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ABSTRACT

The Euro as an International Currency: Explaining Puzzling First Evidence*

This Paper presents evidence that the bid-ask spreads in euro rates increased relative to the corresponding bid-ask spreads in the German mark (DM) prior to the currency union. This comes with a decrease in transaction volume in the euro rates relative to the previous DM rates. The starkest example is the DM(euro)/yen rate in which the spread has risen by almost two-thirds while the volume has almost halved. We propose a microstructure theory for a system of multiple exchange rates in which spreads are endogenously determined. It is argued that the elimination of cross rates due to the introduction of the euro reduced the intra-temporal risk-sharing capacity of the multicurrency dealership market. A second explanation for the increase in the euro bid-ask spreads and the relative euro volume loss is based on an increase in the information content of order flow in euro rates relative to previous DM rates.

JEL Classification: F33 and G15
Keywords: microstructure, spreads, transaction costs and vehicle currency

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NON-TECHNICAL SUMMARY

This Paper asks whether there is any evidence that the euro is about to challenge the dollar's position as an international currency. It might be expected that the consolidation of liquidity into the euro would make the trading volume of the new external euro currency pairs at least as important as the legacy German mark (DM) pairs. We might also expect that the increased liquidity of the euro means that its bid-ask spreads would have narrowed relative to those of the DM. Lower transaction costs would make the euro attractive as a vehicle currency.

Two data sets are used to examine early trends in euro spreads and trading volume. Spread data is presented from the Reuters indicative quotes system for euro spreads during 1999 against the dollar, sterling and yen. These are compared to the corresponding spreads in the legacy DM rates for 1998. The euro is characterized by higher transaction costs in these three markets. Indicative spreads increased by 40%, 62% and 195% against the dollar, yen and sterling respectively. As a control, spreads are also presented for two non-euro pairs: dollar/yen and dollar/sterling. Spreads have marginally declined in these two pairs. Trading volume data is presented from Electronic Broking Services which brokes up to 20% of the world foreign exchange market. Average daily volumes for the euro for 1999 are lower in its dollar, yen and swiss franc pairs by comparison with the volumes for the corresponding legacy DM rates for 1998. Euro/dollar volume is 9% below DM/dollar business. This is particularly surprising in view of the fact that trading volume between the dollar and legacy currencies other than the DM was almost as large as DM/dollar volume in 1998. The volume of yen/euro trade is 44% lower than yen/DM business while Swiss franc/euro volume is 25% down on Swiss franc/DM trading volume. Again as a control, trading volume data is also presented for two non-euro pairs: dollar/yen and dollar/Swiss franc. These show stable and increasing trading volumes, respectively.

The stylized facts on spreads and volumes are contrary to expectations. A number of simple explanations are examined. The volatility hypothesis suggests that the rise in euro spreads and associated decline in euro volumes comes from increased volatility. However there is no evidence of a sustained volatility increase, which is peculiar to the euro. The competition hypothesis attributes the rise in spreads to reduced competition among market makers. This is implausible because any decline in competition would affect all spreads and not just euro spreads. Finally, the tick-size hypothesis interprets the spread increase as arising from a new institutional feature of the foreign exchange market. The legacy dollar/DM rate was quoted in DMs while the euro/dollar rate is quoted in dollars. The unit of measurement of the former method of quotation meant that the common quote tick size (pip) amounted to a smaller percentage value than under the new system. This argument relies on a value illusion since traders are free to change quote tick size. In any event, it cannot be applied to DM/yen and euro/yen where there has been no change in the quoting convention.

Two new explanations are offered which are consistent with the stylized facts. First, inventory-holding costs may have increased because the currency union is characterized by less efficient intra-temporal risk sharing than the system of multiple cross rates which it replaced. This explanation for the increase in the euro spreads is based on the idea that a competitive inter-dealer market with many cross rates provides better opportunities for a diffusion of excess balances among foreign exchange market makers. A dealer who is for example hit by partially informative excess supply in the DM/dollar rate might offset these imbalances by hedging positions in the DM/French franc rate and the dollar/French franc rate. Such cross-currency hedging depends of course on the existence of these multiple cross rates. Cross-hedging opportunities in various bilateral dollar markets with legacy currencies other than the DM appear to have been an important element of the pre-euro market structure. A notable feature of these markets was the very high proportion (86%) of the trading volume that took the form of outright forwards and swaps. The loss of this hedging opportunity implies increased inventory risk in euro pairs *vis a vis* the external pairs of the legacy currencies such as the DM. This implies higher spreads and consequently lower volume for euro pairs.

A second explanation for the euro spread increase focuses on information costs. We argue that the dollar/DM, DM/yen and other external spreads of the DM were particularly low because liquidity providers in these rates profited from the absorption of relatively less informative imbalances in other intra-European cross rates. The external rates of the euro no longer benefit from the spillover from uninformed intra-European order flow. This again implies lower volume and higher spreads for euro pairs.

The advent of the euro raised the expectation that this new currency would establish itself as a vehicle currency of greater global importance than its predecessor, the DM. Such beliefs were grounded in the belief that a currency union is a simple consolidation of the financial liquidity of the members. Spreads in the euro rates could therefore be expected to decrease and volume to increase. Our evidence suggests that the contrary took place. The existence of many currencies helped traders to diffuse undesired excess balances. This allowed for better risk sharing and required lower equilibrium spreads. We also suggest that the pre-eminent role of the DM as Europe's vehicle currency may have been partly induced by relatively uninformative order flow spillovers from other intra-European currency rates.

1 Introduction

How important is the euro as an international currency for financial transactions?[1] This paper makes a first assessment based on new microdata. The euro's prospective role in the international financial arena was not only part of its political promotion, but also the subject of academic debate. Portes and Rey (1998 - see also Rey, 1999) propose an analytical framework in which the international role of a currency is determined by the interactions between foreign exchange and securities markets. Emphasizing network externalities and multiple equilibria, they distinguish different scenarios for the euro's international role. Based on security market size they find it plausible that the euro would expand the role of the German mark (DM) as a regional vehicle currency and could challenge the dollar's supremacy as the world's principal international currency. While this initial analysis might reflect a long-run perspective, it is interesting to confront it with early data. Surprisingly, our evidence shows that the euro was less important as a transaction vehicle in the first eight months of 1999 than the DM was previously. This negative assessment is based on the following stylized facts:

Stylized Fact 1 (Euro Transaction Costs). *The euro is characterized by higher transaction costs in the dollar, yen and sterling markets. Indicative spreads increased from approximately 3.76 to 5.26 basis points for the dollar rate, from 5.1 to 8.3 basis points for the yen rate and from 3.1 to 9.2 basis points for the sterling rate. Other evidence strongly suggests that this widening extends to effective spreads. We also note that the increase in spreads is not explained by changes in exchange rate volatility.*

Stylized Fact 2 (Non-euro Transaction Costs). *The increase in the cost of euro transactions, relative to DM transactions, occurred against a background of constant or even declining costs in dollar markets, other than the euro/dollar market.*

Stylized Fact 3 (Transaction Volume). *A unique data set for brokered interdealer trades shows* ***lower*** *euro transaction volumes compared to the previous DM volumes. The decrease in the role of euro transactions, compared to DM transactions, occurred against stable or even increasing transaction volumes in dollar markets, other than the euro/dollar market.*

How can we explain these three stylized facts in a coherent theoretical framework? We believe that focusing on spread determination in a multicurrency system is crucial for understanding the characteristics of the euro. The theoretical part of the paper proposes two explanations based on the microstructure of a competitive dealer market.

[1] The international status of a currency is, of course, also determined by its use in central bank reserves and for international trade invoicing. These other dimensions are neglected here in our exclusive focus on the role of the Euro in private financial transactions.

First, we argue that a currency union, with the elimination of many cross rates, deteriorates the intratemporal risk sharing capacity of the dealership market if these cross rates provide important opaque hedging opportunities. They slow the revelation of information about excess balances. The liquidity concentration in the euro comes at the cost of higher market transparency, which can in fact increase the inventory risk for the liquidity providers. It is well established that inventory risk is a crucial determinant of trader behavior and foreign exchange (forex) spread quotation (Bollerslev and Melvin, 1994, Lyons, 1995, 1996). However, the role of market transparency for the spread determination is a very recent concern for the design of equity markets. Our knowledge about the linkage between spreads and market transparency is still tenuous. Evidence that higher market transparency can increase spreads has recently been provided by Bloomfield and O'Hara (1999) in an experimental setting.[2]

Second, the euro currency union eliminated the benefits of relatively uninformative hedging demand from intra European rates towards the dollar/DM and DM/yen rates. In the absence of these flows, liquidity providers in the respective euro rates might face higher average information costs of market making implying higher equilibrium spreads for the euro. There is very little empirical evidence on the role of information costs for the spread determination of asset substitutes. An exception is Mayhew et al. (1995), who study the role of spreads in the derivative market for equity after a decrease in option margin requirements. Option spreads decreased and stock spreads increased, suggesting that the lower option spread profited from more uninformative order flow. We conjecture that a similar information externality from intra European rates lowered external DM spreads and enhanced its international currency status. This positive externality is eliminated with the introduction of the euro.

