costs and opportunity costs

When looking only at brokerage costs and opportunity costs what can be said about the relative advantages of non-monetary and monetary exchange? Standard cash management models imply that there is a trade-off between these two types of costs. Opportunity costs can be reduced via incurring higher brokerage costs and vice versa. This trade-off is based on the principle of aggregation. A payer does not need to go to the bank and obtain money for each transaction. He has the choice to obtain enough money in one financial market transaction for many payment transactions. He can do so because in each payment transaction the same asset, 'money', is used.

In the case of non-monetary exchange, the principle of aggregation can be applied only to a very limited extent. Since a large number of assets can be used as medium of payment, it is highly likely that a sequence of *n* transactions will be settled with *n* - or almost *n* - different assets. Therefore, aggregation will not be possible. Thus, there is no benefit from waiting. A merchant may as well make the exchange of an asset he receives in payment into the asset of choice immediately. In this case, in the non-monetary world opportunity costs are zero (disregarding the small span between goods' market transaction and financial market transaction) while brokerage costs are incurred after each transaction in goods' markets

- Simplifying assumptions

In order to facilitate the analysis of the implications of technological change on the relative costs of monetary and non-monetary exchange, a number of simplifying assumptions have to be made.

First, since deposit-based monetary payments as well as a non-monetary payments are carried out through electronic networks, technical costs will be assumed to be equal. Moreover, technical progress is likely to affect technical costs for both types of payments in a similar way. Given these assumptions, technical costs can be excluded from the comparison below.

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feasible. Thus, assets will be bought or sold immediately before/after the transaction.

[10] For 2 randomly picked buyers and sellers, δ=1-$\text{Prob}_i(a_x)$ $\text{Prob}_j(a_x)$, where $\text{Prob}_{j/i}(a_x)$ is the probability that buyer *i* (seller *j*) wishes to transact with asset a_x. $\text{Prob}(a_x)$ can be approximated with the market share of asset a_x.

Second, above it has been argued that opportunity costs also have to be taken into account in a non-monetary regime. However, such costs are likely to be small. Therefore, in order to simplify the analysis, they will be excluded from the analysis.

Third, computational and negotiation costs are difficult to quantify and will thus be excluded.

Fourth, under competition there should be no profits from issuing money.[11] In this case, C_D^m (the costs of issuing money) should equal r^m (seigniorage income).

The second and third assumptions introduce a bias against cash. However, they are not problematic as long as the comparison shows that monetary exchange is less costly than non-monetary exchange. In this case, relaxing these assumptions will simply re-enforce the initial result. Should non-monetary exchange prove to be less costly, the result would have to be reviewed under relaxed assumptions.

Given the four assumptions above, the costs of monetary and non-monetary exchange can be simplified to:

(1) $C^m = (\omega + \beta)\, b^m + (t_b + t_s)P_x\, r^m$ Costs of monetary exchange

(2) $C^{nm} = \delta\, b^{nm}$ Costs of non-monetary exchange

Thus, what remains as costs of monetary exchange are the 'classical' cash management costs (brokerage costs and opportunity costs). Since the standard square root formula implies that cost minimizing agents will always adjust in such a way that brokerage costs and holding costs are equal in size, these costs can be written as:

(3) $C^m = 2(\omega + \beta)\, b^m$

As technical progress drives down b^m agents will engage in more active cash management and $(\omega + \beta)$ will be rising. Under 'perfect cash management' (ω=β=1) costs of cash management would be equal to 2 b^m.[12] If, in addition, 'portfolio management' is also perfect (δ=1), the condition for a switch to non-monetary exchange would be:

(4) $b^{nm} < 2\, b^m$

Thus, in order for non-monetary exchange to prevail, brokerage costs per non-monetary transaction need to be smaller than 2 times brokerage costs per monetary transaction. At first, such a result may seem odd, but a non-monetary system would require fewer transactions. For each purchase and sale in goods' markets, there would only be one purchase or sale in financial markets whereas a monetary system requires two transactions.

[11] In almost all market economies deposit creation is a competitive business carried out by commercial banks.

[12] Assuming that under perfect cash management asset sales (purchases) take place immediately before (after) a goods' transaction, so that opportunity costs would be reduced to zero. If they would take place, on average, in the middle of the period between two transactions, the costs of monetary exchange would be $4b^m$.

Even though the world seems still far away from the state described above (ω=β=1), there is no doubt that transaction costs have been falling substantially. Therefore, it is worthwhile to analyse in more detail the relative size of brokerage costs in a monetary (b^m) and a non-monetary world (b^{nm}) and how they are affected by technological change. Below, a market maker model will be used to shed light on this question.[13]

3 Brokerage Costs: A Market Microstructure Approach

Brokerage costs consist of an individual's time and effort and of the costs of using the market. The first category is difficult to measure. Some authors have argued that these costs can be reduced substantially via the use of automated processes. Thus, in the future, they may increasingly lose significance. In addition, it can be assumed that these costs are roughly the same for monetary and non-monetary transactions. Therefore, the focus will be on the second category, the costs of using the market. These costs consist of explicit fees and implicit costs that arise from the spread between buying and selling prices. Moreover, when larger quantities are involved, market participants have to take into account that the market price may move against them ('market impact'). Technical progress can reduce some of the transaction costs but – as will be shown - it cannot totally eliminate them.

