Liquidity provision in the overnight foreign exchange market[1]

Geir H. Bjønnes[2] Dagfinn Rime[3]
Haakon O.Aa. Solheim[4]

August 15, 2003

[1]We are grateful to Sveriges Riksbank for providing us with the data set used in this paper, and to Antti Koivisto for his help and discussion concerning the data set. We have received valuable comments on previous drafts at seminars in Norges Bank and at the workshop "FOREX microstructure and international macroeconomics", held at Stockholm Institute of Financial Research April 11-12, 2003.

[2]Stockholm Institute for Financial Research and Norwegian School of Management (BI), email: geir.bjonnes@sifr.org.

[3]Norges Bank (Central Bank of Norway), email: dagfinn.rime@norges-bank.no.

[4]Corresponding author. Norwegian School of Management (BI) and Statistics Norway (SSB). email: haakon.o.solheim@bi.no.

Abstract

Recent studies have observed a positive correlation between net purchases of a currency by financial investors and the appreciation of this currency, on horizons like a week or longer. This is consistent with these investors acting as initiators to trading, as in microstructure models. However, if trading conducted by a group of customers is positively correlated with the exchange rate, then the net trading of the rest of the market must, by definition, be negatively correlated with the exchange rate. Such negative correlation will be an indication of liquidity provision. Is it possible to go in closer detail on who the liquidity trader is?

The question is addressed with a extremely detailed data set covering almost all transactions in the SEK/EUR market on a day-to-day basis. The data enable us to track the trading of market making banks and the trading with non-market making banks, customers (non-banks), and the central bank. Central banks provide liquidity in fixed exchange rate regimes, but not in floating exchange rate regimes. Market making banks do provide liquidity, but only intraday. This paper present evidence that customers are the main liquidity providers in the overnight market. This is supported by the following three main findings: (*i*) The net position of customers is negatively correlated with the exchange rate, opposed to the positive correlation found for financial investors. This is the same prediction as for the net position of market makers in the intraday market; (*ii*) Changes in net position of customers are forecasted by changes in non-market making banks net position, indicating that customers take a passive role consistent with liquidity provision; and (*iii*) In response to shocks the trading of customers is almost perfectly negatively correlated with the response of non-market making banks.

JEL Classifications: F31, F41, G15
Keywords: microstructure, international finance, liquidity

1 Introduction

Can trading convey information? Not if markets are efficient, all relevant information is public, and agents are homogenous. However, given the poor performance of this framework in empirical tests, there might be reasons to question some of these assumptions.

One direction of research is to assume that agents are heterogenous. Trading might then be a source of private information. Evans and Lyons (2002) assume that the there are portfolio balance effects in the market. The public will demand a risk premium to change their portfolio holdings. This model predicts a positive correlation between excess demand for a currency and the value of this currency (see e.g. Evans and Lyons, 2002; Lyons, 2001). The concept of order flow—signed transaction volume—has been used to identify excess demand. Using data on intra-dealer trade they find strong empirical support for this proposition.

The foreign exchange market is a multiple-dealer market. One can divide the market into two groups; dealers who operate as market makers, and everyone else. The last group we define as "customers". An important assumption in the Evans and Lyons model is that market makers close their positions at the end of the day. This is confirmed in studies like Lyons (1995) and Bjønnes and Rime (2000). As a result net change in the positions of market makers from close to close is assumed to be zero. Excess demand is driven not by market makers, but by customers.

If one assumes that the world only consists of dealers and customers, and that dealers close their position at night, then total net customer trading must by definition be zero as well. In standard theory agents are homogenous. Any given split of customers should produce the same result as the finding for customer trading as a whole—the correlation between trading and exchange rate changes should be zero. Any observed correlation between net position changes and exchange rate changes should be spurious. Despite this prediction a number of recent papers (see e.g. Fan and Lyons, 2003; Froot and Ramadorai, 2002; Rime, 2001) claim to find a positive correlation between net currency trading of certain customers and the exchange rate.