Previous research has emphasized that the use of a currency in international financial transactions can surpass a country's role in international trade. The notion of a 'vehicle currency' has highlighted the asymmetric role of the dollar in global forex trading and the DM for European currency pairs. Their emergence as vehicle currencies is interpreted as an equilibrium outcome of currency competition under network externalities and decreasing scale economies.[3] Empirical evidence is consistent with the theory. A decomposition of the dollar/yen volume into a predictable and unpredictable turnover component shows for example that predicted volume is negatively correlated with bid-ask spreads, while unpredicted component shows a positive correlation. This provides evidence for both economies of scale effects in market making and information cost effects (Bessembinder, 1994, Hartmann, 1999). But our new evidence in this paper calls for a refinement of the existing microstructure theory of the forex market. Why did the euro not simply inherit and consolidate the forex volume? Any explanation for the imperfect transmission of international currency status therefore has to focus on differences between the euro and the DM.[4]

[2] See also Flood et al. (1999) for an experiment of different design and results.

[3] See Hartmann (1998) for a very good overview.

[4] The 'vehicle currency theory' itself does not speak to this problem except by allowing for an indeterminacy in the number of vehicle currencies. See Hartmann (1998).

The paper is organized as follows. The empirical section 2 starts with a discussion of the foreign exchange market structure and the data sources. Section 2.3 describes the structural break in transaction costs in the external euro rates relative to the previous corresponding DM rates. Section 2.4 uses unique data on brokered inter-dealer transactions to highlight the reduced euro turnover. Section 3 provides a theoretical microstructure framework for interpreting this evidence. We extend a stylized version of Copeland and Galai (1983) to a multicurrency system with endogenously determined spreads and volume. Section 4 summarizes our conclusions.

2 Evidence

2.1 Foreign Exchange Market Structure

The data and the evidence are difficult to understand without reference to the foreign exchange (forex) market structure. A brief overview of the market structure is therefore useful.[5] There are three different types of trades in the forex market. These can best be classified by type of counterparty. We distinguish customer dealer trades, direct interdealer trades and brokered interdealer trades. Dealers are employed in about 100 banks worldwide. The 'customers' are non-dealers in financial firms, non-financial firms and central banks. Financial firms include both leveraged institutions such as hedge funds and unleveraged institutions such as mutual funds.

Customer dealer trades amount to approximately 20 percent of the volume in the former dollar/DM market. Most interdealer order flow is concentrated in about 10 of the 100 participating institutions. Direct interdealer trades amount to approximately 40 percent of the market transactions. The third category, namely brokered interdealer trades, cover the remaining 40 percent of the total turnover. There are two main interdealer broking systems, namely Reuters Dealing 2000-2 and Electronic Broking Services (EBS). We estimate that EBS brokers 40 to 50 percent of the market.

2.2 Data Sources

Our evidence draws from two distinct data sources. For the evidence on transaction costs we rely on indicative quotes from the Reuters information system. These quotes combine the Reuters FXFX and WXWY pages and were purchased from Olsen & Associates in Zurich.[6] This first data source reflects the customer-dealer segment of the market. The evidence on transactions volumes is based on data obtained directly from EBS. The volume data concerns the brokered inter-dealer market.

2.2.1 Reuters Indicative Quote Data

The Reuters indicative quote data is generated by traders who submit electronic quotes 24 hours a day. The submission of quotes incurs no obligation on the dealer to 'make a market' subsequently. The data

[5] This account is based on Lyons (1999)

[6] The Reuters FXFX page itself only contains a subset of the available quotes. In addition the FXFX page only displays Dollar pairs. A subset of DM (now Euro) quotes is displayed on the Reuters WXWY page. Our data set represents *all* available quotes. However, to avoid confusion, we follow the convention of referring to this data as FXFX.

was made available to us in hourly bid and ask prices from which we construct single bid-ask spread series measured in basis points. We have data for eight currency pairs, namely dollar/yen (January 1998 to August 1999), dollar/sterling (January 1998 to August 1999), dollar/DM (January 1998 to December 1998), DM/yen (January 1998 to December 1998), sterling/DM (January 1998 to December 1998), euro/dollar (January 1999 to August 1999), euro/sterling (January 1999 to August 1999) and euro/yen (January 1999 to August 1999). Hartmann (1998) provides a more complete discussion of the Reuters FXFX data. Lyons (1995, 1996) as well as Goodhart, Ito and Payne (1996) have criticized the use of this data to proxy actual interbank spreads. First, they are not transactable prices. Second, while indicative spreads usually 'bracket' true spreads in the interbank market, they are typically 2 to 3 times as wide as transaction spreads. Third, indicative spreads are less likely to bracket true spreads when volatility is highest since there are limits to how frequently the indications can change. While the use of indicative quotes for high frequency spread inference is therefore controversial, low frequency indicative spread measures are more difficult to dismiss as good proxies to actual transaction costs. Goodhart et al. (1996) finds a close enough approximation of indicative quotes to underlying firm quotes at frequencies longer than an hour. All the inference in this paper is concerned with the average spread over monthly periods.

2.2.2 EBS Volume Data

The EBS data consists of monthly averages of daily spot market transaction volume in eight currency pairs. These are dollar/yen (January 1998 to October 1999), dollar/Swiss franc (January 1998 to October 1999)), dollar/DM (January 1998 to December 1998), DM/yen (January 1998 to December 1998), DM/Swiss franc (January 1998 to December 1998), euro/dollar (January 1999 to October 1999), euro/yen (January 1999 to October 1999), and euro/Swiss franc (January 1999 to October 1999). EBS has different market shares in different currency pairs. Using the BIS survey as a benchmark for 1998, we estimate that EBS has captured 40 to 50 percent of the brokered interdealer market. This means that we are effectively measuring at most 20 percent of the total spot forex volume. Nevertheless, we believe that the time series dimension of the EBS volume data provide a useful measurement of overall volume evolution around the introduction of the euro.[7] We highlight that the brokered inter-dealer market is of increasing importance (Lyons, 1999) and anecdotal evidence suggests that EBS is enhancing its share of the brokered inter-dealer market. This is relevant since we are presenting evidence of *declining* euro volumes in relation to its legacy currencies.

[7] For a similar analysis see Goodhart, Ito and Payne (1996) and Payne (1999), who use data from EBS's direct competitor in the brokered interdealer market, Reuters Dealing 2000-2. Goodhart et al. have detailed information from that source on just one day's trading. Payne has similar information for a five day period. Goodhart et al. suggest that brokered interdealer market segment is a reasonable proxy for total spot volume. The most reliable source on transactions volume is the survey carried out by the Bank for International Settlements. However, this data is only available for a single month on a triennial basis. In conclusion the EBS data is as good a picture of forex volumes as we are likely to obtain for the 1998-99 period that we are examining.

2.3 Transaction Costs

For simplicity we refer to the euro as the successor of the DM. The mnemonic USD/DEM-EUR for example refers to the dollar/DM rate for the period prior to January 1999 and to the euro/dollar rate thereafter.[8] Table 1 shows the average spread for two non-euro currency pairs and three euro currency pairs. Column (1) states the average indicative spread for 1998, while column (2) reports the average spreads for the 7 months following the introduction of the euro.

The non-euro pairs USD/JPY and GBP/USD show a small decrease in spread of 6 and 9 percent, respectively. The t-statistics reported in column (4) indicate that this decrease is statistically significant.[9] A graphical illustration of the spread for the USD/JPY is provided by the solid line in Figure 1, which plots monthly average spreads. Spreads increased in the second part of 1998 and then declined in the first part of 1999. Figure 2 shows the spread decline for the GBP/USD currency pair. It is very modest and hard to detect in the time series plot.

The three euro currency pairs USD/DEM-EUR, JPY/DEM-EUR, and GBP/DEM-EUR all show an increase in spreads. The spread increase is 40 percent for the dollar market, 62 percent for the yen rate and a dramatic 195 percent increase for the sterling rate. All three spread increases are highly significant. The time series data based on monthly averages is provided in Figures 3, 4, and 5, respectively. The increase in both the dollar and sterling spreads exactly coincide with the introduction of the euro. While we find some gradual decrease in the spread for the sterling rate in the spring of 1999, this decline shows no tendency to revert to the original spread of less than 4 basis points. All three euro rates indicate a permanent increase in the spreads around the introduction of the euro relative to the previous lower DM spreads. We conclude that foreign exchange transactions are more costly in the euro than in the preceding DM rates.[10]

2.4 Transaction Volume

Table 2 documents the change in EBS brokered transaction volume before and after the euro creation. The corresponding time series evidence, in row order of currency pair, is provided by Figures 1, 6, 3, 4, and 7.