Transaction costs in financial markets do not just consist of hardware and software costs. An important cost component consists of the costs of market making. Without market makers it could be difficult and time-consuming to find a trading partner who is willing to trade at an acceptable price. The service provided by this type of trader is 'immediacy' (Demsetz 1968). The price for this service usually consists of the difference between the bid and the ask price (the 'spread'). In a market without designated market makers, limit orders perform the same function as a market maker (Stoll 1985, 73). In this case, the argument developed below applies to those market participants who place limit orders.

In a frictionless world, the spread would be zero. Matching purchases and sales would be costless. However, in the real world, market makers encounter a number of 'frictions' (Stoll 2000). These frictions are the cause of positive trading costs. The principle types of frictions are processing costs, inventory risk and adverse information. These costs have to be recovered via the spread. In addition, if market makers have market power, the spread may contain monopoly rents.

[13] It has been pointed out by other authors already that the market maker model can be usefully employed in monetary theory. For instance, Goodhart (1989, 2) proposes to use the market maker model instead of the Arrow-Debreu Walrasian auctioneer to analyse monetary phenomena.

There are numerous models to explain the price-setting of market makers. Below, a modified version of Madhavan and Smidt (1991) will be used to show which factors determine the size of transaction costs. Subsequently, the implications for the use of money will be discussed. The model of Madhavan and Smidt has been chosen because it encompasses a number of other well-known models, such as Roll (1984), Ho and Marcis (1984) and Glosten and Harris (1988).

The basics of the model are as follows. Trading of a risky asset is divided into periods $t = 1,2, \ldots, T$. Traders can trade with each other or with a market maker. Each period, a market maker quotes a bid and an ask price. The traders may or may not accept the quote. However, the market maker can observe all trades, even if he is not involved. The full information price $\tilde{v}$ of the asset evolves as follows:

(5) $$\tilde{v} = \sum_{i=0}^{T} \tilde{d}_i$$

where $\tilde{d}$ is i.i.d. with mean zero and variance σ^2 and a tilde indicates a random variable.

The value in period t (after realisation of d_t) is given by $v_t = \sum_{i=0}^{t} d_i$ Since the increment or dividend $\tilde{d}_t$ is realised after the trading took place, in the moment of trading, the value of the risky asset is a random variable with

(6) $$\tilde{v}_t = v_{t-1} + \tilde{d}_t .$$

In a market without transaction costs the asset price would be equal to the expected value of the asset: $p_t = \mathrm{E}[v_t|v_{t-1}] = v_{t-1}$. However, when the market maker quotes prices, he has to take execution costs and adverse information into account.

In the model, execution costs are assumed to be fixed. Adverse information is modelled in the following way. Madhavan and Smidt assume that there is a noisy public signal $\tilde{y}_t$ about the future increment d_t:

(7) $$\tilde{y}_t = v_t + \tilde{\varepsilon}_t$$

where ε_t is i.i.d. with mean zero and variance σ^2_{ε}.

In addition to the public signal, some traders receive a private signal $\tilde{w}_t$:

(8) $$\tilde{w}_t = v_t + \tilde{\omega}_t$$

ω_t is i.i.d. with mean zero and variance σ^2_{ω}.

The public signal, $\widetilde{y}_t$ received by the market maker is treated as costlessly received signal. More realistically, the quality of the signal should depend on effort[14] and on the number of assets n for which the market maker quotes prices. In particular, a trader who trades in various markets, quoting prices for different assets, will find it difficult to monitor information for various assets and update prices in a timely fashion. Therefore, the parameters σ_ε^2 will be treated as a function of the number of assets traded by a market maker:

$$(9) \qquad \sigma_\varepsilon^2 = f(n) \ with \ \partial f / \partial n > 0$$

where n is equal to the number of assets traded by a market maker.

When the market maker sets prices he has to take his own expectations (conditional on trade), the public signal, his own inventory position, execution costs and opportunity costs into account.

$$(10) \qquad p_t = \mu_t - \gamma(I_t - I_d) + (\psi + \tau)D_t \qquad with \, \partial \tau / \partial n < 0$$

where p_t is the quoted price, μ_t is the expectation of v_t conditional on trade, I_t is the current inventory position, I_d is the desired inventory position, D_t is an indicator function which is equal to +1 for sales and –1 for purchases. ψ is a constant and reflects execution costs. τ reflects fixed costs of market making due, for instance, to the opportunity costs of time. n is equal to the number of assets traded by a market maker.

