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HOW HAS THE EURO CHANGED THE FOREIGN EXCHANGE MARKET?

Preliminary version of a paper prepared for the
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Abstract

This paper examines the primary forex statistics for the euro in relationship to the German mark prior to 1999. Contrary to widespread expectations our evidence indicates that the euro lost ground against the German mark in forex spot trading. We argue that the euro changed the forex market structure and particularly increased market transparency through currency elimination. The higher market transparency exposes the dealers to higher inventory risk as his inventory imbalances are revealed more easily to other dealers. Dealers in the euro markets recover increased inventory costs through higher spreads, which make the euro a less attractive transaction medium than the German mark. We explore the policy implications for the ECB, for euro outsiders and reflect upon the future of the forex market.

*Correspondence address: Harald Hau, Department of Finance, INSEAD, Boulevard de Constance, 77305 Fontainbleau Cedex, France. E-mail: Harald.Hau@insead.fr or m.moore@qub.ac.uk.. This paper expresses the view of the authors and not that of Setanta Asset Management. We would like to thank Tina Kane for her help and advice during this project. Helpful comments were provided by Richard Baldwin, Oliver Burkart, Jean Dermine, and three referees.

1 Introduction

The international role of the euro has loomed large in the political rhetoric in favor of the single currency.[1] The creation of the euro was often portrayed as an opportunity for Europe to challenge the post-war dollar hegemony. What is the substance to this agenda more than two years into the experiment? This paper surveys the evidence on the international transaction role of the euro and interprets it in the light our knowledge about the microecomomic foundations of the foreign exchange (forex) market.

Traditionally, monetary theory has distinguished the transaction function of a currency from its storage function for private or official investment (central bank reserves).[2] The euro consolidated national investment opportunities into one common financial market without exchange rate risk. This is certainly an accomplishment in itself. But did the euro also promote the international transaction function of the euro in the forex market? It is only this latter question which we examine in this paper. We justify this narrow focus on the forex market with our ambition to move beyond a statistical survey and provide a coherent microstructure interpretation of the existing quantitative evidence. The microeconomic focus is appropriate for the international forex market in which currency choice is free and unconstrained of legal interference. International investors and dealers can opt for a medium of exchange according to their best commercial interest. Generally, they will tend to privilege the currency which provides the lowest transaction costs. This justifies why transaction cost analysis is the primary concerns in this paper.

The reader is first introduced to the institutional feature of the foreign exchange market. We highlight decentralized market organization in Section 2.1 and the low market transparency in sections 2.2 and 2.3 as important characteristics of the forex trading environment. Section 2.3 also introduces the important but relatively unfamiliar practice of *frontrunning*. Section 3.1 discusses different determinants of transaction costs. Research on transaction costs has made important progress over the past decade. We summarize the main insights to prepare the reader for the two central analytical frameworks which guide the empirical investigation. Most previous work on the international transaction role of the euro has focused on order processing costs which were predicted to decrease along with the market volume increase of the currency consolidation. We call this the *vehicle currency hypothesis* which features in the work of Wyplosz (1999), Portes and Rey (1998) and Hartmann (1998a). This view provides an optimistic vision of the euro's prospect in challenging the dollar's forex dominance. We contrast this dominant view with an alternative hypothesis which stresses the role of market transparency for the determination of transaction costs. Forex dealers engage in interdealer trading primarily as a risk sharing device and this market feature may be highly sensitive to the transparency of the trading structure. Hau, Killeen and Moore (2000) argue that the elimination of many Euro-

[1] Charles Wyplosz (1997) calls it the hidden agenda of Europe's long-planned adoption of a single currency.
[2] We refer to Hartmann (1998a) for a good general discussion.

pean currency rates increased market transparency and this paradoxically increased transaction costs. Traders with excess balances find it more costly to balance their inventory if global imbalances become more easily identifiable. We call this the *market transparency hypothesis* which gives a pessimistic assessment of the international transaction role of the euro. Section 3.2 explains the opposing empirical implications of both market microstructure conjectures.[3]

The evidence on the euro is presented in section 4. We use 4 different data sets to compare the euro market quality in 1999 to the comparable statistics of the German mark. In particular we examine quoted spreads, transacted spreads, currency volume, sensitivity measures of the exchange rate with respect to order flow imbalances as well as their dynamic impact.[4] We interpret the data as unfavorable to the vehicle currency hypothesis. Our evidence contradicts this analytical framework in every single dimension. The euro essentially lost forex transaction status relative to the German mark. Instead we find empirical support for the market transparency hypothesis which emphasizes that the currency union changed the forex market structure. The impatient reader is referred to section 4.4 for a summary of the evidence.

The last section of the paper discusses policy related issues. We distinguish implications for exchange rate management by the European Central Bank (ECB), extract lessons of the first two years for euro outsiders like Britain and speculates on future developments in the forex market.

2 How does the forex market work?

The foreign exchange market is a so-called 'over-the-counter' market. This means that there is no one physical location where traders get together to exchange currencies. Rather traders are located in offices of major commercial banks around the world and communicate using computer terminals, telephones and other information channels. The international scope of the forex market implies the absence of any central regulatory authority. Instead the forex market provides an example of 'private regulation', where market participants agreed on common set of rules governing transactions and their settlement. It is therefore all except a chaotic realm of lawlessness. In fact high ethical and professional standards are essential in an economic environment in which a single verbal agreement on a telephone can commit millions of dollars or euros.

The forex market is special in many other respects. It is by far the world's largest financial market in terms of transaction volume. The daily transaction volume in all currencies is estimated to amount to 1,500 billion US dollars a day.[5] This is gigantic even in comparison to a very active equity market like the New York Stock Exchange which reaches an average daily volume which is two order of magnitudes smaller. This large volume is concentrated in relatively few currency pairs. Approximately

[3] This paper focuses on these two hypothesis only. A variety of other explanations for the evidence are discussed and discarded in Hau, Killeen and Moore (2000).

[4] Order flow analysis has recently been applied to international macroeconomic issues and represents a powerful new tool in exchange rate analysis (Evans and Lyons (2001a); Killeen, Lyons and Moore (2001)).

[5] This and other statistics on forex market size in this paragraph are taken from the BIS (1998) survey of the forex market undertaken in April 1998.

87 percent of all forex transactions involve dollar as one of the two currencies in a transaction. Second to the dollar prior to 1999 was the German mark with a 30 percent representation. The nearest rival in what is now the euro-zone was the French Franc which was involved in 5 percent of all transactions. The German mark dominated all other European currencies and can therefore be taken as the de facto predecessor currency of the euro.

2.1 Centralized versus decentralized markets

Unlike the forex market most equity and bond markets are organized as *centralized* markets. Historically, traders gathered in one place in which buy and sell orders could meet. Such centralization has the advantage of exposing an order to maximum number of potential counterparties. But it also has its drawbacks. By indicating his trading interest a dealer simultaneously reveals private information about his inventory or desired trading position. Centralized markets allow other traders to observe all market activity, get a sense of 'where the market goes' and what positions other traders desire. Today electronic trading platform have by and large taken over the role of the trading floors. This modern versions of a centralized market matches buy and sell orders automatically in electronic order books. The order book allows a trader to expose his order to an even larger group of market participants, which no longer needs to be physically present. But electronic trading platforms also reveal the state of the market to all market participants through the computer screen in which the buy and sell orders are listed and transactions immediately revealed. Centralized markets therefore provide maximal order exposure, but also reveal supply and demand imbalances quickly to the entire trading community. Traditionally, forex trading took place in a *decentralized* market. The state of the market tends to be more opaque since the market operates as a network of bilateral dealer relationships. The dependence on bilateral negotiation limits the exposure of a trading interest to only one counterparty at a time, but also preserves the information about the trading desire of the initiating party. Private information is therefore better protected than under the more transparent centralized market structure.

Recently, two competing electronic trading platforms have emerged as an trading alternative to the traditional over-the-counter market. Both Reuters Dealing 2000-2 and Electronic Brokering Services (EBS) offer competing central market places through electronic terminals. Their combined market share increased to approximately 50 percent in 1998.[6] The increase in electronic trading itself marks an important transformation of the forex market structure and contributes to more market transparency.

2.2 Hot potato trading

Why does the forex market generate such gigantic trading volumes? Lyons (2001) suggests that up to 80 percent of forex trading involves trading exclusively between forex dealers in commercial banks, while less than 20 percent involves transactions between a dealer and a bank customer. Customers

[6] Estimate by the Bank for International Settlement (BIS (2000)) suggest that role of electronic brokerage has further increased since 1998.

are non-dealers in non-financial firms as well as financial firms like mutual, pension or hedge funds. If a customer requests a large foreign currency positions from a dealer, the latter holds a risky position in his inventory. A sudden devaluation of the position amounts to a loss of the inventory value. To diminish his inventory risk, the dealer passes all or part of his position on to other dealers, who in turn may sell it to a third dealer and so on. Foreign exchange imbalances may therefore circulate like a 'hot potato' and each consecutive transaction enters into the volume count. This explains the high turnover volume in the forex market (Lyons (1996a, 1997)). But does the 'hot potato trading' also serve an economic purpose? Two different aspects deserve to be highlighted here. First, 'hot potato trading' disseminates the inventory risk and shares it among many dealers. Shared risk is effectively lower risk. Hot potato trading is therefore a suitable risk sharing mechanism which mutually benefits all dealers. Second, participation in the risk sharing is also necessary for each dealer. In the absence of free, centralized information sources about the state of the market, trading itself represents essential information source. Each transactions provides information about market-wide inventory imbalances and thus helps dealers to anticipate exchange rate changes. Bloomfield and O'Hara (1999) go further and argue that low market transparency increases competition for order flow which becomes more valuable as an information source if transaction prices are not revealed market wide. Spreads may therefore decrease not only as a result of better risk sharing, but also because of more dealer competition.