First, we look at the two non-euro currency pairs. The USD/JPY volume decreased by a modest 7 percent after the introduction of the euro. The scored line in Figure 1 indicates temporary volume changes without any large long-run change. Volume peaked in the Summer/Autumn of 1998. This coincides with the Russian financial crisis, the difficulties of Long Term Capital Management (LTCM)

[8] The other time series mnemonics are USD/JPY for Dollar/Yen; USD/CHF for Dollar/Swiss Franc, GBP/USD for Sterling/Dollar, JPY/DEM-EUR for Yen/DM and Yen/Euro, GBP/DEM-EUR for Sterling/DM and Sterling/Euro and CHF/DEM-EUR for Swiss Franc/DM and Swiss Franc/Euro.

[9] Spread data displays noticeable intra-day and day of the week seasonality as pointed out by Huang and Masculis (1999). Before testing, the data was first filtered to remove the seasonalities.

[10] Hartmann and Detken (2000) also report results on pre and post Euro spreads. Their evidence from Reuters is qualitatively similar to ours. They also report data from Bloomberg. Both appear to be drawn only from end of the day quotes. Because of intra-day seasonality, we discard this data because of its lower sampling frequency. Also, we are unable to find any evaluation of the Bloomberg data in the literature.

and the surge in the value of the yen. However, by the summer of 1999 USD/JPY volume had recovered. Second, USD/CHF volume more than doubled between the two years. This pair has moved ahead of both CHF/DEM-EUR and JPY/DEM-EUR. Figure 6 illustrates the intertemporal increase in volume, which coincides with the introduction of the euro.

More interesting still are the three euro currency pairs for which volume data is available. The most surprising currency pair is USD/DEM-EUR (Figure 3). Table 2 shows that the euro/dollar volume is 9 percent lower than the dollar/DM volume. This is striking given that the DM rate is only one of legacy currencies in the monetary union. In fact statistics from the Bank for International Settlement (1999) shows that in April 1998, global turnover in all market segments in dollar/DM was \$290.5 billion per day while turnover in aggregate dollar/other EMS pairs amounted to \$250.3 billion per day.[11] In other words, the loss of trading activity in the former non-DM legacy dollar pairs cannot be dismissed lightly. Despite the merging of these legacy pairs into a common euro/dollar pair, we register an actual overall volume decrease in the USD/DEM-EUR series for 1999. Second, JPY/DEM-EUR volume fell by 44 percent between 1998 and 1999. The scored line in Figure 4 shows that volume fell from its autumn 1998 peak, but unlike USD/JPY, it never recovered. Finally, CHF/DEM-EUR volume decreased by 25 percent between 1998 and 1999. Like the other two euro pairs, Figure 7 again shows an autumn 1998 peak with no recovery in 1999.

In summary, the EBS transactions volume shows a pattern of lower volumes in euro pairs relative to the corresponding legacy DM pairs. Generally, euro volumes failed to recover from the late autumn 1998 decline in forex volumes unlike non-euro currency volumes.

2.5 Three Alternative Hypotheses

The following section discards three alternative hypothesis which we believe cannot account for the above evidence. We discuss them briefly before proposing our own explanation.

The *volatility hypothesis* attributes the rise in the euro spreads and the parallel decline in volume to an increase in forex risk. If the volatility increase is concentrated in the euro currency pairs this could account for the observed spread and volume pattern. A direct test is to examine the daily return volatility in different euro pairs. Figure 8 plots annualized standard deviations of daily returns (in each month) for JPY/DEM-EUR , USD/DEM-EUR and GBP/DEM-EUR. Though there is some evidence of an increase in JPY/DEM-EUR volatility in particular months, we find no evidence of a general sustained volatility increase. The dollar and sterling rates indicate a constant volatility level throughout the observation period. In short, the rise in euro-spreads cannot be attributed to a change in volatility.

The *competition hypothesis* claims the spread increase is due to reduced market maker competition

[11] This figure is obtained as the sum of Dollar/French Franc, Dollar/Ecu and Dollar/'other EMS' in the BIS survey. A number of caveats need to made about this remark. The above BIS figures refer to all market segments. It also includes forward and swap as well spot volumes. If only spot volumes are considered, Dollar/DM falls to \$142.3 billion per day while the sum of the other three falls to \$35.1 billion per day.

in the forex market. Following a formal question in the European Parliament concerning the widening of spreads for the sterling/euro rate, the EU Commission launched an investigation for anti-competitive market practises.[12] No evidence could be produced.[13] In the light of our own evidence we find the competition hypothesis implausible for a number of reasons. First, it is unclear why reduced quote competition should coincide with the euro introduction between December 1998 and January 1999. Second, any market exit of FX dealers should lead to a general spread increase for all rates. Why such spread increase is limited to the euro currency pairs would remain unexplained. Third, Huang and Masculis (1999) show that the sensitivity of the indicative spread with respect to entry is relatively low. They estimate that the withdrawal of one trader increases spreads by only 1.7 percent. To obtain a the nearly 40 percent rise in the USD/DEM-EUR spread would require the exit of more than 20 traders. This represents massive exit in a market for which trader participation fluctuates between 5 and 30 traders.[14]

Finally, the *tick size hypothesis* interprets the spread increase as a the consequence of behavioral quoting practises in the forex market. The legacy sterling/DM rate for example was quoted in DM with a spread of 5 DM pips or 0.0001 DM. In contrast, sterling/euro is quoted in sterling with a spread of 3 sterling pips. Because of the change in the nominal unit of measurement, the nominal spread is closer to zero in terms of pip integers. Traders may be under the illusion of lower spreads and stick to the previous nominal pip-based spreads. We find this value illusion difficult to believe. No formal constraints exists to quote fractions of pips. Also, economic stakes in the market seem too high for market makers not to learn about this simplistic value illusion.

3 A Microstructure Explanation

This section presents a microtheoretical interpretation of the stylized euro characteristics. We start with an intuitive description of the central idea in section 3.1. Section 3.2 presents the model with endogenously determined spreads and volume. It is a generalization of the Copeland and Galai model (1983) to a multicurrency system with risk averse market makers. The multicurrency system is represented by a triangular system of three currencies and three cross rates. The currency union corresponds to the case in which two of the currencies merge and the triangular system collapses to a single bilateral exchange rate. In section 3.3 we solve for the external equilibrium spread under the currency union. Section 3.4 solves for the equilibrium spread in the more complicated triangular currency system which corresponds to the pre euro setting. Section 3.5 extends the model to the general case in which the degree of information asymmetry differs across different currency pairs. This provides an interesting additional perspective on the spread increase in the euro.

[12] See also Financial Times, 29.10.99 and 20.12.99.
[13] See EU Commission (1999).
[14] Compare Huang and Masculis (1999), Figure 2, page 75.

3.1 An Informal Discussion

Microstruture theory has distinguished three components of spread determination: Inventory holding costs, information costs and order processing costs.[15] We are not aware of any reason which could plausibly explain a sudden increase in order processing costs around the introduction of the euro.[16] We therefore focus on the two remaining spread components.

First, inventory holding costs may have increased, because the currency union, which replaces the system of multiple cross rates within Europe, is characterized by less efficient intra-temporal risk sharing. This explanation for the increase in the euro spreads is based on the idea that a competitive interdealer market with many cross rates provides better opportunities for a diffusion of excess balances among liquidity providers prior to an exchange rate change and the risk realization. A dealer who is for example hit by partially informative excess supply in the dollar/DM rate might offset these imbalances by a hedging positions in the DM/FF rate and the dollar/FF rate. Such cross currency hedging depends, of course, on the existence of these multiple cross rates and low transaction spreads. Cross hedging opportunities in various bilateral dollar markets with legacy currencies other than the DM appear to have been an important element of the pre euro market structure. A notable feature of these markets was the very high proportion (88 percent) of the trading volume that took the form of outright forwards and swaps. After the currency union the trader has to transfer excess balances to liquidity providers in the same market, namely the euro/dollar market. This can accelerate information revelation and imply a faster exchange rate reaction. This in turn implies more inventory risk for the liquidity providers, which in equilibrium should be reflected in higher spreads. Our stylized model in section 3.2 tries to capture this intuition. A recent literature on optimal transparency in equity markets has emphasized that higher transparency may actually increase spreads in dealership markets. Evidence of this effect is provided in an experimental setting by Bloomfield and O'Hara (1999).