The equation states that the market maker will raise (lower) prices whenever he is net short (long) relative to his desired portfolio position. Execution costs and the fixed costs of market making raise the ask price and lower the bid price. As in Howitt (2005), the fixed cost of market making 'τ' is a crucial variable. It is assumed that, ceteris paribus, the number of transactions rises with the number assets for of which a market maker is quoting prices. Thus, τ rises when the market maker reduces the number of assets in which he quotes bid and ask prices.

When setting prices, a crucial problem is the determination of μ_t. The market maker knows the public signal and its statistical properties. He does not know the private signal but he knows its statistical properties. Finally, he knows the function determining order quantity:

$$(11) \qquad q_t = \alpha(m_t - p_t) - x_t$$

where α reflects 'animal spirits' of the insiders. m_t is the market makers conditional expectation of $\widetilde{v}_t$. x_t represents liquidity trading. x_t is i.i.d. with mean zero and variance σ_x^2.

[14] See Grossman and Stiglitz (1980).

The market maker can use his knowledge of the function determining quantity and the statistical properties of the insider's estimate to form the conditional expectation μ_t of the asset value v_t given that there was a trade:[15]

$$(12) \quad \mu_t = \pi\, y_t + (1-\pi)(p_t + q_t/\alpha)$$

where π is the weight placed on public information:

$$(13) \quad \pi = \frac{\left(1+\sigma_\omega^2/\sigma_\varepsilon^2\right)\left(\sigma_x/\alpha\right)^2}{\sigma_\varepsilon^2 + \left(\sigma_x/\alpha\right)^2\left(1+\sigma_\omega^2/\sigma_\varepsilon^2\right)}.$$

Substituting equation (12) into equation (10) and solving for p_t: yields:

$$(14) \quad p_t = y_t + \frac{1-\pi}{\pi}\frac{q_t}{\alpha} - \frac{\gamma(I_t - I_d)}{\pi} + \frac{(\psi+\tau)D_t}{\pi}$$

This equation can be more easily interpreted if it is split into two parts, one equation for the bid price and one equation for the ask price. Taking into account that D is negative when q is negative:

$$(15) \quad p_t^{ask} = y_t + \frac{1-\pi}{\pi\alpha}|q_t| - \frac{\gamma(I_t - I_d)}{\pi} + \frac{(\psi+\tau)}{\pi}$$

$$(16) \quad p_t^{bid} = y_t - \frac{1-\pi}{\pi\alpha}|q_t| - \frac{\gamma(I_t - I_d)}{\pi} - \frac{(\psi+\tau)}{\pi}$$

When deriving bid and ask prices, market makers take publicly available information, order flow information, inventory positions, processing and opportunity costs into account. The role of processing and opportunity costs is straight-forward. Making a market requires inputs - including the market maker' time - that have to be paid for. Therefore, the ask price has to be somewhat higher than the expected value of the asset and the bid price has to be lower. Market makers also have to be concerned about their inventory position. Large long or short positions will expose them to price risks. Consequently, they will use prices to achieve an adjustment towards their preferred inventory position.[16] Another important effect on prices comes from adverse information (Bagehot 1971, Glosten and Milgrom 1985). If there are traders with inside information the order flow conveys information. A sale signals that insiders have information that leads to a higher valuation of the asset, a purchase implies that insiders may have information that the asset is currently overvalued. Therefore, market

[15] Compare Madhavan and Smidt (1991, 104).
[16] Inventories may also yield a return. But they are not diversified and therefore very risky.

makers will set an ask price that is equal to the expected value in the case of a sale. Similarly, the bid price is the expected value – given that there is a purchase. Thus, they incorporate order flow information into their prices before the actual transaction has taken place. By doing so, they set what has been labelled 'regret-free prices'.

The bid-ask spread can be used as a measure of the costs of trading in financial markets. Subtracting equation (15) and (14) yields the following result for the bid-ask spread:

$$(17) \qquad p_t^{ask} - p_t^{bid} = 2\left[\chi q + (\psi + \tau)(1 + \alpha\chi)\right]$$

The term χ determines how much weight market makers give to order flow and the information it may contain.

$$(17) \qquad \chi = \frac{\sigma_\varepsilon^2}{\left(\sigma_x^2/\alpha\right)\left(1 + \sigma_\omega^2/\sigma_\varepsilon^2\right)}$$

where σ_ε^2 is the variance of the market maker's prior, σ_x^2 is the variance of liquidity trading and serves as a proxy of the volume of liquidity trading, σ_ω^2 is the variance of the private signal and α represents 'animal spirits' of insiders (i.e. their willingness to trade on perceived profit opportunities).