A claim that customer trades might be *positively* correlated with the exchange rate is however not convincing. Saying that customers as such provide excess demand can not be true. If the trading of one group of customers is *positively* correlated with changes in the exchange rate, the trading by some other group of customers must by definition be *negatively* correlated with changes in the exchange rate. In other words, if someone bids the exchange rate down, other must provide the liquidity if trades shall occur. Given the assumptions above, market makers will not do this job in the overnight mar-

ket. In a fixed exchange rate regime the central bank will be obliged to fill the role as liquidity provider. However, in floating exchange rate the central bank is mainly passive. This leaves the question of who takes the role as a liquidity provider in the floating exchange rate.

The only way one can give a satisfying answer to this question is to observe total trading in a currency market. That is what we set out to do in this paper. The data set we use is from the Swedish krona (SEK) market. The set contains observations of 90–95 per cent of all transactions in the SEK/EUR market on a day-to-day basis from the beginning of 1993 up to the summer of 2002. Furthermore, the data set allows us to track the trading of four distinct groups: (*i*) Market-making banks; (*ii*) Non-market making banks; (*iii*) the central bank; and (*iv*) non-bank customers.[1] These features are to our knowledge unique. There currently exists no other data set on the foreign exchange market that gives such broad insight into the trading of a single currency. This gives us the opportunity to identify how exchange rate risk is distributed between different types of counterparties in the exchange rate market in a way not seen before.

We do not observe separate traders. But we can distinguish between groups of customers. Especially the distinction between financial (non-market making banks) and non-financial (non-bank) customers is pivotal. We know that most actual trading in the foreign exchange market is related to asset allocations and financial investments. However, some currency trading is still conducted for current account reasons. At closer examination, the above cited papers finding a positive correlation between exchange rate changes and trading all focus on financial traders. Froot and Ramadorai (2002) have data from the global custodian State Street Corporation, covering transactions over a period of seven years in 111 currencies. Given the source of the data, it is reasonable to believe that the transactions in general represent financial investors, or at least financial transactions, as opposed to current account transactions. Fan and Lyons (2003), using data on customer trading with Citibank, find that the trading of financial customers is positively related to exchange rate movements and is more important than that of non-financial customers. Rime (2001) finds similar results using US Treasury data on the foreign exchange holdings of large US banks.

How can we identify the liquidity provider? From the theory of market making we can imply that excess demand will be positively correlated with the exchange rate. The group supplying the asset will fill the role described

[1]Note that "customers" as used in the text refer to all counterparties trading with a market maker, i.e. to both non-market making banks and non-bank customers. Non-bank customers will below be referred to as "non-financial customers".

as "liquidity provider". There are in particular two characteristics of a liquidity provider: (a) The change in the net currency position of the liquidity provider will be negatively correlated with the change in the value of the currency; and (b) The liquidity provider will be matching others' demand and supply passively. If the observation that the trades of financial customers are positively related with the change in the exchange rate also holds true in the Swedish market, it must suggest, by contradicting characteristic (a) above on *negative* correlation with the exchange rate, that non-financial customers, if any, are the main liquidity providers in the Swedish market.

We have three main findings supporting the proposition that non-financial customers are the main liquidity providers in the Swedish market. First, we confirm that there is a positive correlation between the net purchases made by non-market making banks and the exchange rate. The correlation is weak when we correlate daily change with daily returns, but becomes stronger as we lower the frequency from day to week to month to quarter. This is in line with Froot and Ramadorai (2002), who find that net flows and returns in the given currency are positively related, and that the correlation increases as one increases the horizon from one to seventy trading days.

Second, we find that the positive correlation between net purchases of non-market making banks and the exchange rate is matched by a negative correlation between the net purchases of the non-financial customers and the exchange rate. The coefficient is not only similar to the one of non-market making banks in absolute value, but also very stable. These findings lead us to conclude that the non-financial customers we observe fulfill requirement (a) above, while non-market making banks do not.