A second explanation for the euro spread increase focuses on information costs. We conjecture that the dollar/DM and the DM/yen spreads were particularly narrow because liquidity providers in these rates profited from the absorption of relatively less informative imbalances in other intra-European cross rates. If the currency markets have informed traders with heterogenous information precision about the respective cross rate changes, then cross currency hedging by risk averse liquidity providers benefits the traders in the rates with a more informative demand. The information content of their currency rates is diluted by the hedging coming from other cross rates. It is plausible that the dollar/DM and DM/yen spread were reduced by such spillover of relatively uninformative imbalances in the system of European currencies. This second explanation is not specific to the imperfect diffusion of excess balances in a dealership market. Section 3.5 elaborates the intuition in an extension of the baseline model.

[15] See for example Huang and Stoll (1997) or Sarno and Taylor (2000) for a survey.

[16] The introduction of the Euro coincided with the use of the TARGET clearing system. However, the apparent success of the TARGET system points to a possible decrease in order processing costs for Euro rates.

3.2 A Simple Model

Let there be a triangular market in three currency exchange rates denoted AB, AC and BC. These cross rates might for example represent the dollar/DM rate, the DM/FF rate and the dollar/FF rate. The three markets are decentralized dealership markets. However, it takes time to find a trading partner who is willing to trade. We capture the non-simultaneous nature of the interdealer market by assuming that the market in currency pair AB is open in period 1, while markets for the currency pairs AC and BC are open only in period 2. We assume that currency balances in each currency pair can be liquidated in period 3 at prices P_{AB}^L, P_{AC}^L and P_{BC}^L, respectively[17]. Trader AB is the market maker in currency pair AB and quotes a bid-ask spread s_{AB} in the currency rate AB around a midprice P_{AB}^M in period 1.[18] Similarly, traders AC and BC are market makers in currency pairs AC and BC, respectively, and quote bid-ask spreads s_{AC} and s_{BC} around midprices P_{AC}^M and P_{BC}^M, respectively. To begin with, let AB be the currency pair in which temporary imbalances arise. They are related to a stochastic shock ϵ to the liquidation price P_{AB}^L, such that

$$P_{AB}^L = P_{AB}^M + \epsilon.$$

We assume that the shock ϵ has mean zero and variance σ_ϵ^2. The shock to the currency pair AB can have two distinct sources. It can be related to a value change for the currency A (state a) or alternatively to a value change for the currency B (state b). For example an appreciation of the dollar/DM rate can come either as appreciation of the DM against both dollar and FF or as an appreciation of the DM and the FF against the dollar. We assume for simplicity that both states a and b are distinct and occur with equal probability of $\frac{1}{2}$. Therefore,

$$P_{AC}^L = \begin{cases} P_{AC}^M + \epsilon & \text{if } a \\ P_{AC}^M & \text{if } b \end{cases}$$

and

$$P_{BC}^L = \begin{cases} P_{BC}^M & \text{if } a \\ P_{BC}^M + \epsilon & \text{if } b \end{cases}.$$

In period 1 the trader in the currency pair AB faces informed and uninformed currency demand. Currency demand from informed traders is denoted $X^I(s)$ and demand from uninformed traders (noise traders) is denoted $X^U(s)$. We make simple closed form assumptions about this demand, namely

$$\begin{aligned} X^I(s) &= f(s)\chi^I \\ X^U(s) &= f(s)\chi^U, \end{aligned}$$

where χ^I and χ^U are independent random variables which can take on the values -1 and 1 with equal probability $\frac{1}{2}$. The function $f(s) > 0$ is assumed to be continuous and decreasing in the spread

[17] The three periods are best considered as a sequence of intra-day trading. There is no time preference between them.

[18] We assume that the three spreads are quoted independently of trade-size. Traders cannot condition on trade size.

$s \in (0, \infty)$ and has a maximum at zero. This captures in reduced form the inverse relationship between spreads and both informed and uninformed currency demand. We also assume that χ^I is informative about price innovations ϵ. This is captured by a negative covariance of informed demand and the price innovation given by[19]

$$Cov(\epsilon, \chi^I) = -\gamma < 0.$$

The quoting trader AB incurs losses in his trades with the better informed. But he can use the two other currency markets AC and BC to hedge against losses from the informed demand. We assume that in period 2 trader AB can choose to sell 50 percent of his excess demand short in the currency rates AC and BC. This is referred to as the cross currency hedging option ($h = 1$). Alternatively, trader AB may decide not to hedge and keep his excess balances until liquidation in period 3. We restrict the hedging options of trader AB to simplify the analysis. The imperfect hedging of 50 percent can be shown to present an optimal distribution of currency risk across the three traders.[20] The attractiveness of the hedging option clearly depends on the endogenous size of the spreads s_{AC} and s_{BC}. We assume that traders are risk averse. Let their utility depend only on the expected profit and its variance, namely

$$U(\Pi_i) = E(\Pi_i) - \frac{1}{2}\rho Var(\Pi_i), \qquad i = AB, AC, BC,$$

where the parameter ρ governs his risk aversion[21].

3.2.1 The Triangular System

In the above exposition the supply and price shock originates in the currency rate AB with distinct states a and b. Generally, the order-flow shock might occur first in any of the three currencies, allowing for states a, b and c. For simplicity, we assume a symmetric set-up in which the supply shock and price change ϵ originates with equal probability $\frac{1}{3}$ in each of the three currencies. Moreover, traders are assumed not to know at the moment of spread determination in which of the three currencies A, B, or C the supply shock occurs. This is formally equivalent to a set-up in which traders have to chose first their spread s and then are assigned by nature one of the three cross rates. A lack of information with respect to the origin of the supply shock is equivalent to not allowing any conditioning of the spread s on the respective currency pairs AB, AC, or BC. The maximization problem of the traders

[19] This covariance can be made illustrated as follows: If P_{AB} is the DM price of Dollars, then $\epsilon > 0$ is a depreciation of the DM and $\chi^I > 0$ is a purchase of DM's.

[20] Traders generally have an incentive to hedge more than 50 percent of their informative excess balances *as long as* the spreads s_{AC} and s_{BC} do not adjust, which they would of course as trader AB overexploits the information signal in his excess demand. We abstract from this dimension of spread adjustment process by limiting the hedging possibilities to 50 percent of the excess balances. This happens to coincide with the optimal level of intertrader risk sharing. But other suboptimal intertrader risk sharing outcomes still support our conclusions as long as at least some marginal improvement in intertrader risk sharing is achieved through the existance (or only improvement) of the cross hedging opportunity. For a more elaborate theoretical analysis see Viswanathan and Wang (2000).

[21] The utility function of the market makers is a "Selten utility" defined in the first and second moment of profits. Since the order-flow shocks in the model are the product of a binomial and normal random variable, the formulation does not reduce to CARA preferences.

in the triangular currency system therefore amounts to setting a single spread $s \in (0, \infty)$ and choosing a hedging strategy $h \in \{0, 1\}$ so as to maximize

$$\tfrac{1}{3}U(\Pi_{AB}) + \tfrac{1}{3}U(\Pi_{AC}) + \tfrac{1}{3}U(\Pi_{BC}). \tag{1}$$

We denote the solution for the equilibrium spread by s^T.

3.2.2 The Currency Union

The introduction of the euro is represented by a union of the currencies A and C. The triangular currency system therefore collapses to a single rate AB. We assume for simplicity that the exogenous demand per trader does not change. The trader AB faces the same demand as before and the trader BC is now quoting in currency AB with a currency demand of the same information features as before, only that it is now in currency rate AB. Trader AC and his demand disappears. Since by assumption no currency cross rates exists and excess balances are revealed to the second trader in same currency, hedging opportunity are absent in period 2.[22] This implies that $h = 0$ and two remaining traders chose a spread $s \in (0, \infty)$ to maximize

$$U(\Pi_{AB}).$$

The equilibrium spread in this case is denoted by s^U. The simple set-up allows for a straightforward comparison to the equilibrium spread s^T in the triangular system.

It is clear that even after the introduction of the euro, traders had other cross hedging opportunities to their disposal. The Swiss franc and the British Pound for example continued to provide such options. The somewhat stylized opposition of a trilateral versus a single rate currency system ignores this aspect for expositional simplicity. But we underline that our qualitative argument depend only on a marginal decrease of hedging opportunities (due to the currency union) and the fact that these hedging opportunities contributed to the opaqueness of the true aggregate excess balance of all market makers.

3.3 External Spreads of the Currency Union

We start solving for the optimal spreads in the currency union in which no (intra-union) cross currency hedging exists. The expected profit of a trader who quotes a bid-ask spread consists of two components. First, the trader earns spread profits denoted Π^S on the exogenous informed and uninformed transaction volume. We can evaluate these profits relative to the midprice which is also the (unconditional) expected liquidation price. Formally, for expected spread profits relative to the midprice of $\frac{s}{2}$ we obtain[23]

$$E(\Pi^S) = \tfrac{s}{2}E\left[\left|X^I\right| + \left|X^U\right|\right] = \tfrac{s}{2}\left[\left|X^I\right| + \left|X^U\right|\right] = sf(s).$$

[22] We could also assume that the two traders in AB can still share their inventory risk. But since they are only two traders (instead of three as before) spreads would still be higher. In this case the spread increase would not be explained by increased market transparency, but by a decrease in the risk sharing capacity of the market.