For the typical trader, brokerage costs b of a sale or purchase consist of 0.5 times the spread:[17]

$$(18) \qquad b = \chi q + (\psi + \tau)(1 + \alpha\chi)$$

Technological change has been (and still is) driving down the technical costs of trading ψ. As these costs are approaching zero, (18) can be simplified to (normalising q and α to 1):

$$(19) \qquad b = \chi + \tau(1 + \chi)$$

Since non-monetary exchange becomes efficient if b^{nm} is smaller than 2 times b^m the condition for a shift to non-monetary exchange becomes:

$$(20) \quad b^{nm} = \left(\chi^{nm} + \tau^{nm} + \chi^{nm}\tau^{nm}\right) < \; 2b^m = 2\left(\chi^m + \tau^m + \chi^m\tau^m\right)$$

The term χ can be interpreted as measure of the effect of inverse information. χ will rise, and thus the spread will increase if

- the quality of the public signal is reduced (if σ_ε^2 rises),
- the volume of liquidity trading (measured by σ_x^2) is reduced,
- the quality of the private signal increases (σ_ω^2 falls) or

[17] Since the costs of accessing the market (communication costs, costs of maintaining a trading account, etc.) are the same for monetary and non-monetary exchange, they have been omitted.

- traders with private information become more responsive to perceived profit opportunities (α rises).

When assessing the consequences of a change from monetary to non-monetary exchange, basically two effects have to be considered:

First, for a given number of underlying exchanges '(i.e. portfolio shifts or goods' purchases/sales) the number of transactions is cut in half. Indeed, this is the underlying rationale of inequality (20). Non-monetary exchange requires fewer transactions in asset markets and thus implied lower costs (ceteris paribus).

Second, the shift towards non-monetary trading increases the number of markets from n to $n(n\text{-}1)/2$. At the same time, the number of transactions per market is reduced and each trader will have to substantially increase the number of markets in which he is active, i.e. augment the range of assets for which he quotes bid and ask prices. Such a change affects χ (representing risk related costs) and/or τ (the fixed costs of market making). Both are likely to rise, augmenting the costs of trading.

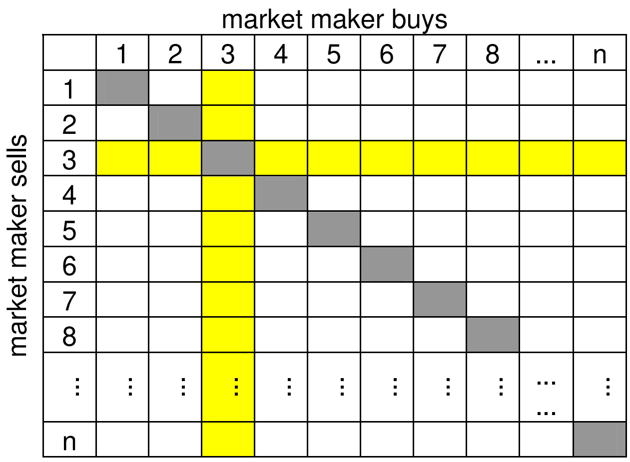
Before comparing brokerage costs in both regimes, it is necessary to analyse in which manner market makers will organise their trade in a non-monetary world. In order to do so it is useful to define two concepts:

- In the following, 'a market' is defined as a place where one particular asset a_j is exchanged against another asset a_i ($j \neq i$). In a non-monetary world, it can best be understood as a swap-market.
- An 'underlying transaction' is a sale/purchase of goods or assets that triggers payment transactions. It is assumed that the number of underlying transactions is the same for both types of regimes.

After a switch to non-monetary exchange, if a market maker wants to cover the same spectrum of the market as in monetary exchange he has to trade one asset against all other assets. For instance, if he used to make a market in asset 3, he now would have to quote a bid price for asset 3 in terms of other assets and stand ready to deliver whatever asset the customer wishes. At the same time, he has to quote an ask price for asset 3 in terms of all other assets and accept in payment whatever customers chose. In this manner the market maker would be capable to serve the entire demand for and supply of asset 3 (see Figure 3). However, given that the market maker has to accept all assets in exchange and also offer all assets in exchange he also has to be informed about all assets. Consequently, the question arises why he would confine himself to this small spectrum of the market. There really is no reason not to trade asset 4 against 5, 7 against 8 etc. Thus, there would be no specialisation. In the case discussed above, the market maker would make a market in all assets.

Therefore, for this trader, the average error regarding the true value of an asset ($\overline{\sigma}_{\varepsilon}^{2}$) would be vastly increased. If n is taken literally to comprise all assets, the error variance would be so high as to make trade prohibitively expensive. But even for a moderate number of assets, say those stocks included in the Standard&Poor's 500 index (S&P500), a market maker would face a daunting task. He would constantly have to adjust 124,750 prices.