Third, we test the requirement (b) , that the presumed liquidity providers passively match changes in the demand and supply of others. We find that the trading of non-market making banks tends to forecast the changes in net holdings of non-financial customers. We interpret this as evidence that the non-financial customer group is not the one in the active end of trading. Furthermore, we find that in response to a shock to the exchange rate the purchases of non-market making banks are closely matched by the selling of non-financial customers. Last, we provide some evidence indicating that non-financial customers differ from non-market making banks with regard to purpose of trading. We find that the currency trading of non-financial customers is correlated with the Swedish current account. Such correlation is not found for the non-market making banks.

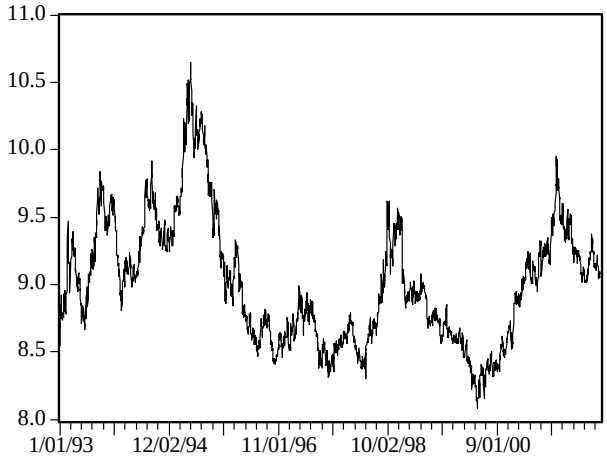
In section 2 we present the data. In section 3 we provide some background on how we can distinguish between different groups. Section 4 reports the results on our attempts to identify the liquidity provider. Section 5 gives some results on how active and passive traders react to changes in real variables.

Section 6 presents some concluding remarks.

2 Data from the Swedish krona vs. euro market

The Riksbank receives *daily* reports from a number of Swedish and foreign banks (*primary dealers* or market makers, currently 10)[2] on their *buying and selling* of *five different instruments* (spot, forward, short swap, standard swap and option), over the period from January 1, 1993 to June 28, 2002. The reporting banks are anonymised in the data set. The reported series is an aggregate of Swedish krona (SEK) trading against all other currencies, measured in krona, and covers 90–95 per cent of all worldwide trading in the SEK. Close to 100 per cent of all interbank trading and 80–90 per cent of customer trading are made in SEK/EUR. In our analysis we will therefore focus on the SEK/EUR exchange rate, which is shown in figure 1.[3]

Figure 1: The SEK/EUR exchange rate



Aggregate volume information is not available to the market. Foreign exchange markets are organized as multiple dealer markets, and have low transparency. The specific reporter will only know its own volume and a noisy signal on aggregate volume that it receives through brokers. Reporting banks do obtain some statistical summaries of volume aggregates from the

[2]Currently means during the spring of 2002.

[3]Note that for observations prior to January 1, 1999, we use DEM instead of EUR. One should notice that almost all trading in SEK prior to January 1., 1999 was conducted in DEM as it is currently conducted in EUR.

Riksbank, but only with a considerable lag. The data set used in this paper is not available to market participants.

Each market maker reports trading with seven counterparties: (*i*) Swedish market makers; (*ii*) Foreign market makers (*iii*) Swedish non-market makers; (*iv*) Foreign non-market makers; (*v*) Swedish non-bank customers; (*vi*) Foreign non-bank customers; and (*vii*) Sveriges Riksbank.[4] We choose to aggregate our data into three distinct groups. These are (*a*) market making banks (reporters); (*b*) foreign non-market making banks (foreign non-reporters); and (*c*) non-bank customers. The last group we define as non-financial customers. We return to this division in the next section.

This paper concentrates on net changes in currency positions (for a discussion of gross flows, see Bjønnes, Rime and Solheim, 2002). Note an important distinction here: this is changes in *currency positions*, or *currency risk*, it is not the holdings of cash denominated in a specific currency. An investor purchasing SEK will of course use this to invest in other assets, like equity or bonds. However, these assets will be denominated in SEK. A swap is by definition a position that net itself out. In other words we can ignore trading in swaps. Options might contain interesting information. However, the option market in SEK is limited. More specifically, we focus on the sum net spot and forward positions. Table 1 shows that market participants clearly hedge their spot positions with forwards. Only using spot positions would give a distorted picture of the risk the participants are willing to take.