[23] Spread profits are non-stochastic.

A higher spread increases spread profits linearly in s, but decreases volume in the term $f(s)$ as $df(s)/ds < 0$. The second component of the expected profit is the directional loss from providing a bid-ask spread to informed traders. We can quantify these expected directional profits $E(\Pi^D)$ as the covariance of the excess balances $X^E = X^I + X^U$ with the consecutive exchange rate change ϵ, hence

$$E(\Pi^D) = E(X^E \epsilon) = E[\left(X^I + X^U\right)\epsilon] = -\gamma f(s).$$

Finally, we have to take into account the risk aversion of the traders. The excess balances X^E in the stylized set-up can take only one of three values, namely

$$X^E = \begin{cases} 2f(s) & p = \frac{1}{4} \\ 0 & p = \frac{1}{2} \\ -2f(s) & p = \frac{1}{4} \end{cases}.$$

The unconditional variance follows as the weighted average of the conditional variances, therefore

$$Var(\Pi^D) = \tfrac{1}{4} Var\left[2f(s)\epsilon\right] + \tfrac{1}{4} Var\left[-2f(s)\epsilon\right] = 2\sigma_\epsilon^2 f(s)^2.$$

We note that the variance of the spread profit Π^S is zero. Total utility of a trader under a currency union follows as

$$U(\Pi_{AB})^{h=0} = sf(s) - \gamma f(s) - \rho\sigma_\epsilon^2 f(s)^2.$$

In an equilibrium with competitive entry the traders should be indifferent between quote provision and no quote provision. This implies that in equilibrium trader utility should be zero. This in turn implies the competitive spread under a currency union. Proposition 1 summarizes the result.

Proposition 1 *Under a currency union the competitive external spread s^U is defined by the equation*

$$s^U = \gamma + \rho\sigma_\epsilon^2 f(s^U), \tag{2}$$

where γ measures the covariance of informed trader demand with consecutive exchange rate changes, ρ characterizes the risk aversion of the trader, σ_ϵ^2 the variance of exchange rate changes and $f(s)$ captures the (inverse) relationship between spread size and currency demand. Expected volume (per trader) is given by

$$E(Vol) = 2f(s^U).$$

Proof. Follows directly from $U(\Pi_{AB})^{h=0} = 0$. ■

Figure 9 provides a graphical illustration. The left hand side of eq. (2) is represented as a 45 degree line. The decreasing line represents the right hand side and the intersection marks the competitive equilibrium spread s^U. The comparative statics are intuitive and straightforward. More asymmetric information represented in a higher parameter γ shifts the second line upwards and increases the equilibrium spread. The same holds for a higher risk aversion parameter ρ and higher exchange rate volatility captured by σ_ϵ^2.

3.4 Spreads in the Triangular System

Next we analyze the triangular currency system in which cross currency hedging is possible. We proceed in three steps. First we show under which conditions the trader AB desires to hedge half of his excess balances with contrarian positions in the two other currencies. This will be an optimal strategy only if the spread in the currency pairs AC and BC are below a certain threshold. In a second step we derive the competitive spread in the triangular system if trader AB hedges ($h = 1$). Finally, we show that the resulting competitive spread is indeed low enough to make traders want to hedge in period 2. This justifies the hedging assumption in the derivation of the competitive spread level and completes the equilibrium argument.

The following proposition characterizes the cross currency hedging condition:

Proposition 2 *In the competitive triangular currency system with a spread s^T, the trader who is experiencing excess balances desires a cross currency hedge if*

$$s^T < \gamma + \tfrac{3}{2}\rho\sigma_\epsilon^2 f(s^T). \tag{3}$$

Proof. The trader prefers a hedged over an unhedged position if

$$U(\Pi_{AB})^{h=1} - U(\Pi_{AB})^{h=0} > 0.$$

Under the assumption that trader AB can hedge 50 percent of his excess balances X^E in period 2, we obtain

$$\begin{aligned} E(\Pi^S) &= \frac{s}{2}E\left[\tfrac{1}{2}\left|X^I\right| + \tfrac{1}{2}\left|X^U\right|\right] = \tfrac{1}{2}sf(s) \\ E(\Pi^D) &= E(\tfrac{1}{2}X^E\epsilon) = -\tfrac{1}{2}\gamma f(s) \\ Var(\Pi^D) &= \tfrac{1}{2}\sigma_\epsilon^2 f(s)^2 \end{aligned}$$

for the spread profit, the expected directional profit and the profit variance, respectively. Calculating the trader utility for $h = 1$ implies

$$U(\Pi_{AB})^{h=1} = \tfrac{1}{2}sf(s) - \tfrac{1}{2}\gamma f(s) - \tfrac{1}{4}\rho\sigma_\epsilon^2 f(s)^2,$$

and subtracting the utility for $h = 0$ calculated previously directly implies the inequality (3). ■

By hedging, a trader foregoes spread income (Π^S), but reduces his losses from liquidity provision to informed traders (Π^D), and also lowers his inventory risk. He desires to hedge if spreads are sufficiently low. A more informative currency demand, higher risk aversion or higher exchange rates volatility increase his hedging benefit. We can determine a critical spread threshold at which expression (3) holds with equality. At this spread trader AB is just indifferent between hedging and not hedging. Next we conjecture that the equilibrium spread in the triangular currency system is lower than the threshold spread. This implies that trader AB hedges though acquisition of short positions $-\frac{1}{2}X^E$ in both currency pairs AC and BC. It is straightforward to determine the utility of traders AC and BC

under hedging. Traders AC and BC experience the same excess supply shock from trader AB. They both earn a spread profit given by

$$E(\Pi^S) = \frac{s}{2} E\left[\frac{1}{2}\left|X^E\right|\right] = \frac{1}{4} s f(s)$$

Also their exchange rate risk and the information content of their hedging demand are the same. Trader AC for example faces exchange rate risk in the state a, while trader BC faces risk in the complementary state b. Both states have by assumption the same probability ($p_a = p_b = \frac{1}{2}$). The expected loss from the informative excess demand amounts to

$$\begin{aligned} E(\Pi^D_{AC}) &= p_a E(\tfrac{1}{2} X^E \epsilon \mid a) = -\tfrac{1}{4}\gamma f(s) \\ E(\Pi^D_{BC}) &= p_b E(\tfrac{1}{2} X^E \epsilon \mid b) = -\tfrac{1}{4}\gamma f(s) \end{aligned}$$

and inventory risk follows as[24]

$$Var(\Pi^D) = \tfrac{1}{4}\sigma^2_\epsilon f(s)^2.$$

The utility of traders AC and BC under hedging is therefore given by

$$U(\Pi_{AC})^{h=1} = U(\Pi_{BC})^{h=1} = \tfrac{1}{4} s f(s) - \tfrac{1}{4}\gamma f(s) - \tfrac{1}{8}\rho\sigma^2_\epsilon f(s)^2.$$

Finally, we have to take into consideration that currency imbalances need not arise in the currency rate AB, but happen with equal probability $\frac{1}{3}$ in each of the three cross rates. This amounts to a simple permutation of the trader indices. Each trader therefore has an expected utility given by expression (1). The competitive entry condition (zero equilibrium utility for traders) implies the following proposition.

Proposition 3 *In the competitive triangular currency system the equilibrium spread s^T is characterized by*

$$s^T = \gamma + \tfrac{1}{2}\rho\sigma^2_\epsilon f(s^T). \tag{4}$$

Spreads in the triangular currency system are lower than in the currency union. Expected volume (per trader)

$$E(Vol) = 2f(s^T)$$

is higher than for the external currency union rate.

Proof. Expression (1) set equal to zero implicitly defines s^T. First we have to verify that under this spread s^T hedging is indeed optimal for trader AB as conjectured. We note that right hand side of eq. (4) is smaller than the right hand side of eq. (3) for all s, therefore s^T is smaller than the hedging threshold s^* and it is optimal for traders to hedge. Second, the right hand side of eq. (4) is also smaller than the right hand side of eq. (2), which implies $s^T < s^U$. Expected volume (per trader) decreases as $df(s)/ds < 0$. ■

[24] This variance is calculated as the probability weighted average of the conditional variance of $\frac{1}{2}\epsilon X^E$ conditioned on the three realizations of X^E and the two independent realizations a and b of the cross rate changes.