2.3 Market transparency and frontrunning

It is straightforward to understand that information about market-wide inventory imbalances are very valuable as they predict imminent exchange rate change. Assume a dealer A has large positive (long) dollar position and a negative balance (short position) in euros following a client transaction. To reduce his inventory risk he wishes to sell dollars and buy euros. If all other traders have a balanced inventory, a dollar depreciation against the euro tends to follow as someone has to be induced to hold the dollar excess balances. If dealer B learn about this situation, he may buy euros for dollars prior to the dollar depreciation. He will thereby further increase the shortage of euro balances and depreciate the dollar value even further. In a second step dealer B then sells the euro balances to dealer A at a much higher euro currency price and earns a trading profit. At that stage, part of the dollar depreciation is reversed. This trading strategy is called frontrunning. It consists of anticipating desired trading positions of other dealers and preempting their trades. For trader A, this implies higher trading costs unless he can successfully hide his own inventory imbalances or desired positions. The latter task becomes easier if the market is relatively opaque. Bilateral forex transactions do not immediately communicate a trading desire to the dealer community at large. By contrast, a highly transparent market facilitates anticipation of desired positions and encourages frontrunning. Implied in the above description, is the idea that front-running induces negative autocorrelation in spot rate changes at high frequency.

Concerns about parasitic frontrunning has also influenced the design of centralized electronic trading systems. The Paris and Toronto stock exchanges for example allow dealers to conceal the size of limit orders. The order book may indicate only a proportion of the desired position, but not the full amount. Harris (1997) argues that higher market transparency is particularly problematic for markets with low transaction costs. He documents that the possibility of hiding quote size is used more frequently for stocks with low transaction costs (Harris (1996)). This suggests that market transparency changes may be particularly critical for the forex market because transaction costs tend to be exceptionally low. The following section discusses the role of transaction costs in more detail.

3 What to expect for the euro?

Historically, governments have imposed the use of a particular currency as legal tender for domestic transactions. But for international transactions, competition between different currencies is unconstrained. Which currency emerges as the predominant transaction medium is therefore the outcome of a competitive process in which market participants agree on a particular payment medium according to their commercial interest. In practice this typically means that the transaction medium or currency with the lowest transaction costs is preferred. The transaction role of an international currency is therefore intimately linked to its respective transaction costs.

What then determined the transaction costs of a currency? Section 3.1 provides an overview about the different types of transaction costs. We distinguish three basic components of the forex transaction costs and review the evidence. This section prepares the discussion on how the euro's transaction costs could be expected to differ from those of the predecessor currencies. Two different hypothesis about the impact of the euro on the international currency are discussed in section 3.2.

3.1 What determines forex transaction costs?

Forex transaction costs themselves result from the microeconomic interaction of competitive currency dealers. Dealers provide customers and other dealers with price quotes in the form of a bid and an ask prices which allow immediate execution up to a fixed volume. It is common to interpret the difference between the bid (buy) and the ask (sell) price as a measure of the transaction costs because it corresponds to the loss incurred in a hypothetical simultaneous buy and sell transaction of a fixed currency amount. This measure commonly referred to as the bid-ask spread can be standardized by expressing it as a percentage of the midprice between bid and ask.

Financial theory has identified three basic sources which determine the bid-ask spread, namely order-processing costs, inventory holding costs and information costs. We discuss each cost component separately.

3.1.1 Order processing costs

Order processing costs comprise all operating costs related to the dealer presence in a particular market. These include clearing and settlement costs as well as considerable fixed costs for infrastructure investments like communication networks and information systems. The fixed cost component implies that higher volume in a market reduces the average costs per transaction. This implies that the dealers' transaction service is characterized by scale economies. Spread evidence on 33 currency pairs analyzed by Hartmann (1998) provides some support for a negative long-run relationship between volume and spreads. Time series data also reveals a negative volume spread linkage if volume is measured appropriately as predictable volume (Bessembinder (1994), Hartmann (1998b, 1999)).

3.1.2 Inventory costs

Inventory costs are related to the management of his excess balances (inventory) following a demand or supply shock. The excess balances expose the dealer to considerable risk as the exchange rate may change. Inventory risk management concerns are very important in the forex market. This can be inferred from very short average inventory holding periods. Lyons (1998) estimates that a dealer's average inventory holding period may have a half time as short as 10 minutes.

More importantly, inventory risk is also sensitive to so-called "market transparency", namely a dealer's information about current demand and supply imbalances. High market transparency may accelerate the adjustment process to the new equilibrium price, and dealers with high excess balances may not be able to share those with other traders prior to the price deterioration. Market transparency can therefore be detrimental for the interdealer risk sharing and increase the inventory risk of the dealers (Hau, Killeen, Moore (2001)).

Empirical evidence on the role of transparency for the market quality is unfortunately limited and available only for equity markets. A well-known example is the trading competition in cross-listed stocks between the London Stock Exchange and the Paris Bourse in the early 1990. The trading activity concentrated in the less transparent London market and forced the Paris Bourse to change its reporting rules (Gemmill (1996)). Some evidence that higher market transparency can indeed increase spreads and price volatility is provided by Madhavan et al. (2000) for the Toronto stock exchange. He shows that a regulatory change requiring public real-time dissemination of the limit order book triggered a simultaneous increase in spreads, which was concentrated in floor traded stocks with previously low market transparency. Some evidence that higher transparency can increase spreads has recently been provided by Bloomfield and O'Hara (1999) in an experimental setting.[7] More research on the role of market transparency is certainly needed.

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

3.1.3 Information costs

Information costs refer to all dealer trading losses which result from trading with better informed counterparties. Speculative customers who systematically acquire appreciating positions incur a loss to the liquidity providing dealers. The dealers have to increase their bid-ask spread to compensate for such costs as well. This information component in the forex spread has been inferred from indirect evidence suggesting that unpredictable (surprise) volume tends to increase spreads (Bessembinder (1994), Hartmann (1998b)). The role of information costs for the spread determination is emphasized in research on equity markets. Bacidore and Sofianos (2000) demonstrate that NYSE specialist dealers quote systematically higher spreads for foreign stocks listed at the NYSE than for domestic equity for which information asymmetries between the dealer and the speculators are presumably less severe. The role of asymmetric information in the forex market is still controversial. But recent evidence by Lyons and Evans (2001a) shows that net order flow defined as the difference between buyer and seller initiated trades has a considerable exchange rate impact. If dealers have imperfect information about the net order flow, they always risk providing liquidity at a 'stale' or outdated exchange rate and then take a loss once they rebalance their position at the new equilibrium price.

3.2 Predictions for the euro

Equipped with these basic concepts of spread determination, we formulate two different hypothesis about the impact of a currency union on the international status of the euro. The first scenario we call the *vehicle currency hypothesis.* It was the favored analytical framework in most previous work on the European currency union (Portes and Rey (1998), Hartmann (1998a)). The vehicle currency hypothesis interprets the euro primarily as consolidation of the transaction volumes of the participating European currencies into one single external rate with lower transaction costs due to scale economies. This vision predicts that the euro should surpass the international currency status of its predecessor currencies, in particular the German mark. A competing interpretation of the currency union is provided by the *market transparency hypothesis.* It emphasizes that a currency union is not only a consolidation of liquidity, but also changes the structure of the forex market (Hau, Killeen and Moore (2001)). It highlights in particular the role of market transparency for the inter-dealer risk sharing. Higher market transparency after the currency union may in fact increase dealer inventory risk resulting in higher spreads and higher transaction costs. The market transparency hypothesis implies a more pessimistic view of the role of the euro as a challenger to the dollar in forex trading.