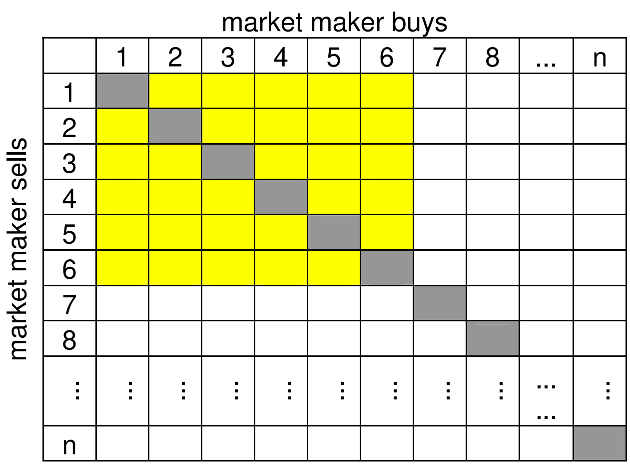
Figure 3 Non-monetary exchange: a market maker specialised in asset 3



1,2, …, n: assets that can be used for payments

Thus, in order to reduce the error variance of his prior, a market maker would have to drastically cut the number of markets in which he is active. This, however, implies that the volume of trading is falling. Thus, fixed costs have to be spread over fewer transactions and τ rises. As each market maker serves a smaller segment of the market, the total number of market makers would have to increase.

Figure 4 Non-monetary exchange: a market maker specialised in asset 1 to 6



1,2, …, n: assets that can be used for payments

A market maker who wants to specialise has to specialise on a number of cross rates (to borrow a term from foreign exchange markets). In Figure 4, for instance, a market maker specialises in the assets 1 to 6 and serves all bilateral trading pairs. Although specialised, for instance, in asset 4, he does not quote prices of asset 4 against asset 7 or 8. So, from the point of view of customers who want to buy or sell a particular asset, there is a market split. From the point of view of the market maker, specialisation goes hand in hand with a sharp decrease in trading volume.

So, when comparing b^n and b^{nm}, we have to compare a system in which a market maker trades one asset against money with a system in which he trades in $n^{nm}(n^{nm}-1)/2$ markets. As the number of assets rises for which a market maker quotes prices, liquidity trading rises (reducing τ) and at the same time the market makers error rises (increasing χ). The functional form of τ is fairly straight forward:

(21) $$\tau = w/x$$

with w =opportunity costs of time, x = number of transactions.

In order to derive the number of transactions, it is assumed that the number of underlying transactions (z) is fix. Since each underlying transaction makes 2 monetary transactions necessary, the number of transactions in a monetary world is $2z$. Thus, for a market maker in a monetary world (trading one asset) we get:

(22) $$x^m = \frac{1}{n}2z = \frac{1}{n}n(n-1)d = (n-1)d$$

with z = number of underlying transactions, d = number of transactions per market , n = total number of assets.

The number of transactions per non-monetary trader depends on the number of assets (n^{nm}) he is trading:

(23) $$x^{nm} = \frac{n^{nm}\left(n^{nm}-1\right)}{2}d$$

Thus, for non-monetary trade, opportunity costs are

(24) $$\tau^{nm} = \frac{w}{x^{nm}} = \frac{2w}{n^{nm}\left(n^{nm}-1\right)\,d}$$

and for monetary trade they are equal to

(25) $$\tau^{m} = \frac{w}{x^{m}} = \frac{w}{d(n-1)}$$

The model does not have, however, straight forward implications as to the functional form of risk related costs. To be sure χ is rising in σ_ε^2. Under the assumption of economies of scale in information processing, the rise would be less then proportional. If it is assumed, however, that the progressively rising number of cross rates has a strong influence on the error variance, it could also be assumed that σ_{ε}^{2} is rising progressively in the number of assets. Given that both alternatives are possible, it is assumed that χ is rising linearly in the number of assets.[18]

(26) $$\chi^{nm} = sn^{nm}$$

(27) $$\chi^{m} = sn^{m} = s$$

where s is a coefficient representing the effect of the number of assets traded on risk-based costs.