For the special case in which the demand of informed traders loses its information content ($\gamma = 0$), the equilibrium spread in the triangular system is exactly half the currency union spread. Generally, a higher information content of the informed demand component (higher γ) tends to diminish the relative difference of the spreads in the two systems. This follows from the fact that cross currency hedging facilitates collective risk sharing, but does not provide alleviation for the adverse selection problem which spread quoting traders face relative to the informed market demand. This illustrates in a simple manner that all economic benefits of the multicurrency over the single currency system are due to the improved risk sharing characteristics of the former. Asymmetric information, while a building block of spread determination, does not alter spreads with the move to a single currency. This is straightforward since the degree of information asymmetry (in the order flow) was assumed to be the same for each trader across the two regimes. We relax the latter assumption in section 3.5.

The aggregate trade volume for the currency union is smaller than the sum of the turnover for the two pre-union rates AB and AC. If the external currency demand is strongly price elastic in the spread s, it is possible that the currency turnover of the union is even below the turnover in an individual rate in spite of the liquidity concentration. The evidence presented in Section 2 suggests that this was indeed the case for the euro relative to the DM.

3.5 Asymmetries in the Information Asymmetry

An interesting extension of the model is to assume that the precision of the informed demand differs across the three markets, for example $\gamma_{AB} = \gamma_{BC} > \gamma_{AC}$. Exchange rate stabilization within the EMS system might have considerably reduced the scope of asymmetric information with respect to intra EMS rate (here AC). Let $\overline{\gamma}$ denote the average covariance of the informed demand shock χ^I and the currency rate change ϵ,

$$\overline{\gamma} = \tfrac{1}{3}(\gamma_{AB} + \gamma_{AC} + \gamma_{BC}).$$

In this case the individual spreads in each currency should reflect the severity of the adverse selection problem for the spread quoting traders. However, since the trader with the excess balances transfers a proportion of this adverse selection risk to the two other traders, they are affected more if the excess balances come from traders AB or BC than if they come from trader AC. The spread in each currency is therefore a weighted average of the own adverse selection risk and adverse selection risk in the cross currency transfers. Let the transformed adverse selection parameter be defined by

$$\widetilde{\gamma}_{AB} = \tfrac{3}{4}\overline{\gamma} + \tfrac{1}{4}\gamma_{AB}.$$

The transformed adverse selection parameter $\widetilde{\gamma}_{AB}$ collapses to γ_{AB} for $\gamma_{AB} = \gamma_{AC} = \gamma_{BC}$. Generally, the term $\widetilde{\gamma}_{AB}$ captures the adverse selection externality in the triangular currency system. The derivation is straightforward. Market maker AB keeps 50 percent of the excess order flow and eliminates the rest through hedging. This implies an expected loss (due to asymmetric infromation) of $-\frac{1}{2}\gamma_{AB} f(s)$ from his residual position, while receiving the hedging demand from traders AC and BC

implies an additional loss of $-\frac{1}{4}\gamma_{AC}f(s)$ and $-\frac{1}{4}\gamma_{BC}f(s)$, respectively. We recall that the respective cross rate changes only with probability $\frac{1}{2}$. The total expected loss for trader AB due to asymmetric information is therefore proportional to

$$-\tfrac{1}{2}\gamma_{AB} - \tfrac{1}{4}\gamma_{AC} - \tfrac{1}{4}\gamma_{BC} = -\widetilde{\gamma}_{AB}.$$

In a triangular system the currency rates with less informative trading exercises a positive externality on the rates with more informative trading. With the elimination of the cross rates this positive externality is eliminated. The composition of informed and uninformed demand therefore changes for the currency union. If the remaining rate is γ_{AB}, then the spread increase should be higher than implied by forgone risk sharing benefits of the triangular system. The following proposition summarizes this intuition:

Proposition 4 *A competitive triangular currency system with unevenly informative demand across the rates ($\gamma_{AB} = \gamma_{BC} > \gamma_{AC}$) has equilibrium spread for the cross rates $i = AB, AC, BC$ characterized by*

$$s_i^T = \widetilde{\gamma}_i + \tfrac{1}{2}\rho\sigma_\epsilon^2 f(s_i^T), \tag{5}$$

where

$$\widetilde{\gamma}_i = \tfrac{3}{4}\overline{\gamma} + \tfrac{1}{4}\gamma_i.$$

The term $\overline{\gamma}$ denotes the average covariance of informed demand with consecutive currency rate changes. The external spread under the currency union is given (as before) by

$$s_i^U = \gamma_i + \rho\sigma_\epsilon^2 f(s_i^U). \tag{6}$$

Proof. Similar to proposition 3. We assume that the condition for the hedging conjecture of proposition 2 is fulfilled for trader AC, who faces the highest spreads for implementing the hedging strategy. ■

Any spread increase following a move from a triangular system to a currency union of currencies A and C may now have two causes. The first cause is the loss in risk sharing efficiency in the dealership market due to the loss of the cross hedging option. This aspect is captured by the lower risk component of the spread, $\rho\sigma_\epsilon^2 f(s_i^U) > \frac{1}{2}\rho\sigma_\epsilon^2 f(s_i^T)$. The second cause is that the traders in the remaining unilateral rate may face a more severe adverse selection problem since the uninformative demand from the currency imbalances in the rate AC is now missing. This is captured by $\gamma_{AB} > \widetilde{\gamma}_{AB}$.

Our simple model contrasts the risk sharing inefficiency of the currency union with a better sequential diffusion of imbalances in the triangular system. It might exaggerate this benefit by imposing a lack of cross trader diffusion options in the currency union case. While this is certainly a shortcoming of the model approach, it seems nevertheless plausible that the time span available for such cross trader diffusion prior to price adjustment might shorten if all hedging has to be undertaken in the same cross rate. The second reason for the spread increase in the unilateral currency system is less sensitive to our timing assumptions. In this view a triangular dealership market provides an automatic cross rate subsidization of spreads in which the cross rate with the less informative excess demand can reduce the spread in the two other cross rates. The intra-European cross rate might have had temporary imbalances primarily because of exogenous transaction needs with a low information content for rate movements. This spillover to the dollar/DM rate is a benefit of which the euro/dollar rate is deprived.

4 Conclusions

The advent of the euro raised the expectation that this new currency would establish itself as a currency of greater global importance than its predecessor, the DM. Such expectations were grounded in the belief that a currency union is a simple consolidation of the financial liquidity of the members. Spreads in the euro rates could therefore be expected to decrease and volume to increase. Our evidence suggests that the contrary took place. This surprising outcome of the market consolidation calls for a refined microstructure analysis of the foreign exchange market. We suggest that understanding the relationship between market transparency and risk sharing might be crucial to explaining the puzzling evidence. The existence of many currencies helped traders to diffuse undesired excess balances prior to price revelation and risk realization. This allowed for better risk sharing and required lower equilibrium spreads. We also point out that the degree of asymmetric information may differ in various rates of a multicurrency system. But spread determination is a systemic process and spread subsidization across markets a natural equilibrium outcome. The pre-eminent role of the DM as Europe's vehicle currency may have been partly induced by relatively uninformative orderflow spillovers from other intra-European currency rates.

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Table 1: Average Spreads (in Bps)

Currency	Mean Spread Jan 98 - Dec 98 (1)	Mean Spread Jan 99 - Aug 99 (2)	Change (Percentage) (3)	Difference Test (T-Statistic) (4)
Non-Euro Pairs				
USD/JPY	6.05	5.71	−6%	−10.03
GBP/USD	5.37	4.89	−9%	−19.38
Euro Pairs				
USD/DEM-EUR	3.76	5.26	40%	41.49
JPY/DEM-EUR	5.12	8.30	62%	55.41
GBP/DEM-EUR	3.12	9.20	195%	106.90

Table 2: Average Daily Volume (in US$ Billions)

Currency	Mean Volume Jan 98 - Dec 98 (1)	Mean Volume Jan 99 - Aug 99 (2)	Change (Percentage) (3)
Non-Euro Pairs			
USD/JPY	29.0	27.1	−7%
USD/CHF	3.3	6.7	103%
Euro Pairs			
USD/DEM-EUR	45.2	41.1	−9%
JPY/DEM-EUR	7.1	4.0	−44%
CHF/DEM-EUR	5.3	4.0	−25%