3.2.1 Vehicle currency hypothesis

The vehicle currency theory emphasizes the role of order processing costs for the spread determination. If there are important fixed costs to a dealership presence in a particular market, then high volume markets should have ceteris paribus lower average order processing costs per unit of transaction

volume. A competitive dealership market then implies that currencies with high volume should have lower spreads. The dealers' fixed costs are recovered from more transactions making each transaction on average cheaper. This negative relationship between transaction costs and volume has important implications for the emergence of a dominant international currency. A transaction from Japanese yen into the US dollar could either be undertaken directly in the yen/dollar currency pair, or as two consecutive transactions via the euro as a so-called vehicle currency. In the latter case yen balances are exchanged against the euro and the euro against the dollar. This two step procedure is more advantageous if the combined transaction costs in the yen/euro and dollar/euro market are below the transaction costs in the yen/dollar pair. Let $\text{SREAD}_{\text{JPY/EUR}}$, $\text{SREAD}_{\text{USD/EUR}}$ and $\text{SREAD}_{\text{JPY/USD}}$ denote the respective percentage spreads in the three triangular currency pairs.[8] It is clear that the dollar can maintain vehicle currency status if direct dollar/yen exchange is cheap enough to render two consecutive euro market transactions unattractive. A hypothetical 'roundtrip' of buy and immediate sell in the yen/dollar rate implies transaction costs $\text{SPREAD}_{\text{JPY/USD}}$. Undertaking the same roundtrip using both the yen/euro and the dollar/euro market results in transaction costs $\text{SPREAD}_{\text{JPY/EUR}}+$ $\text{SPREAD}_{\text{USD/EUR}}$. The cost saving for the direct transaction relative to the intermediate use of the euro can be expressed as

$$\text{TSD}^{\text{EUR}} = \text{SPREAD}_{\text{JPY/USD}} - \text{SPREAD}_{\text{JPY/EUR}} - \text{SPREAD}_{\text{USD/EUR}},$$

where we define TSD^{EUR} as the 'triangular spread differential' for the euro. A lower value for TSD^{EUR} will tend to consolidate the direct yen/dollar market. If on the contrary TSD^{EUR} increases, the international currency status of the euro relative to the dollar is strengthened. If $\text{TSD}^{\text{EUR}} > 0$, the euro would dislodge the direct yen/dollar market.

Once a particular currency has vehicle currency status, it accumulates all the transactions volume of otherwise bilateral exchanges. This explains why according to the Bank for International Settlement (BIS) survey for 1998 approximately 87 percent of all transactions in the forex market involve the dollar. These high volumes then explain why spreads in the dollar markets are very low compared to the direct non-dollar rates. The creation of the euro implies that the liquidity of the eleven external rates of euro members are consolidated in one single exchange rate.[9] This consolidation effect should increase euro relative to German mark volumes and decrease euro spreads due to scale economies. Lower spreads again have a positive feedback effect on volume and this may reduce spreads even further. Table 1 summarizes these two main empirical implications for the vehicle currency hypothesis.

3.2.2 Market transparency hypothesis

The creation of the euro not only consolidates external liquidity, but it also eliminates many internal rates. For the initial $n = 11$ euro members a total of $n(n-1)/2 = 55$ currency rates vanish in both

[8] We use the following ISO-codes for exchange rates: USD = US dollar, DEM = German mark, JPY = Japanese yen, GBP = pound sterling, CHF = Swiss francs and EUR = euro.

[9] On January 1, 2001, Greece joined as the twelfth euro member.

the spot and various derivative markets. This amounts to a considerable simplification of the forex market structure. The market transparency hypothesis claims that the simplified market structure increases "market transparency". The market transparency is the knowledge of the dealers about current demand and supply imbalances in the market system. Different market organizations differ critically in their market transparency. Modern electronic trading systems have typically a high market transparency as price quotes are centrally collected and publicly disseminated. Often the order book with a list of the best bid and ask prices is available on screen in real time and executed transactions prices and quantities are instantaneously communicated. The forex market however is characterized by a very different market organization. Most transactions are undertaken as direct inter-dealer transactions without public revelation of the transaction amount or price. This makes the forex market relative opaque with respect to the supply and demand shocks. The existence of many parallel markets only adds to the opaqueness. Imbalances in one market, say the dollar/pound rate, can be hidden as equivalent positions in both the dollar/DM and DM/pound market. Only the consolidation of all positions in all markets could give a clear insight into the net imbalance in any particular rate. The creation of the euro reduced the number of parallel trading venues and conveniently aggregated all imbalances in one single external euro market. Transparency effect of consolidation operates for both the spot and the derivative markets.[10]

A low degree of market transparency in the forex market offers a paradoxical benefit for dealers. If the dealer has a considerable imbalance in his forex position following a large customer order, he can disseminate his excess supply among the other market participants without triggering an instantaneous large price movement to his disadvantage. A more transparent market by contrast will tend to produce a swifter price response prior to full dissemination of the excess balances as other traders perceive the demand and supply imbalance. This implies that the inventory risk of a dealer increases as the market becomes more transparent. But a competitive market will incorporate the higher inventory risk of the trader into a higher quoted spread. Therefore, the higher market transparency of the post-euro regime has implications for euro spreads opposite to the vehicle currency hypothesis. The euro should have higher transaction costs than the previous DM rates. Also higher transaction costs should reduce the transaction volume. Moreover, the higher euro related spreads will decrease the triangular spread differential with respect to other currency pairs like the yen-dollar pair. The implication is that euro is less of an international currency than the German mark on its own.

We can derive two additional testable implications from the market transparency hypothesis. First, dealers can respond to their increased inventory risk by reducing the average transaction size. If their quoted price is valid for a smaller transaction volume, dealers effectively reduce their inventory risk exposure. Table 1 therefore lists a reduced average transactions size as an additional implication of the market transparency hypothesis. Second, we should expect that the higher market transparency and the decreased inter-dealer risk sharing implies a stronger impact of order flow imbalances on the

[10] For a more formal theoretical treatment, see Hau, Killeen and Moore (2000).

price. We therefore conjecture that the exchange rate sensitivity with respect to order flow should be higher in the post-euro than in the pre-euro regime. The lower risk sharing capacity of the post-euro dealership market therefore increases the exchange rate effect of any given exogenous supply or demand shock.

4 What happened to the euro?

4.1 Data sources

Our study uses four different data sets, which are best discussed with reference to the forex market structure. We distinguished the customer trades from interdealer trades. Customer trades amount to approximately 20 percent of the volume in the forex market. Transaction data in this market segment is generally not available. In order to access transaction costs we resort to quotes disseminated through Reuters quote system (Table 2, Data Set A). Dealers use the Reuters indicative quote system to advertise their quotes to forex customers. The prices quoted are generally inferior to those which result from interdealer trades. Larger customers may also achieve more favorable prices than those provided by the Reuters quotes. But in the absence of customer transaction data, the Reuters quote data is the best available information source. Reuters quoted data is also available at relatively high frequency. We obtained the best buy and sell quote in 5 different currency rates at every full hour for 12 months prior and 8 month posterior to the euro introduction.

Interdealer trades amount to 80 percent of all spot transactions, of which in 1998 approximately 50 percent are direct trades and 50 percent are (electronically) brokered trades. Reuters and EBS dealing systems share the market for electronically brokered trades. EBS transaction price data (Table 2, Data Set B) is therefore based on a market segment which presents about 20 percent of the total spot volume. For the two months of August 1998 and August 1999, EBS data was made available to us as the last executed buy and sell price at each full hour and we calculated an hourly transaction spread as the percentage difference of the buy and sell price. The hourly transaction spreads are averaged over the 24 hours and used as a daily transaction cost series for each of the 5 currency pairs listed in Table 2. The EBS transaction spreads data allows a valuable cross check of the transaction cost pattern in the Reuters data.

Evidence on transaction volume is again based on the interdealer trading system EBS (Table 2, Data Set C). The volume data consists of monthly averages of daily transaction volumes in 8 currency pairs and covers 12 pre-euro and 12 post-euro months. There is anecdotal evidence that electronically brokered trades in general and EBS trades in particular increased their relative market share.[11] This market trend should bias any finding in favor of higher euro transaction volumes relative to previous DM volumes.

[11] According to EBS, its market share is increasing. See also BIS (2001) for recent estimates for the market share of electronic brokering.

For the most important currency pair, the USD/DEM-EUR rate, we obtained additional and more detailed transaction data (Table 2, Data Set D). EBS provided daily data of the number of buy and sell orders as well as the cash value of daily buy and sell order quantities for the 24 month period from January 5, 1998 to December 31, 1999. This allows us to calculate the average transaction size in the interdealer market before and after the euro introduction. But we can also infer the price effect of order flow imbalances measured as net order flow (buyer minus seller initiated orders) on daily exchange rate changes. A simple regression of daily exchange rate changes on daily net order flow indicates the sensitivity of the exchange rate change with respect to order flow (Evans and Lyons (2001)).