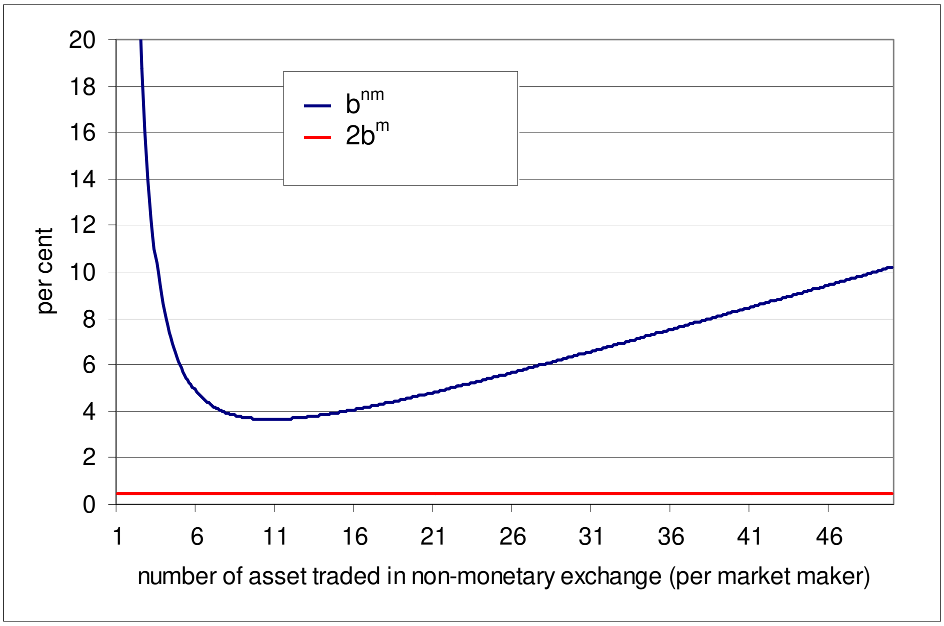
Combining (24) and (26) as well as (25) and (27) yields brokerage costs:

(26) $$b^{nm} = \frac{2w}{n^{nm}\left(n^{nm}-1\right)\,d} + sn^{nm} + \frac{2ws}{\left(n^{nm}-1\right)\,d}$$

(27) $$b^{m} = \frac{w}{\left(n-1\right)\,d} + s + \frac{sw}{\left(n-1\right)\,d}$$

Minimal brokerage costs in a non-monetary world can be derived by setting the first derivative of b^{nm} with respect to n^{nm} to zero and solving for n^{nm}. This yields a fourth degree polynomial with no apparent solution. Figure 5 provides the results for a number of plausible parameter values.

Figure 5: The costs of monetary and non-monetary exchange



Assumptions: n^{nm}=1; w=500€ per day; s=0,2; d=20 per day, n=1000, value per transaction=100€

[18] Such a linear relationship emerges if the market maker's error is proportional to the square root of assets traded. This may actually be understating the effect of the number of assets traded on risk.

Given the assumptions underlying Figure 5, in a non-monetary world a market maker reaches minimum costs at about 8 assets. These minimum costs are far about the threshold level of two times brokerage costs in monetary exchange. Variations in the risk coefficient *s* affect both $(n^{nm})_{min}$ and n^m without changing their ratio dramatically. Increases in trading per market *d* lower $(n^{nm})_{min}$ and also reduce the relative advantage of monetary exchange. For very high value of *d*, $(n^{nm})_{min}$ finally falls below n^m. However, given that *d* represents trading in one bi-lateral pair (say Karlsruhe municipal 5 year debt against shares of a mid-sized US bank) the average *d* is likely to be small. A fall in *w* also reduces the relative advantage of monetary exchange. However, a value far below 500€ per day would seem unrealistic. Finally, even when moving all parameters in a way favourable for non-monetary exchange, the advantage of monetary exchange remains for a wide array of parameter values.

Notwithstanding the uncertainty with respect to the slope of χ, an important conclusion can be drawn: Unless the number of assets has an extremely small effect on risk related costs, market makers have to confine themselves to trading only a few assets. Few assets and consequently low trading volume implies high fixed costs per transaction. In such a case, brokerage costs of non-monetary exchange are far above the required level of 50% of monetary exchange.

The model underlines the particular advantages of monetary exchange. Market makers can specialise in a single asset allowing them to contain risk related costs; and at the same time they can serve a fairly big part of the market.[19] Thus, market microstructure theory suggests that inflating the number of markets leads to higher costs in terms of labour input and higher costs of adverse information than monetary exchange. These findings confirm the results of Alchian (1977) who argues that the main advantage of money is that it allows for the emergence of specialised trade.

Before concluding that monetary exchange is superior to non-monetary exchange, it is necessary to address the issue of monetary separation. In a system of monetary separation it may seem possible to have (n-1) markets just as in system of monetary exchange. After all, it is assumed that there still is a common unit of account. Consequently, for each asset (apart from the ‘unit asset’) market makers can quote prices in terms of the common unit of account. Anybody wanting to buy or sell assets only has to cope with (n-1) markets. Thus, monetary separation promises to combine the advantages of a single unit of account with freedom of

[19] Aspects of competition have been neglected in this analysis. Of course, as traders specialise in smaller market segments there would be less competition in each segment. The inclusion of this aspect would re-enforce the argument in favour of monetary exchange.

choice in payment media. However, the need to settle in different assets leads to a split of markets in many respects similar to financial barter.[20]

An example will help to understand why market integration is not possible unless there is a common medium of exchange. Suppose the unit of account is defined as one kilo of gold. Bonds and shares can be used as medium of exchange. In this case, the question arises who decides about the settlement medium: In an environment with specialised market makers it could be either the market maker or the client.