Figure 1. USD/JPY Monthly Average Bid-Ask Spread and EBS US$ Volume

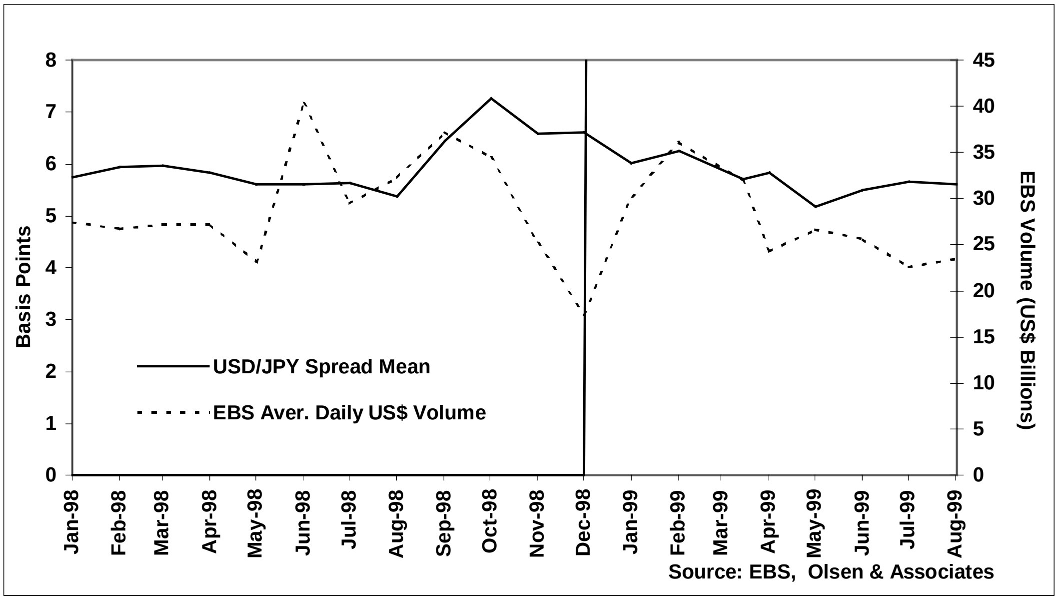

Figure 2. GBP/USD Monthly Average Bid-Ask Spread

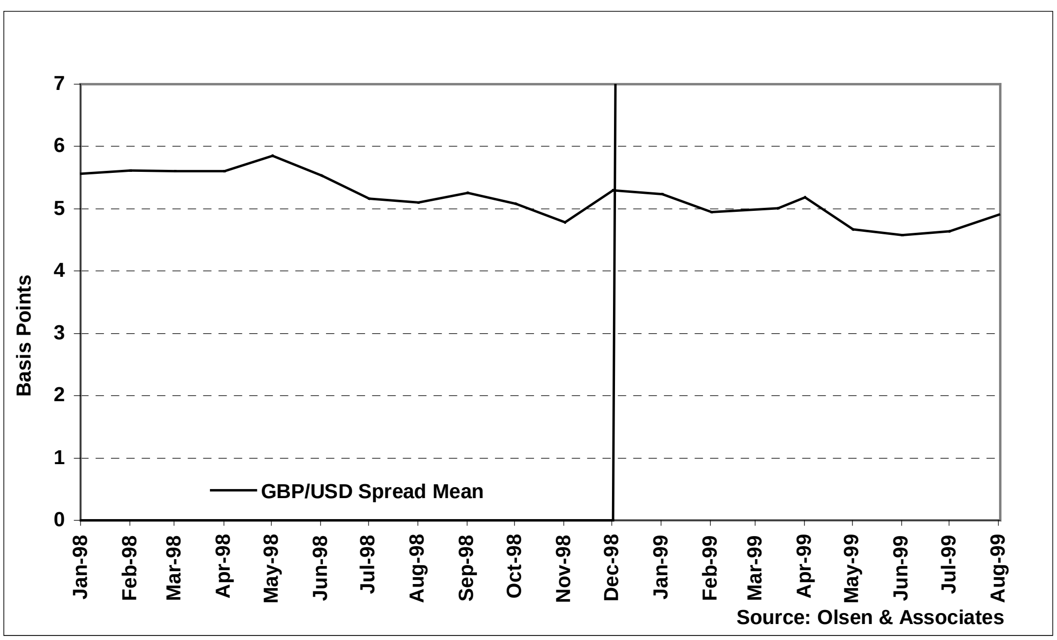

Figure 3. USD/DEM-EUR Monthly Average Bid-Ask Spread and EBS US$ Volume

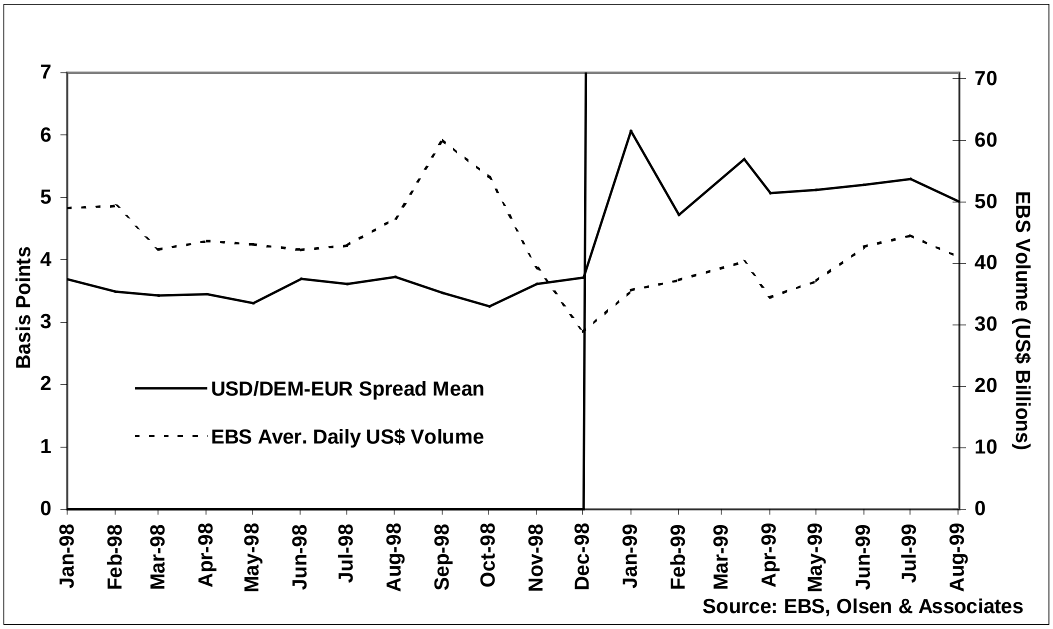

Figure 4. JPY/DEM-EUR Monthly Average Bid-Ask Spread and EBS US$ Volume

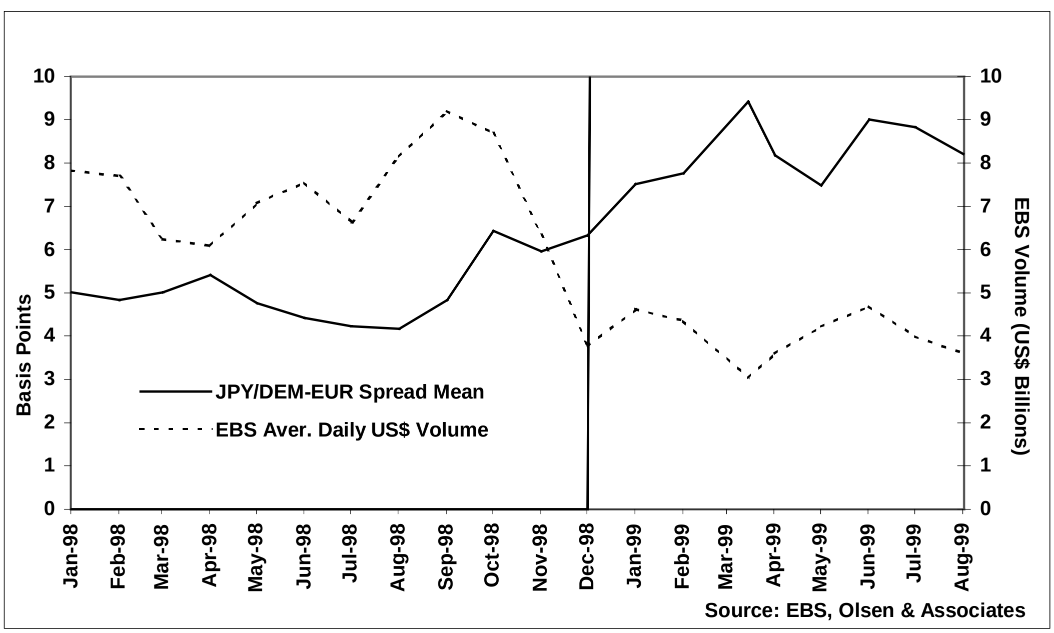