Table 1: Correlation between accumulated spot and forward positions. Sample: 1.1993-6.2002

The table reports correlation between the level of accumulated spot and forward positions of three different groups in the Swedish market; Cust. is non-financial customers, non-MM is non market making banks, and MM is market makers.

	Cust. spot	**Non-MM spot**	**MM spot**
Cust. forw.	-0.99		
Non-MM forw.		-0.99	
MM forw.			-0.96

As far as we know, it has not been reported results on the use of forward contracts to hedge spot positions. However, as can be seen in table 1, spot and forward positions are almost perfectly negatively correlated when we measure them in levels. The correlation when measured in changes is about -0.7—a spot transactions is almost always met with an opposing forward transaction.

Table 2 gives an indication of statistical properties of the time series, on

[4]Origin of counterparties are determined by their address.

both daily and monthly data. We note that as a percentage of total volume in the market, non-market making banks and non-financial customers are dominating, making up 52 and 28 per cent of the market respectively. We here note that non-market making banks have a larger share of total trading over all instruments than they have of just spot trading. Total gross trading between reporters is about 19 per cent of the total gross trading.

None of the series are normally distributed. However, at least for the monthly data most of the non-normality is due to the distribution of skewness. The lower part of the table reports cross correlation between the different groups. We note that only the trade of two groups are closely correlated; the change in currency positions of non-market making banks and non-financial customers have a negative correlation of -0.63.

3 Distinguishing groups

In the traditional portfolio balance model, the focus is on nationality. However, this is probably mainly a reflection of data availability—as there has been no data on actual currency transactions, researchers have used the current account as a proxy for portfolio shifts over time. As we have data on currency transaction, we need not heed to this limitation. In this paper we are more interested in looking at which roles are played by different groups in the FX-market. We therefore focus on the split between different groups of counterparties.

The trade of market making banks can be divided into four groups; trade with other market making banks (MM-trade),[5] trade with non-market making banks (non-reporters), trade with customers (non-banks) and trade with Sveriges Riksbank (CB). The sum of this trading will amount to the change in the currency positions of the reporting banks (MM). Throughout we will let these names indicate net accumulated positions, where accumulation begins January 2, 1993. By definition we have

$$\Delta\left(MM-trade\right)+\Delta\left(Non-MM\right)+\Delta Cus+\Delta CB=-\Delta\left(MM\right), \quad (1)$$

when all positions are measured as a more positive number if holdings of foreign currency increase.

As described above, we focus on the following three groups: (a) market making banks (reporters); (b) foreign non-market making banks (foreign non-reporters); and (c) customers (non-banks). To understand the role of these groups it is natural to turn to the BIS triennial statistics on the foreign

[5]Aggregating over all banks this number should however be zero.

Table 2: Changes in net holdings - statistical properties. Sample: 1.1993-6.2002

"Size" is gross trade (in all instruments) of the group calculated as percentage of total volume (in all instruments); on a daily basis. All series are in 10 billion SEK (approximate worth 1 billion USD).

MM: numbers are on intra-MM trading for gross numbers, net MM-positions when we report net numbers.

	Non-MM	**Cus**	**MM**	**CB**	**D(lsekeur)**
Size (gross)	0.52	0.28	0.19	0.01	na.
Daily obs.					
Mean	-0.02	0.00	0.00	0.01	0.000
Std. Dev.	0.14	0.14	0.05	0.02	0.005
Skewness	0.66	-0.71	-0.60	-3.55	0.217
Kurtosis	7.78	8.79	13.01	39.90	5.352
Month. obs.					
Mean	-0.42	0.07	0.20	0.11	0.000
Std. Dev.	1.01	0.98	0.57	0.31	0.021
Skewness	0.47	-0.49	-0.36	-3.17	-0.083
Kurtosis	4.64	4.24	4.09	18.64	4.006
Correlation	**Fin.**	**Cust.**	**MM**	**CB**	
Fin.	1				
Cust.	*-0.63*	1			
MM	-0.31	-0.45	1		
CB	-0.06	-0.08	-0.01	1	

exchange market (see Bank of International Settlements, 2002). The data used here are comparable to these reports.[6]