If market makers decide about the medium of settlement, they will be likely to limit the number of assets they are prepared to use as means of payment to a very small number – possibly one. Otherwise they would not be able to use the proceeds of their sales directly to pay for their purchases. Indeed, the whole process of clearing and settlement would be vastly more complicated if they accepted more than one asset. However, from the point of view of clients, this leads to a split of the market. There are market makers of asset A that accept asset B in payment others accept C in payment, and so on. Thus, a customer who wants to sell A and wishes to buy D will approach a market maker in A that settles in D. The same market maker may also be approached by a customer wishing to buy D and wanting to sell A. Indeed, this market maker looks exactly like a market maker in A-D swaps – just like market makers in a system of financial barter.

If clients are the ones to decide about the medium of settlement, they will be willing to deal with any market maker who trades asset A. However, from the point of view of market makers, business becomes very complicated because under the 'client decides' rule he can be long or short in any asset selected by clients. It is not possible for him to be a specialist in all of these assets. Thus, a market maker is much more prone to become a victim of insiders – just as in a system of financial barter. And just as in a system of financial barter market makers face the choice between specialisation in one or a few swap markets or acceptance of significantly higher risks.

While at first sight monetary separation seems to offer the best of two worlds, use of a common unit of account and choice in media of payment, the analysis above shows that it either leads to a system similar to financial barter (monetary separation with 'market maker decides' rule) or that it becomes so costly that markets may break down completely (monetary

[20] In the literature, there has been a debate whether such a system would be feasible. See, for instance, Greenfield and Yeager (1983), (1986) and (1995), Hoover (1988), White (1984) and (1986), Trautwein (1993) and Woolsey and Yeager (1994). The main argument against monetary separation is that the price level is indeterminate in such a system. In the following, the problem of determinacy will be ignored. Rather, it will be analysed how such a system would perform in terms of transaction costs.

separation with ‘client decides’ rule). Thus, monetary separation is not a feasible option. Non-monetary exchange has to be imagined as a system of [*n*(*n*-1)/2] swap markets.

4 Transaction Costs: Empirical Observations

There are numerous studies that show, that transaction costs in financial markets do not simply consist of the technical costs of trading.

First, risk-related costs are quantitatively significant. Various empirical studies have tried to quantify the relative importance of the different factors for the size of the spread. Using NASDAQ data Stoll (1989, 132) finds that order processing costs account for 47 percent of the spread, adverse information for 43 percent and holding costs (incl. risk) for 10 percent. A more recent study Menyah and Paudyal (2000) report values between 30% and 79% for processing costs, 21% to 47% for asymmetric information and 0% to 23% for inventory risk. Stoll (2000) estimates a share of ‘real frictions’ (processing plus inventory costs) of 47% of the spread for NYSE/AMSE and 63% for Nasdaq.

The size of the spread is mainly determined by a number of characteristics of the individual asset (Stoll 2000, Madhavan 2000):

- daily dollar trading volume
- the return variance
- the stock’s market value
- the stock’s price
- the number of trades per day

There is wide agreement that these factors ‘explain most of the variability in the bid-ask spread’ (Madhavan 2000, 213). Moreover, the empirical relationship seems to be surprisingly robust (Stoll 2000, 1481). Thus, even if technical costs should fall to zero, there still would be considerable transactions costs.

Second, in order to support the theoretical argument developed above it is useful to look at markets that are characterised by very low transaction costs. Already today, many of the existing wholesale markets operate with highly sophisticated technical equipment that makes it possible to communicate and deal at extremely low costs. Therefore, these markets can provide insights about the structure of trade in a low-transaction-cost environment. One such market that is particularly interesting in the present context is the foreign exchange market. In the foreign exchange market different monies are exchanged against each other and a system of financial barter might evolve more naturally than in other markets. If it were true that falling transaction costs trigger a switch from indirect exchange to direct exchange we should observe that all currencies are directly traded against each other. Thus, for *n* currencies that should be *n*(*n*-1)/2 markets.

Table 6: Currency Distribution of Global Fx Market Activity

	April 1989	April 1992	April 1995	April 1998	April 2001	April 2004	April 2007
US dollar	90	82	83,3	87,3	90,4	88.7	86.3
Deutsche mark	27	39,6	36,1	30,1	--	--	--
Euro	(33)	(55,2)	(59,7)	(52,5)	37,6	37.2	37.0
Japanese yen	27	23,4	24,1	20,2	22,7	20.3	16,5
Pound sterling	15	13,6	9,4	11	13,2	16.9	15.0
All currencies	200	200	200	200	200	200	200

Percentage shares of daily turnover
Source: BIS (2007) (2002 and (1999).

While it is not completely impossible to directly exchange a particular currency against any other currency, in most cases, such a direct exchange will not take place. Rather, traders will use a ‘vehicle currency’, such as the US dollar. For instance, instead of exchanging Australian dollars into Euros directly, traders will usually exchange Australian dollars into US dollars and then US dollar into Euros. The explanation for this trading structure is simple. It is usually cheaper to use the US dollar. Since the volume of trade is higher in the US$-Austr.$ and the US$-EUR market, the spreads are lower. Thus, two transactions can be cheaper than one.