4.2 Evidence on the key market statistics

4.2.1 Transaction costs

Low transaction costs are a key characteristic of an international currency. Transaction costs data is therefore essential for any evaluation of the euro's role relative to its most important predecessor currency, the German mark. But transaction data in the forex market are hard to obtain because of the decentralized market structure. We therefore consider quoted prices posted by forex dealers in the Reuters system (data set A). Table 3, panel A reports pre- and post-euro quoted Reuters spreads for two non-euro and three euro pairs. Quoted spreads cover 12 months pre-euro and the first 8 months of the post-euro period and are registered by Reuters at every full hour. All spreads are expressed in basis points. The two non-euro pairs dollar/yen (USD/JPY) and pound/dollar (GBP/USD) indicate an economically small spread decrease, which is significant in statistical terms for the pound/dollar pair. Comparable time series are constructed for the euro. We treat the German mark as the relevant predecessor to the euro. Hence the mnemonic USD/DEM-EUR refers to the dollar/DM rate prior to January 1, 1999 and to the dollar/euro rate thereafter. The three euro pairs show a remarkably large increase in quoted spread of 40 percent for the USD/DEM-EUR rate, of 62 percent for the JPY/DEM-EUR rate and of 195 percent for the GBP/DEM-EUR rate. This difference between the pre- and post-euro spread is statistically highly significant. Visual inspection of the time series confirms that the spread increase coincides with the introduction of the euro.[12] The Reuters quote data therefore suggest an important transaction cost increase for the euro relative to the German mark.

Since quoted spreads may overstate actual transaction costs of interdealer trades, we examine a second data containing interdealer transactions (data set B). The electronic brokerage system registered the last buy and sell transaction at each full hour for the two months of August 1998 and 1999. The hourly transaction spreads are obtained as daily averages of the 24 full hour intraday spreads. The transaction data provides a valuable cross check about the accuracy of the quoted spread data. Table 3, panel B summarizes the results for the pre- and post euro period for 5 currency

[12] For diagrams of some of the data discussed here, see Hau Killeen and Moore (2000).

pairs. Data on the pound/dollar rate was not available because EBS has a relatively small market share in this rate. Not surprisingly, transaction spreads are considerably smaller than the Reuters quoted spreads. For the USD/JPY rate we find only a marginally significant spread change, while the two euro pairs USD/DEM-EUR and JPY/DEM-EUR have noticeably higher transaction costs. The transaction data set also contains two time series involving the Swiss Franc, namely the USD/CHF and the DEM-EUR/CHF rate. Both show a noticeable decrease in transaction costs suggesting a stronger role for the Swiss Franc in the post-euro environment. But we also note that the Swiss franc benefited from lower volatility in August 1999 compared to August 1998.[13] Overall the transaction data confirms our conclusion about higher effective spreads after 1999. This evidence supports the transparency hypothesis, but not the vehicle currency hypothesis.

4.2.2 Triangular spread differentials

A triangular system of three currencies allows dealers obtain the same position either through one direct transaction or by two indirect transaction though a vehicle currency. The dealer can for example acquire a yen/dollar position directly or indirectly though transactions in the yen/euro pair and consecutively in the euro/dollar pair. The vehicle currency status of a currency is enhanced if the sum of the indirect transaction costs involving this currency is low relative to the direct transaction costs in some other currency pair. Measuring transaction costs by spreads (expressed in basis points), we can therefore define the triangular spread differential TSD as the difference between the direct spread and the sum of the two indirect spreads, therefore

$$\begin{aligned}
\text{TSD}^{\text{DEM-EUR}} &= \text{SPREAD}_{\text{JPY/USD}} - \text{SPREAD}_{\text{JPY/DEM-EUR}} - \text{SPREAD}_{\text{USD/DEM-EUR}} \\
\text{TSD}^{\text{USD}} &= \text{SPREAD}_{\text{JPY/DEM-EUR}} - \text{SPREAD}_{\text{JPY/USD}} - \text{SPREAD}_{\text{USD/DEM-EUR}} \\
\text{TSD}^{\text{JPY}} &= \text{SPREAD}_{\text{USD/DEM-EUR}} - \text{SPREAD}_{\text{JPY/USD}} - \text{SPREAD}_{\text{JPY/DEM-EUR}}
\end{aligned}$$

A negative triangular spread differential $\text{TSD}^{\text{DEM-EUR}} < 0$ implies that the direct market transaction in the JPY/USD pair cannot be dislodged by two vehicle transaction involving the euro (or the German mark as its predecessor). The larger the triangular spread differential, the more attractive it becomes to use the indirect transaction route. The vehicle differential therefore presents a direct (transaction cost based) measure of international currency status.

Did the triangular spread differential increase for the move from the German mark to the euro? We use 14,592 hourly spread observations based on Reuter quotes to calculate the distribution of the triangular spread differential for the above three currency pairs. Figure 1 to 3 plot the respective density distributions separately for the pre- and post-euro period. The vehicle differential for the euro shows a clear distributional shift to the left indicating a loss of international currency status from 1998 to 1999. No such shift can be identified for the dollar or yen triangular spread differentials.

[13] The standard deviation of daily returns for CHF/DEM was 4.96 percent in August 1998 compared to 3.38 percent for the CHF/EUR in August 1999, which amounts to a 32 percent volatility decline.

Using the euro as a vehicle is therefore on average more expensive compared to the German mark. We interpret this a evidence against the vehicle currency hypothesis. But the evidence is consistent with the transparency hypothesis.

4.2.3 Transaction volume

Are the relatively high euro transaction costs documented above reflected in low euro transaction volume? To address this question we use transaction volume statistics from EBS to access the volume evolution consecutive to the euro introduction. Again we treat the German mark as the predecessor of the euro. The time series USD/DEM-EUR therefore contains the German mark volume prior to January 1, 1999 and the euro volumes thereafter. Since the euro consolidated liquidity of many European predecessor currencies in one external rate, one might expect euro volumes to surpass DM volumes for pure accounting reasons. But the EBS volume data presented in Table 3 provide a surprise. Transaction volumes decrease considerably in all three euro pairs, namely the USD/DEM-EUR, the JPY/DEM-EUR and the CHF/DEM-EUR rate. The decrease is economically and statistically significant. The USD/CHF rate registered an astonishing volume increase of 71 percent.

This confirms the previous result on the transaction cost that the Swiss franc increased its international role in the forex market. This suggests that the euro did not achieve greater vehicle currency status in spite of liquidity consolidation. But the evidence supports the transparency hypothesis which conjectures a structural change in the euro related currency pairs.

4.2.4 The role of volume and volatility for spreads

The evidence in support of higher transaction costs in the euro relative to the DM does not account other economic market changes from 1998 to 1999. Following the discussion in sections 3.1.1 and 3.1.2, we expect volatility and volume to be the two leading determinants of spreads. If the euro rates show for example higher short-run volatility, then the inventory risk of the forex dealers might have increased and this could explain the higher spreads. Similarly, volume shifts could also influence transaction costs if scale economies in currency dealing are important.

We examine next if the previous spread evidence on the euro is robust to possible simultaneous changes in volatility and volume. To do this we can construct a simple panel data set which measures not only spreads, but also volatility and volume. Since inventory holding periods in the forex market are short, we measure volatility at the highest available frequency, namely over hourly intervals. We define realized VOLATILITY as the sum of the squared return of the Reuters hourly midprice (between ask and bid price) aggregated into one monthly observation. As a measure of trading VOLUME we use the EBS statistics on monthly electronically brokered volume. Both volume and realized volatility statistics are available only for three currency pairs, namely USD/JPY, USD/DEM-EUR and JPY/DEM-EUR with 20 observations for each pair.

For each of these three exchange rate, we explore the relationship between spreads, volatility,

volume and a DUMMY variable which takes on the value of 1 for monthly observations in 1999 and 0 for observations in 1998. The dummy variable therefore captures shift in the spread not explained by either volatility or volume changes. Formally, the regression is of the form

$$\text{SPREAD}_{i,t} = \alpha_i + \beta_i \text{ VOLATILITY}_{i,t} + \gamma_i \text{ VOLUME}_{i,t} + \delta_i \text{ DUMMY(t=99)} + \varepsilon_{i,t}$$

where the index i represents on of the three exchange rate pairs and t a particular month from January 1998 to August 1999. Since the error term $\varepsilon_{i,t}$ is presumably correlated across the three currency pairs, we use SUR-technique (Seemingly Uncorrelated Regression) to account for common effects in the disturbances.

The parameter estimates are presented in Table 5. In accordance with economic theory, we find that higher volatility tends to increase spreads and higher volume tends to decrease spreads.[14] But it is also clear that the volatility and volume statistics cannot explain the increase in the spreads for the two euro rates for 1999. The dummy variable is highly significant for both the USD/DEM-EUR and the JPY/DEM-EUR currency pair, while it is insignificant for the USD/JPY rate. Particularly, the transaction costs in the important USD/DEM-EUR rate show little dependence on either volatility or volume, but a very strong one-time upward shift in transaction costs for 1999.

4.2.5 Transaction size

Did the new post-euro market structure feature higher dealer inventory risk as the market transparency hypothesis asserts? If this is indeed the case we should expect dealers to adjust their average trade size downwards. If any quote price can be obtained only for a smaller volume, then the dealer reduces his exposure due to quote provision. We can directly verify this implication for the dollar/DEM-EUR rate for which we have two years of order flow data. We define daily average trade size as the ratio of the daily trading volume and the number of trades. Table 6 reports the average daily trade size both in dollars (USD) as well as in German marks (DEM) for the pre- and post-euro regime. Both the number of trades and the volume decreased. But the volume fell more than the number of trades, implying a reduced average trade size. The average daily trade size decreases by -7.6 percent in dollar term and by -3.7 percent in German mark terms. This fall in the average trade size is statistically highly significant independently of the currency of measurement. Figure 4 provides a graphical representation of the shift of the trade size distribution from 1998 to 1999. We interpret the reduction in average trade size as the dealer response to higher inventory risk under the post-euro market structure.