BIS operates with three groups; "reporting dealers" (i.e. market makers), "other financial institutions" and "non-financial customers". "Other financial institutions" are identical to the group we define as "non-reporting banks". One should note that this group does not only include banks. According to BIS other financial institutions are "all categories of financial institutions that are *not* classified as reporting dealers"(Bank of International Settlements, 2002, p. 38). Non-financial customers are "any counterparty other than those described above, in practice mainly corporate firms and governments." The main difference from our data set is that we can explicitly take out the trade of Sveriges Riksbank from this last category, thereby strengthening the link between non-financial customers and corporate firms.

Table 3 shows the share of non-market makers' and non-financial customers' trading with the reporters when we differentiate on address. Non-financial customer trading is dominated by Swedish investors trading with Swedish reporters. We also see that foreign non-financial customers tend to use foreign reporters as their counterparty. The trading of the non-financial customers is one of the remaining "mysteries" in the FX-market. Few sources have had actual data on these positions.

As can be seen from table 3 the group non-market making banks consists almost entirely of foreign banks. Their trading is divided between foreign and Swedish market makers. We have been told by Sveriges Riksbank that Swedish non-market making banks are mostly small regional banks. To assure that the group of non-market makers is homogenous we will in the following only include foreign non-market makers in this definition. However, as seen from table 3 we do not exclude much trading.

In what other way can we distinguish non-financial customers from non-market making banks? Or is it so that they more or less represent the same, in the sense that behind the non-market making banks there will be non-financial customers. We argue below that our non-financial customer group is dominated by current account traders, while the non-market making banks group is not. The banks that have a wide non-financial customer base trading in SEK will probably also be making markets in SEK, and hence be part of the reporters. These customers are our customer group. The potential customers behind the non-market making banks are probably customers that do not have an ongoing interest in SEK, but shift from currency to currency over time. These customers will most likely be financial customers. In this

[6]Indeed it should be, as it is from these data the Riksbank computes its contribution the the BIS statistics.

Table 3: Gross spot trade of customers and non-market making banks as per cent of total spot trade - after nationality of reporter. Sample: 1.1993-6.2002

Foreign Cust. - For. MM	0.03
Foreign Cust. - Swe. MM	0.02
Swedish Cust. - For. MM	0.02
Swedish Cust. - Swe. MM	0.22
Total Customer	0.27
Foreign Non-MM - For. MM	0.10
Foreign Non-MM - Swe. MM	0.31
Swedish Non-MM - For. MM	0.01
Swedish Non-MM - Swe. MM	0.01
Total Non-Market making banks	0.43

respect our non-financial customer group and our non-market making group are two distinct groups.

The reporting banks are the main "market makers" for SEK. In total 27 reporting banks are represented in our sample, but there are never more than 15 at any point of time. Only five banks are represented in the whole sample. The two largest Swedish banks conduct about 43 per cent of all gross trading in the market. It is well known that market makers tend to close most of their positions at the end of the day, and hence do not provide liquidity overnight (see Lyons, 1995; Yao, 1998; Bjønnes and Rime, 2001).[7] Market making banks do of course have proprietary trading desks, but (*i*) their trading is limited compared to the other groups and (*ii*) due both to the relationship with the central bank and their customers they are less likely to do heavy trading against the SEK. We do however observe in the data that market makers are accumulating currency positions over time. But this currency risk is probably not held by these banks. It is reasonable to believe that this currency risk is held by customers of the banks.

In a fixed exchange rate regime the central bank stands ready to buy and sell if the exchange rate moves too much. In this sense the central bank is the main liquidity provider overnight in such regime. In a floating exchange rate regime, like the one Sweden has had since 1993, the central bank does intervene only infrequently, and hence cannot be relied upon as a liquidity provider. Most of the transactions of Sveriges Riksbank (CB) in our sample are due to transactions related to Swedish government debt.