Table 6 provides the fx market share of some major currencies. In the pre-Euro period, the US$ could be found on one side of transactions accounting for 87 percent of daily turnover. In the other 13 percent of transactions, the DM figured prominently. This can probably be explained by the fact, that the DM was the anchor currency in the EMS. DM and US$ together could be found in transactions that covered about 97 percent of the entire foreign exchange turnover. Even for heavily traded currencies, such as the Japanese yen and the UK pound there are very few non-US$/non-DM transactions (see Table 7).

Table 7: Percentage Shares of Some Currency Pairs

	DM	EUR	Yen		UK£	
	1998	2007	1998	2007	1998	2007
Against US$	20	27.0	18.5	13	8.2	12.0
Against DM	--	--	1.7	--	2.1	--
Against EUR	--	--	--	2.0		2.0
Against others	10*	10.0	0.8	1.5	0.7	1.0
Total share	30	37.0	21.0	16.5	11.0	15.0

Percentage shares of global daily turnover
*: Of which 60% were against non-EMS currencies.
Source: BIS (2007) (2002 and (1999), own calculations.

So far, the introduction of the Euro has not changed the picture. In April 2007, the market share of the US$ was around 86%. Still, the Euro does seem to have captured the status of a vehicle currency in a number of Northern European and Central and Eastern European countries (ECB 2002). Overall, the combined share of the Euro and the US$ is about 96%. Thus, there are only very few transactions that do no involve a vehicle currency.

The evidence from fx-markets shows that, although transaction costs are low in these markets, market participants use a common medium of exchange. Thus, there is hardly any 'foreign exchange barter' in the foreign exchange market. This example shows, that even if the current technical innovations are carried further, making retail payments as efficient as current wholesale transactions, it can be doubted that this would lead to the demise of the use of a common medium of exchange.

5 Conclusions

Proponents of the New Monetary Economics basically claim that barter can be more efficient in a low transaction cost environment than monetary exchange. In the moneyless world, goods and assets are exchanged without using a common means of payment and the 'payment system' is reduced to a mere accounting system that keeps track of the values exchanged. However, the mere fact that transaction costs are falling does not imply that the advantages of monetary exchange are going to vanish.

First, the use of common medium of account economises costs of negotiating the means of transaction and determining the price of good in terms of the chosen medium of exchange. These costs may well be high enough to establish the superiority of monetary exchange. However, they are difficult to measure and they could possibly be off-set by disadvantages in other areas.

Second, cost such as account keeping and electronic transfer of payment information should be more or less equal for deposits or other assets.

Third, from the point of view of the money holder, opportunity costs may be seen as an important disadvantage of cash. However, from a social point of view these costs are off-set by seigniorage income. Moreover, payment of interest (implicit or explicit) limits the size of these costs. Finally, with falling transaction costs the significance of this factor is further reduced (due to more active cash management).

Fourth, brokerage costs consist of 'technical costs', opportunity costs and the costs of adverse information. Technical cost are falling and are likely to full further. Thus, for a comparison of monetary and non-monetary exchange, opportunity costs and the costs of adverse information will be increasingly important. Using a market microstructure model, it can be shown that in non-monetary exchange both types of costs are higher than in monetary exchange. The main reason for the higher costs of non-monetary exchange is that traders have to trade a larger number of different assets and at the same time face a lower volume of trading. Thus, they are less informed and trading involves higher risks and higher fixed costs per transaction.

While the current pace of financial innovation is clearly remarkable, it should not be overlooked that this innovation has mainly to do with the reduction of communication and technical processing costs. Of course, this also reduces transaction costs. However, it is erroneous to assume that a reduction of communication and technical processing costs towards zero reduces overall transaction costs to zero. Transaction costs depend also on many market characteristics such as the size of the market and the volatility of supply and demand. The use of a common medium of exchange that also functions as a unit of account is a way to increase the size of the market and make it more liquid. This reduces transaction costs – when communication costs are high and when they are low.

Finally, the discussion above has shown that the function of a medium of exchange and unit of account belong together. If the medium of exchange does not serve as a unit of account, the informational content of a price quotation will be drastically reduced. In this case, a quoted price no longer conveys information about the type of settlement asset that can be used. This is particularly relevant for market makers. They are facing either higher risks or smaller market volumes. In both cases, they will have to widen their spreads – making it more costly to trade. Therefore, in order to reap the full potential of money to reduce transaction costs, both functions must be performed jointly.[21]

[21] The only exceptions to this rule are assets that can be exchanged at a fixed exchange rate of 1:1 into the unit asset (i.e. the asset that serves as a unit of account). Thus, non-banks treat privately issued deposits just like central bank money.

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