4.2.6 Order flow sensitivities

The large share of interdealer trading in the forex market can be motivated by the inventory risk sharing benefits obtained from a swift diffusion of aggregate inventory imbalances. Such aggregate or

[14] See also Hartmann (1998) for a pure cross-sectional examination with similar results.

market-wide imbalances can be measured if we compare buyer and seller initiated transactions and calculate the difference known as order flow. Each transaction has by definition a buyer and a seller, but microdata on individual transactions often allows us to distinguish those transactions where the buyer contacted the seller from those in which the seller took the initiative. The difference, namely order flow, simple characterizes the buying or selling pressure in a financial market. To what extend does such buying or selling pressure translate into exchange rate changes? Moreover, did the euro modify this linkage?

Recent research indeed finds forex order flow to be highly correlated with exchange rate changes (Evans and Lyons (2001a), Killeen, Lyons and Moore (2001)). This high correlation implies that supply and demand shifts are important for the exchange rate determination. This 'supply and demand perspective' can be contrasted with the conventional 'asset view' according to which exchange rates move primarily as a consequence of new expectations on interest rate differentials without the need for trading. In the latter case the exchange rates movement need not reflect momentary supply and demand imbalances.

The important role of inventory risk highlighted in the microstructure literature suggests that temporary demand and supply imbalances should indeed have a price impact if the dealers are risk averse and unwilling to buffer substantial imbalances. Moreover, the market transparency hypothesis asserts that the inventory risk increases in the more transparent post-euro regime. We can therefore expect that the price impact of supply and demand imbalances as measured by order flow should also increase. We can test this implication of the transparency hypothesis by comparing the pre- to the post-euro order flow sensitivity. Order flow sensitivities have previously been estimated by Evans and Lyons (2001a), Rime (2001) and Killeen, Lyons and Moore (2001). Here we generalize the econometric specification by allowing for a change of the order flow sensitivity subsequent to the introduction to the euro. Again, we use a DUMMY(t=99) variable which takes on the value of 0 for observations in 1998 and 1 for observations in 1999. Interacting this dummy for the post-euro period with the ORDER FLOW$_t$ variable captures the shift in the order flow sensitivity in the following estimation:

$$\begin{aligned}\Delta \log E_t &= \alpha + \beta \text{ DUMMY(t=99)} + \gamma \text{ ORDER FLOW}_t + \delta \text{ ORDER FLOW}_t \times \text{DUMMY(t=99)} + \\ &\quad + \theta \, \Delta \log E_{t-1} + \sigma \, \Delta \log E_{t-1} \times \text{DUMMY(t=99)} + \varepsilon_t.\end{aligned}$$

The exchange rate change $\Delta \log E_t$ is regressed on a constant term α and a shift dummy with parameter β to allow for a different exchange rate trend in 1999. The coefficient γ represents the order flow sensitivity of the exchange rate. The most important parameter is the coefficient δ which identifies the post-euro shift in the order flow sensitivity. We include lagged (past) exchange rate changes $\Delta \log E_{t-1}$ as well as lagged (past) exchange rate changes interacted with the year dummy allow to allow for autocorrelation of the exchange rate changes and a change in this autocorrelation in 1999.

Table 7 reports the regression results. The order flow has the predicted and highly significant positive correlation with contemporaneous exchange rate changes. Moreover, the coefficient δ is positive

and statistically highly significant. The order flow sensitivity substantially increased in the post-euro period. The same order flow imbalance therefore generates a stronger contemporaneous exchange rate change for the euro than for the German mark. This suggest that the euro behaves differently from German mark. The evidence is supportive of the market transparency hypothesis.

4.3 A reduced form model

To access the role of order flow for the exchange rate dynamics, we have to extend the sensitivity analysis of the previous section. Evidence for a stronger contemporaneous correlation between order flow and exchange rate change in the post-euro regime does not necessarily imply a stronger overall exchange rate effect for order flow imbalances. But we can capture the overall dynamics in a simple bivariate vector autoregressive model (VAR). This more general model specification allows for feedback effects from exchange rate changes to order flow and can therefore capture the intertemporal response of the exchange rate to an order flow shock. The two dimensional vector describing the state of the foreign exchange market on day t is given by $X_t = (\text{ORDER FLOW}_t, \Delta \log E_t)$, where ORDER FLOW_t denotes the daily difference of buy and sell orders and $\Delta \log E_t$ the daily exchange rate change. The order flow on day t can depend on past order flow or past exchange rate changes in a linear form according to coefficients estimated from the data. The exchange rate change $\Delta \log E_t$ on day t is a linear function of the order flow on the same day t (capturing the contemporaneous relationship) as well as past values $(X_t, X_{t-1}, ...)$ of both the exchange rate change and order flow. To allow a direct estimation of all coefficients our estimation procedure excludes a direct contemporaneous feedback effect from exchange rate changes on day t to order flow on the same day. This estimation requirement is typically referred to as an identification condition in econometrics.[15].

We estimate the time series model separately for the pre-euro and post-euro period. The coefficients and the number of past variables (lags) are estimated to provide the best possible description of the data. We find that only one lag of X_t is enough to eliminate all residual autocorrelation and thus provide a good specification. Given the estimated interaction between the current (X_t) and past state vector (X_{t-1}), we can trace out the dynamic impact of a order flow shock over consecutive days. Technically, this is referred to as the impulse response function $\text{IR}(k)$ and expresses the cumulative exchange rate change

$$\text{IR}(k) = \sum_{s=0}^{k} \Delta E_s$$

over k consecutive days. The impulse response function therefore summarizes the typical exchange rate dynamics for a standardized shock over the data period of estimation. We choose 1 billion dollars as the size of such a unit shock and compare the pre- and post-euro exchange rate change in Figure 5. We also plot a 95 percent confidence intervals around each impulse response graph. The bold

[15] Testing for the reverse causality from exchange rate changes to order flow under the reverse ordering of the variables did not indicate any significant lagged effect of exchange rate changes on order flow. This point is also made in a general context in both Evans and Lyons (2001) and Killeen, Lyons and Moore (2001)

line representing the exchange rate response for 1999 (post-euro) is noticeable above the respective exchange rate response for 1998. Moreover, the exchange rate effect is incorporated within two days and the exchange rate effect is permanent thereafter for both regimes.

The dynamic analysis provides three insights. First, we confirm the larger short-term impact of inventory imbalances for the post-euro period which is visible in the previous sensitivity analysis. Second, we find that order flow shocks have permanent effects both in the 1998 and 1999 data. The permanent impact of order flow on exchange rates is also documented by Evans and Lyons (2001a) and Rime (2001). But how can order flow imbalances have permanent effects on the exchange rate? Evans and Lyons assert that order flow suitably aggregates dispersed information about (unobservable) fundamentals between two economies. If these fundamental changes are persistent, then the impulse response of a correlated order flow shock should also be persistent. But this interpretation is difficult to reconcile with our third result. The permanent order flow effect appears noticeably larger for the post-euro than for the pre-euro exchange rate regime. Can we assume that order flow is a stronger reflection of economic fundamentals in 1999 than in 1998?

On this issue we add one more speculative remark. One might believe that higher market transparency in 1999 reduces the incentives of informed speculators to participate in the market.[16] Incomplete appropriation of information rents have featured prominent in the theoretical finance literature (Grossman and Stiglitz (1980)). Higher market transparency and the associated information rent stealing through frontrunning may therefore reduce the stabilizing trading incentives of informed speculators. This could explain why order flow shocks generate permanently higher exchange rate effects. But in the absence of any data on market participation it is impossible to quantify this effect.

4.4 Summary of the evidence and our data interpretation

The creation of the euro generated expectations that the new currency would challenge the dollar dominance in international financial transactions. We use various statistical measures to compare the international role of the euro in 1999 to the German mark characteristics in 1998. The evidence suggests that the euro's role in the forex market is different in various respects. We can summarize the statistical evidence as follows:

1. Quoted spreads in euro currency pairs generally increased relative to the corresponding spreads for the German mark. This suggest that euro transactions have become more expensive to the forex market customers. Non-euro transaction costs in the dollar markets have stayed broadly stable or decreased over the same time two year interval.

2. Spreads for interdealer transactions in the electronically brokered market segment measured for August 1998 and August 1999 also show a qualitatively large transaction cost increase for the dollar/euro and yen/euro market.

[16] For a model of endogenous forex participation explaining forex volatility patterns see Hau (1998) and Jeanne and Rose (2000).

3. A comparison of triangular spread differentials shows that the relative attractiveness of a two step vehicle transaction through the euro as a trading alternative to a direct market transaction (in the yen/dollar market) has decreased relative to the analogous vehicle benefits provided by the German mark.