Figure 5. DEM-EUR/GBP Monthly Average Bid-Ask Spread

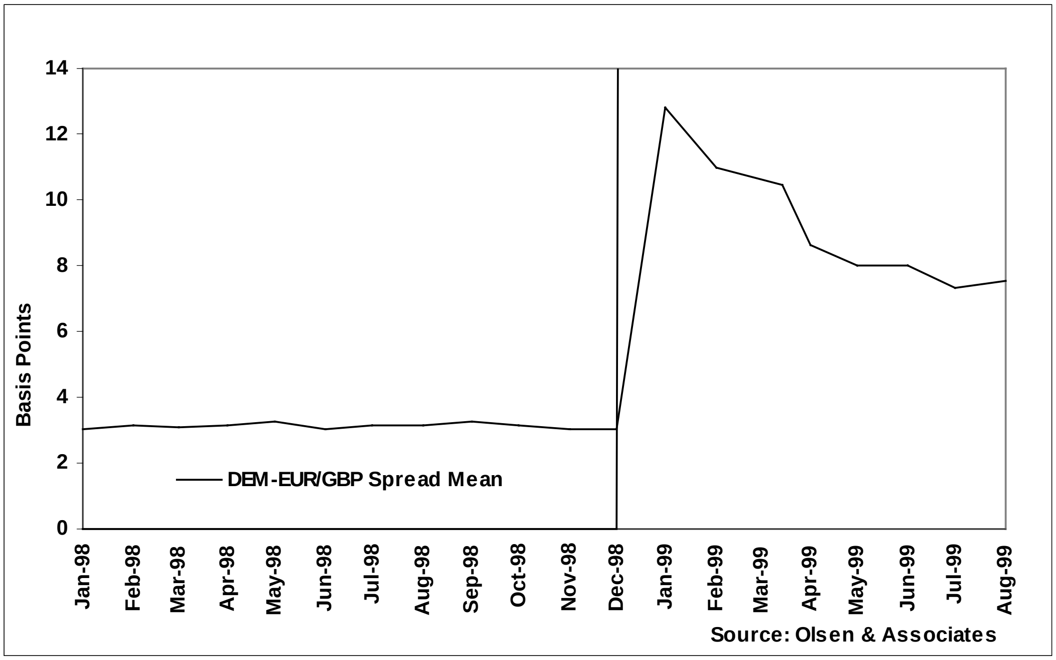

Figure 6. USD/CHF Average Daily EBS US$ Volume Each Month

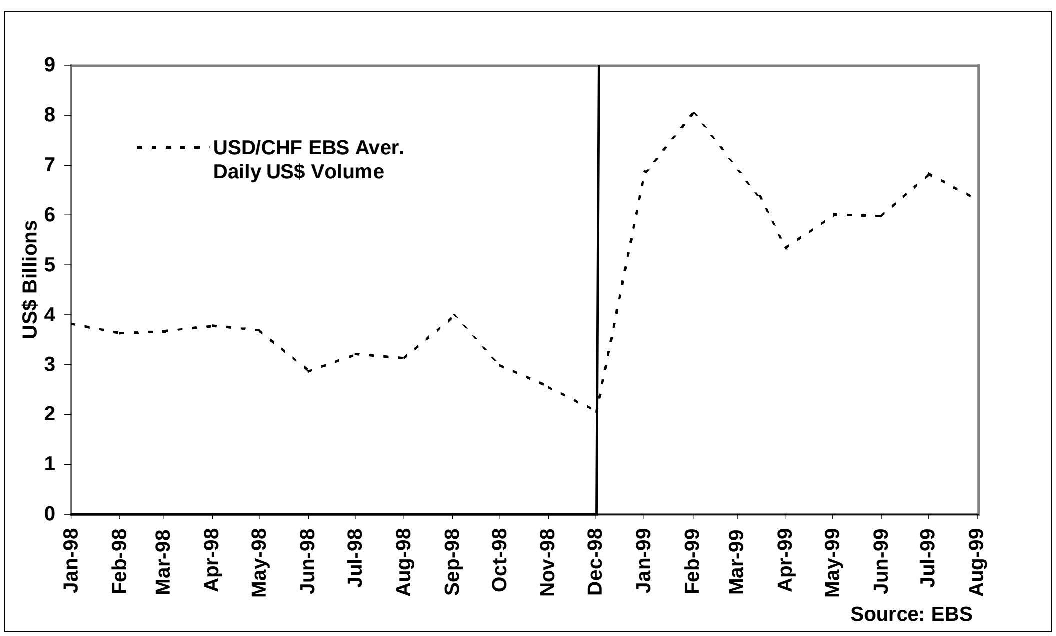

Figure 7. CHF/DEM-EUR Average Daily EBS US$ Volume Each Month

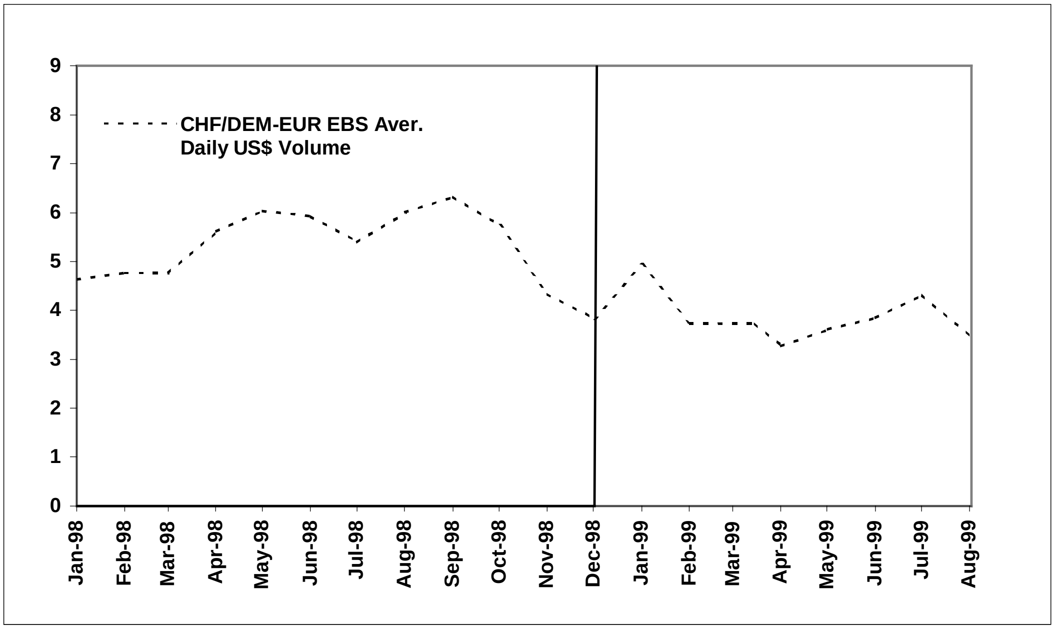

Figure 8. Volatility of DEM (EUR) Currencies against USD, JPY and GBP

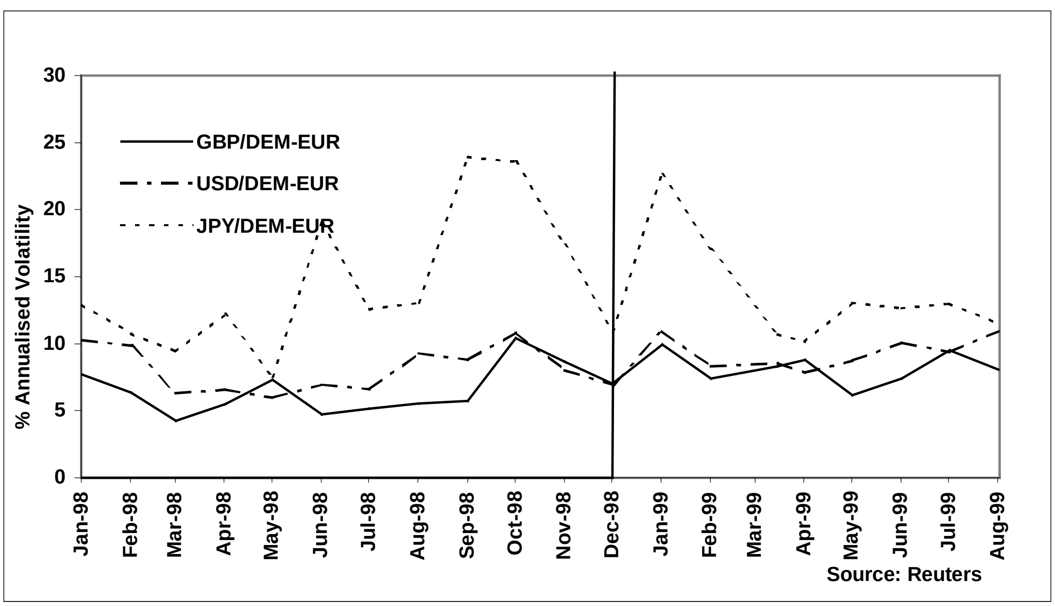

Figure 9. External Equilibrium Currency Spread for a Currency Union