4. We find that electronically brokered transaction volumes have substantially decreased for the euro currency pairs relative to the corresponding external German mark rates. The volume decline for the euro happens in spite of the liquidity concentration of 11 European currencies and against a rising market share of electronically brokered transactions.

5. Daily data on electronically brokered order flow (buyer minus seller initiated trades) reveals that the dollar/euro exchange rate level is substantially more sensitive to order flow imbalances in 1999 than the dollar/German mark rate was in 1998.

6. A dynamic time series analysis shows that a comparable order flow imbalance has a larger permanent exchange rate level effect on the dollar/euro rate than on the dollar/German mark rate.

Our paper tries to provide a coherent theoretical interpretation for these 6 different changes of the forex market. We argued that the evidence is not favorable to the vehicle currency hypothesis which interprets the euro creation primarily as a liquidity consolidation and invokes economics of scale effects in order processing with positive implications for the international currency status of the euro. Our evidence contradicts this analytical framework in every single dimension. The euro lost international transaction status relative to the German mark. We therefore advocate an alternative perspective which emphasizes that the euro changed the forex market structure. In particular we argue that market transparency increased with the elimination of many currency pairs. The intra-European currency elimination reduced the number of parallel markets which allowed for alternative trading venues and therefore reduced the complexity of the market. Market transparency may have been further enhanced by a general market trend towards electronically brokered transactions to the detriment of the more opaque interdealer market segment. But, how can transparency be harmful? The answer focuses on the inventory risk of the currency dealers. His inventory imbalances are revealed more easily to other dealers who can use this information opportunistically. The very low overall forex trading costs allow profitable front-running on inventory imbalances by parasitic dealers. Inventory imbalances become more costly as transparency increases. Dealers in the euro markets will try to recover these costs through higher spreads, which make the euro a less attractive transaction medium than the German mark.

5 Policy implications

This final sections points out policy implications. The evidence we present in this paper relates to the first year of the euro. Obviously, some of our conclusions are predicated on the assumption that observed market characteristics are persistent. Our comments concern the exchange rate management by the ECB and countries which opted not to join the euro zone. Finally, we discuss the issue of forex market quality and add some speculations about the future of the forex market.

5.1 Exchange rate management

A comparison of the pre- and post-euro forex market characteristics shows higher sensitivity of the euro exchange rate level to order flow imbalances. The same order flow imbalance therefore triggers a larger permanent exchange rate movement after 1999. This result may strengthen concerns that private capital flows generate larger exchange rate movements. The strong devaluation of the euro against the dollar over the period 1999-2001 was often perceived as favorable for European employment and growth. Political pressure on the ECB to stabilize the euro was thus constrained. But future portfolio shifts might as well produce a strong euro appreciation with stronger political pressure on ECB to actively intervene. At the same time exchange rate intervention might be more effective under the new forex structure. Evans and Lyons (2001b) claim that the sensitivity of the exchange rate to private order flow is comparable to intervention order flows by central banks. But no evidence is available to confirm the equivalence of private and official flows.

To evaluate the prospects for a more active exchange rate management central banks have to enhance their analytical ability with new data sources. We advocate the systematic collection of high frequency order flow data in all forex market segments. Recent work by Killeen, Lyons and Moore (2001) shows that order flow analysis may also provide valuable insights with respect to the stability of exchange rate pegs. This will become particularly important if emerging market countries like Argentina desire to link their exchange rate to the euro.

5.2 Implications for euro outsiders

The observed structural change in the forex markets and the associated change in forex transaction costs concerns euro outsiders like United Kingdom. Transactions costs measured by Reuters quoted spreads in the euro/pound rate have approximately trebled relative to preceding German mark/pound spreads. The British decision to remain outside did not preserve a pre-euro status quo, but induced a financial segregation of the pound market from the continental European markets. This assessment makes British non-membership more expensive in its financial and trade relations with the rest of Europe. Since between 50% and 60% of Britain's trade is with the euro-zone, the penalty is direct and specific. If Britain joins, the remaining 40% of its trade will be penalized by the higher transactions costs between the euro and other currencies such as the dollar and yen. However, this transaction cost

increase appears more modest according to our data. Overall, the transaction costs argument clearly favors British membership. But it is also fair to say that the overall welfare costs of higher spreads are certainly very modest.

We have presented no evidence in relation to Sweden and Denmark as the two Scandinavian currencies are thinly traded on electronic platforms. It would be valuable if the respective central banks collect and publish data on spreads, liquidity and order flow in these markets. Until such data becomes available, it is impossible to assess the euro's impact on these euro outsiders. The BIS 2001 survey of foreign exchange markets may, however, provide some preliminary indications when its published.

5.3 Market quality and the future

The economic debate about the euro's international transaction role has often been cast in terms of a zero sum game for dominant vehicle status (Portes and Rey (1998) and Hartmann (1998)). The experience of the euro creation suggests a more complex reality than the vehicle currency hypothesis captures. Currency unification generally increased transaction costs in the euro markets. This implies that other forces shape the forex market than scale economies in order processing costs. We argue here that the liquidity consolidation in relatively few external markets eliminated alternative trading venues and reduced the complexity of the forex market structure. Paradoxically, it may thus be increased market transparency which raised transaction costs. Market transparency allows easier inference of other dealers desired trading positions and thereby facilitates 'parasitic' frontrunning. This implies that inventory imbalances become more expensive. Dealers react by quoting higher spreads and/or reduce their trade size to limit the size of inventory imbalances.

Unfortunately, our knowledge about the role of market transparency for market quality is limited. Most evidence relates to equity markets and none is available for the forex market. But it is plausible that the forex market may be more sensitive to a change in the market transparency than the equity market because of considerably lower overall transaction costs. Low transaction costs encourage frontrunning on inventory imbalances (Harris (1996)) and may therefore discourage liquidity provision if market transparency increases. Some of the theoretical literature (Grossman and Stiglitz (1980)) has highlighted a second effect of such externalities on the information efficiency of financial markets, which refers to ability of a financial markets to aggregate all dispersed information in one single price. As the informational rents embodied in customer portfolio shift are more easily cannibalized in the more transparent trading environment, trading incentives for informed customers may diminish. Their information is no longer incorporated into the price. Short of this customers with large trading volumes may find other strategic responses. They may desire a slower portfolio adjustment to render their trading objectives less visible. Overall, the more transparent market may paradoxically result in a less informative exchange rate. However, the importance of this incentive effect for customer trading is hard to access.

The forex market certainly faces further structural change. The introduction of the euro also coincides with a general trend towards electronic trading platforms in the forex market. The two leading systems, namely Reuters Dealing 2000-2 and Electronic Broking Services (EBS), are likely to increase their market share in the interdealer market. Also electronic forex trading is likely to expand to the customer segment of the market. The spreads in the customer segement are considerably higher than in the interbank market and this is the principle source of profit for bank dealers. Customer oriented electronic trading systems can break down this segmentation. Systems like Cognotex and Currenex are currently active in this market and at the time of writing Atiax and FXall are about to enter (BIS (2000)). The traditional currency dealer in commercial banks thus faces a disintermediation challenge similar to the floor traders in the traditional stock exchanges.

References

[1] Bacidore, J. and G. Sofianos, (2000), NYSE specialists trading in non-U.S. stocks, working paper 2000-05, NYSE.

[2] Bank for International Settlements (BIS) (2000), Survey of foreign exchange market activity.

[3] Bessembinder, H. (1994), Bid-ask spreads in the interbank foreign exchange markets, *Journal of Financial Economics*, 35(3): 317-48.

[4] Black, S. (1991), Transactions costs and vehicle currencies, *Journal of International Money and Finance*, 3: 209-222.

[5] Bollerslev, T., and I. Domowitz, (1993), Trading patterns and prices in the interbank foreign exchange market, *Journal of Finance*, 48: 1421-1443.

[6] Bollerslev, T., and M. Melvin, (1994), Bid-ask spreads and volatility in the foreign exchange market: An empirical analysis, *Journal of International Economics*, 36(3-4): 355-72.

[7] Bloomfield, R., and M. O'Hara, (1999), Market transparency: who wins and who looses?, *Review of Financial Studies*, 12(1): 5-35.

[8] Boothe, P. (1998), Exchange rate risk and the bid-ask spread: a seven country comparison, *Economic Inquiry*, 26: 485-492.

[9] Copeland, T., and D. Galai, (1983), Information effects and the bid-ask spread, *Journal of Finance*, 38: 1457-1469.

[10] Detken C., and P. Hartmann, (2000), The euro and international capital markets, *International Finance*, 3(1): 53-94.

[11] Evans, M., and R. Lyons, (2001a), Order flow and exchange rate dynamics, *Quarterly Jounral of Economics,* forthcoming.

[12] Evans, M., and R. Lyons, (2001b), Portfolio balance, price impact and secret intervention, NBER Working Paper 8356, July 2001.

[13] Flood, M., R. Huisman, K. Koedijk, and R. Mahieu, (1999), Quote disclosure and price discovery in multiple-dealer financial markets, *Review of Financial Studies*, 12(1): 37-59.

[14] Gemmill, G., (1996), Transparency and liquidity: a study of block tranactions in the London Stock Exchange under different publication rules, *Journal of Finance*, 1765-1790.

[15] Giavazzi, F., J.-P. Danthine and E.-L. von Thadden, (2000), European financial markets after EMU, CEPR Discussion Paper, no. 2413, London, April.

[16] Glassman, D. (1987), Exchange rate risk and transactions costs: evidence from bid-ask spreads, *Journal of International Money and Finance*, 6: 481-490.

[17] Goodhart, C., Ito, T., and R. Payne (1996), One day in June 1993: a study of the working of Reuters 2000-2 electronic foreign exchange trading system, in Frankel J. et al. (eds.), *The microstructure of foreign exchange markets* (Chicago: University of Chicago Press), 107-179.

[18] Grossman, S.J., and J.E. Stiglitz, (1980), On the Impossibility of Informationally Efficient Markets, *American Economic Review* 70, 393-408.

[19] Hau, H., (1998), Competitive entry and endogenous risk in the foreign exchange market, *Review of Financial Studies*, vol. 11, no. 4, 757-787.

[20] Hau, H., W. Killeen, and M. Moore, (2000), The euro as an international currency: explaining puzzling first evidence, CEPR discussion paper 2510, July 2000.

[21] Harris, Laurence, (1996), Does a large minimum price variation encourage order exposure? University of Southern California working paper.

[22] Harris, Laurence, (1997), Order exposure and parasitic traders, University of Southern California working paper.

[23] Hartmann, P., (1998a), *Currency competition and foreign exchange markets: The Dollar, the Yen and the Euro* (Cambridge, UK: Cambridge University Press).

[24] Hartmann, P., (1998b), Do Reuters spreads affect currencies' differences in global trading activity?, *Journal of International Money and Finance*, 17(5): 757-784.

[25] Hartmann, P., (1999), Trade volumes and transaction costs in the foreign exchange market, *Journal of Banking and Finance*, 23: 801-824.

[26] Huang, R.D., and R. W. Masulis, (1999), FX spreads and dealer competition across the 24-hour trading day, *Review of Financial Studies*, 12: 61-93.

[27] Huang, R.D., and H.R. Stoll, (1997), The components of the bid-ask spread: A general approach, *Review of Financial Studies*, 10: 995-1034.

[28] Jeanne, O., and A. Rose, (2000), Noise trading and exchange rate regimes, CEPR Discussion Paper, no. 2142, NBER Working Paper, no. 7104.

[29] Killeen, W., R. Lyons, and M. Moore, (2000), Fixed versus floating: lessons from the EMS order flow, Paper presented at the NBER IFM conference, available at http://haas.berkeley.edu/~lyons.

[30] Lyons, R.K., (1995), Tests of microstructural hypotheses in the foreign exchange market, *Journal of Financial Economics*, 39: 321-351.

[31] Lyons, R.K., (1996a), Foreign exchange volume: Sound and fury signifying nothing? in Frankel J. et al. (eds.), *The microstructure of foreign exchange markets* (Chicago: University of Chicago Press), 183-205.

[32] Lyons, R.,K. (1996b), Optimal Transparency in a Dealer Market with an Application to Foreign Exchange, *Journal of Financial Intermediation*, 225-254.

[33] Lyons, R.K., (1997), A simultaneous trade model of the foreign exchange hot potato, *Journal of International Economics*, 275-298.

[34] Lyons, R.K., (1999), *The microstructure approach to exchange rates*, MIT Press forthcoming, available at http://www.haas.berkeley.edu/~lyons.

[35] Lyons, R.K., (2001), New perspective on FX markets: order-flow analysis, *International Finance*, forthcoming.

[36] Madhavan, A., D. Porter and D.Weaver, (2000), Should securities markets be transparent? University of Southern California working paper.

[37] Payne, R., (1999), Informed trade in spot foreign exchange markets: an empirical investigation, mimeo, Financial Markets Group, London School of Economics.

[38] Portes, R., and H. Rey, (1998), The emergence of the euro as an international currency, *Economic Policy*, 26: 307-343.

[39] Daginn, R., (2001), Four essays on the microstructure of foreign exchange, series of dissertations no 2 - 2001, Norwegian School of Management.

[40] Sarno, L., and M.P. Taylor (2000), The microstructure of the foreign exchange market, mimeo Department of Economics, University of Oxford.

[41] Viswanathan, S., and J. Wang, (2000), Why is inter-dealer trading so pervasive in financial markets?, mimeo, Fuqua School of Business.

[42] Wyplosz, C., (1999), An international role for the euro?, in *European capital markets with a single currency*, Dermine, J. and P. Hillion (eds.), Oxford University Press, Oxford.

Table 1: Change in forex market characteristics with euro

	Vehicle currency hypothesis	Market transparency hypothesis
Key aspect	Lower order processing costs	Higher inventory risk
Spreads	Decrease	Increase
Triangular spread differential	Increase	Decrease
Volume	Increase	Decrease
Transaction size	-	Decrease
Order flow sensitivity	-	Increase

Table 2: Summary of data sources

	Data set A Quoted prices	Data set B Transacted prices	Data set C Volume series	Data set D Order flow series
Source	Reuters	EBS	EBS	EBS
Currencies	USD/JPY GBP/USD USD/DEM-EUR JPY/DEM-EUR GBP/DEM-EUR	USD/JPY USD/CHF USD/DEM-EUR JPY/DEM-EUR CHF/DEM-EUR	USD/JPY USD/CHF USD/DEM-EUR JPY/DEM-EUR CHF/DEM-EUR	USD/DEM-EUR
Time period	Jan. 98 - Aug. 99	Aug. 98 and Aug. 99	Jan. 98 - Dec. 99	Jan. 98 - Dec. 99
Frequency	Hourly	Daily	Monthly	Daily
Obs.	14592	48	24	519
Design	Best bid and ask quote at every full hour	Average of daily spreads at every full hour	Monthly averages of daily volumes	Daily buy and sell order as number of trades and cash volumes
Output	Bid-ask spread (Quote based) Triangular spread differential (TSD)	Bid-ask spread (Transaction based)	Volume	Price sensitivity Av. transaction size

Table 3: Pre- and post-euro FX spot transaction cost comparison

Panel A: Reuters quoted spreads

Currency	Pre-Euro Jan. 98 - Dec. 98 (1)	Post-Euro Jan. 99 - Aug. 99 (2)	Change (Percentage) (3)	Difference Test (T-Statistics) (4)
Non-Euro Pairs				
USD/JPY	6.05	5.71	−6%	−0.71
GBP/USD	5.37	4.89	−9%	−4.48**
Euro Pairs				
USD/DEM-EUR	3.76	5.26	40%	21.70**
JPY/DEM-EUR	5.12	8.30	62%	17.10**
GBP/DEM-EUR	3.12	9.20	195%	73.55**

Panel B: EBS transaction spreads

Currency	Pre-Euro August 1998 (1)	Post-Euro August 1999 (2)	Change (Percentage) (3)	Difference Test (T-Statistics) (4)
Non-Euro Pairs				
USD/JPY	0.82	1.04	26.6%	2.13*
USD/CHF	2.03	1.28	−37.3%	−3.03**
Euro Pairs				
USD/DEM-EUR	0.50	0.73	44.2%	5.76**
JPY/DEM-EUR	1.39	2.74	97.0%	7.44**
CHF/DEM-EUR	0.72	0.43	−39.5%	−6.76**

Note: We indicate significance at the 5 percent level (*) and the 1 percent level (**).

T-statistics are calculated using White's adjustment for heteroscedasticity.

Table 4: Pre- and post-euro FX spot transaction volume comparison

Currency (Daily averages in billions)	Pre-Euro Jan. 98 - Dec. 98 (1)	Post-Euro Jan. 99 - Dec. 99 (2)	Change (Percentage) (3)	Difference Test (T-Statistics) (4)
Non-Euro Pairs				
USD/JPY	29.0	25.3	−12.9%	−2.18*
USD/CHF	3.3	5.6	70.8%	4.85**
Euro Pairs				
USD/DEM-EUR	45.1	37.9	−17.9%	−2.80**
JPY/DEM-EUR	7.1	4.0	−44.4%	−8.03**
CHF/DEM-EUR	5.3	3.5	−33.7%	−5.65**

Note: We indicate significance at the 5 percent level (*) and the 1 percent level (**).

T-statistics are calculated using White's adjustment for heteroscedasticity.

Table 5: Reuters Spreads explained by volatility and volume

Dependent variable: Reuters Bid-Ask Spread	Coefficient	T-Statistic
	(1)	(2)
USD/JPY Equation		
Constant term	8.270	7.57**
VOLATILITY	0.022	6.36**
VOLUME	−0.847	−2.50**
DUMMY(t=99)	−0.086	−0.685
	$\overline{R}^2 = 0.645$	
USD/DEM-EUR Equation		
Constant term	5.410	2.64**
VOLATILITY	0.012	0.562
VOLUME	−0.519	−0.917
DUMMY(t=99)	1.580	8.30**
	$\overline{R}^2 = 0.888$	
JPY/DEM-EUR Equation		
Constant term	9.820	9.36**
VOLATILITY	0.047	4.29**
VOLUME	−2.830	−4.92**
DUMMY(t=99)	1.840	5.52**
	$\overline{R}^2 = 0.918$	

Note: We indicate significance at the 5 percent level (*) and the 1 percent level (**).

T-statistics are calculated using White's adjustment for heteroscedasticity.

Table 6: Pre- and post-euro average FX trade size

		Pre-Euro	Post-Euro	Change	Difference Test
USD/DEM-EUR		Jan. 98 - Dec. 98	Jan. 99 - Dec. 99	(Percentage)	(T-Statistics)
Daily average		(1)	(2)	(3)	(4)
Number of trades		20933	19768	−5.6%	−2.11*
Trade size in USD	(millions)	2.154	1.990	−7.6%	−18.79**
Trade size in DEM	(millions)	3.793	3.653	−3.7%	−7.229**
Cash volume	(USD billions)	45.1	39.2	−13.0%	−4.71**
Absolute order flow	(USD billions)	1.08	0.95	−12.2%	−2.77**

Note: We indicate significance at the 5 percent level (*) and the 1 percent level (**).

T-statistics are calculated using White's adjustment for heteroscedasticity.

Table 7: Pre- and post-euro order flow sensitivities

Dependent variable: Daily exchange rate change	Coefficient (1)	T-Statistics (2)
Constant term	-0.263	-6.91^{**}
DUMMY(t=99)	0.527	11.15^{**}
ORDER FLOW$_t$	0.247	9.58^{**}
ORDER FLOW$_t$ $\times$ DUMMY(t=99)	0.104	2.97^{**}
$\Delta \log E_{t-1}$	-0.080	-1.29
$\Delta \log E_{t-1}\times$ DUMMY(t=99)	-0.134	-1.72^{*}
Obs.	515	
$\overline{R}^2$	0.363	
Q(36)-p-value	38.12	
DW	2.02	

Note: We indicate significance at the 5 percent level (*) and the 1 percent level (**).

T-statistics are calculated using White's adjustment for heteroscedasticity.

Figure 1: Pre- and post-euro triangular spread differential for the German mark/euro as a vehicle

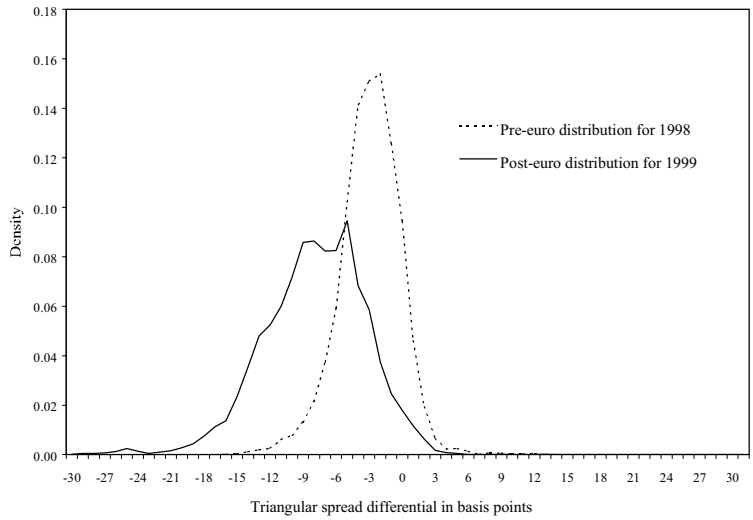


Figure 2: Pre- and post-euro triangular spread differentials for the yen as the vehicle currency

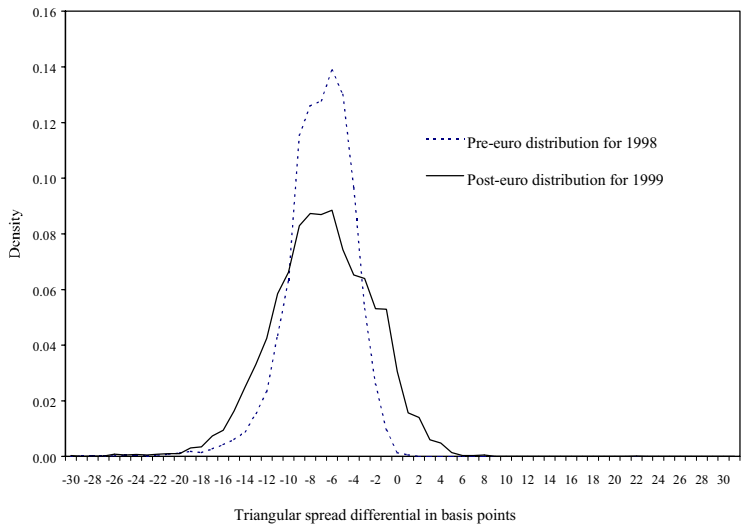


Figure 3: Pre- and post-euro triangular spread differentials for the US dollar as the vehicle currency

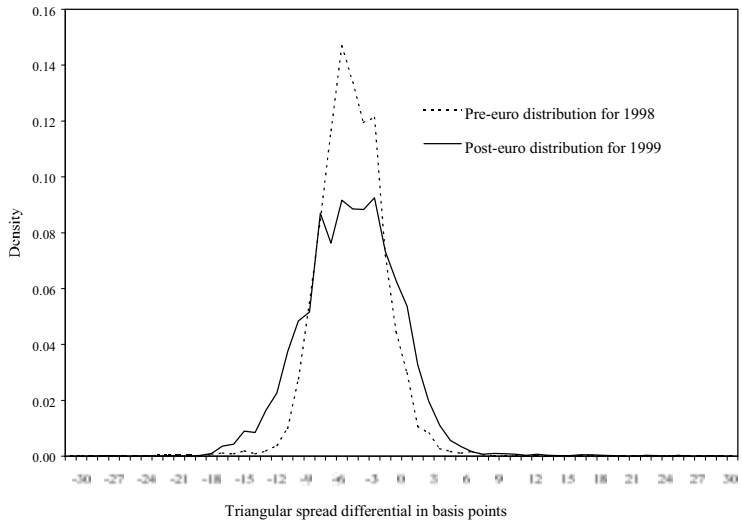


Figure 4: Pre- and post-euro trade size distribution for EBS brokered transactions

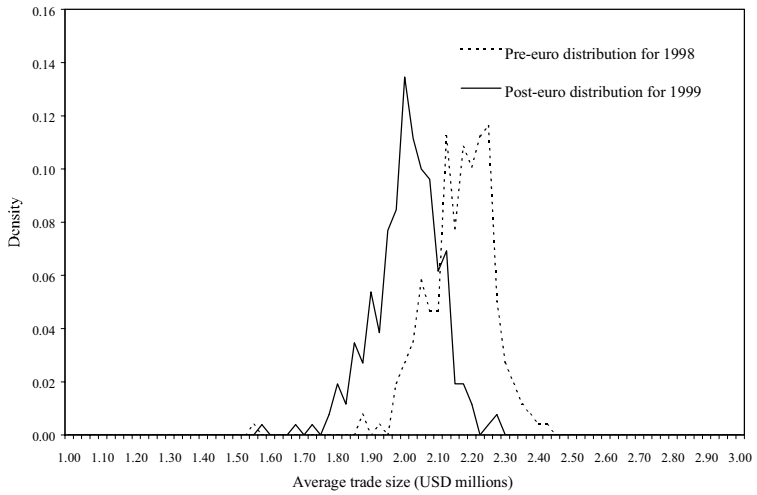
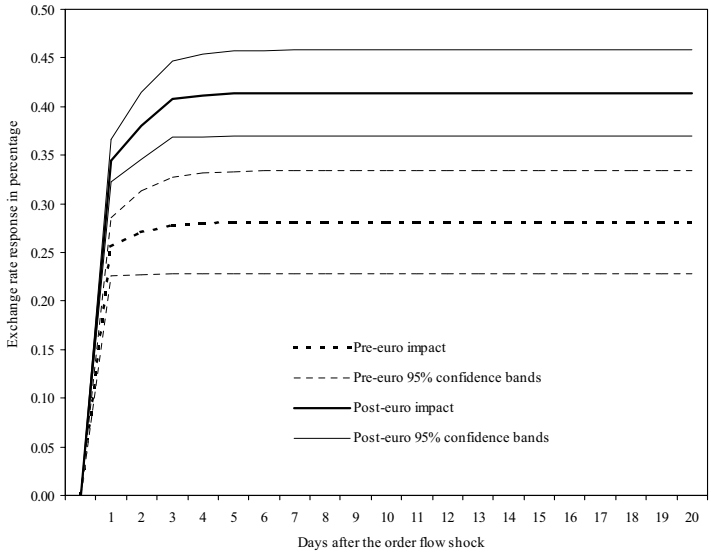


Figure 5: Pre- and post-euro exchange rate impact of a 1 billion dollar order flow shock



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