[7]Bjønnes and Rime (2001) finds that this property is stronger in the big currencies than in smaller currencies, as dealers do not want to be squeezed at the end of the day. However, even in small currencies dealers take very limited positions.

Such transactions are announced in advance. We should therefore expect that these transactions have negligible effect on the market. We also have some information on the amount of interventions. In volume, interventions are only important in the very early part of the data, i.e. during the spring of 1993.

Total net trade in the market each day is of course zero—and can therefore not be correlated with anything. If our a priori prediction is correct, then aggregated trade of market makers and the central bank should not be correlated with the exchange rate, at least not at horisons beyond a few days. As a result the sum of non-market making positions and non-financial customer positions can not be correlated with the exchange rate either. However, if we look at at these two groups separately, we should expect that non-market making banks is the group that best match the data reported by Rime (2001) and Froot and Ramadorai (2002). If our results are consistent with previous findings we should expect a positive correlation between changes in the currency position of non-market making banks and changes in the exchange rate.

4 Liquidity provision

To provide evidence of liquidity provision we need to convince the reader of three things. First, we need to establish that there is a systematic correlation between the trading of a group and the exchange rate, and that this correlation is matched (and have the opposite sign) for some other group. Second, to convince the reader that the theory matches the data we need to establish that the changes in positions of the group positively correlated with the exchange rate is actually leading the changes in positions of the group negatively correlated with the exchange rate, i.e. we need to establish that the "supplier" is actually the passive part of the trade. Third, we need to show that the group we identify as "aggressors" and "liquidity providers" actually take opposite positions in the market. This can be investigated by looking at how flows react to shocks. In the next section we will discuss other properties of trading of the two groups.

Our a priori hypothesis is that non-financial customers will fill the role of liquidity provider. As we will see, this prediction is borne out in the data. In the next section we show that non-financial customer's trading is more related to the current account than the trading of non-market making banks. This might indicate that non-financial customers and non-market making banks have different motives for trading.

The most important part of this section is to firmly establish the corre-

lation between trade flows and the exchange rate. We therefore begin with this issue. We do so in two ways. First we apply a standard macroeconomic setting and use the flow data as monthly aggregates in a vector equilibrium correction model together with prices and interest rates. Second, we use daily observations, applying GMM to analyse overlapping samples. We then look at the impact of flows and flows, and discuss how shocks to asset prices affect flows.

4.1 A vector equilibrium model

Lyons (2001) suggests that regressions on exchange rates should combine traditional macro information with information on trading. He suggests that one should estimate regressions on the form

$$\Delta e = \alpha X + \beta Z, \tag{2}$$

where e is the log of the exchange rate, X is a vector of macro variables and Z is a vector of trading variables.

Standard macro analysis on the exchange rate tend to use monthly data. To come as close to this type of analysis as possible we therefore aggregate our series of currency positions up to monthly levels.[8] We estimate a model of the exchange rate including foreign and local prices (measured as the log of the CPI), foreign and local bond rates and the accumulated currency position. For currency positions we use specifications that include only non-financial customer or only non-market making banks.

As all these variables are first order stationary, it is natural to utilise the framework of a vector equilibrium model. This allows us to look at both long-term and short-term relationships.

We estimate the cointegration vector of our vector stochastic process. A detailed discussion of this procedure is found in the appendix. We conclude that while it is not natural to include the positions of non-market making banks in the cointegration vector, it is evidence in support of including non-financial customer positions in the cointegration vector. A restricted cointegration vector, estimated assuming augmented PPP and UIP to hold, is reported in table 4. We also find that accumulated non-financial customer currency positions, when measured on monthly data, are weakly exogenous. The long term effect of changes in positions on the exchange rate is found to be 0.7 per cent per 10 billion SEK.

We include the first lag of the cointegration vector in the VECM. We include the contemporaneous values of the weakly exogenous variables, i.e.

[8] We use end of month observations for all series.

Table 4: Restricted cointegration vector

The vector stochastic process is defined as:

$$X_t = (log(SEK/EUR), acc.\ \ pos.\ \ of\ \ non-financial\ \ cust., pSWE, pDEM, iSWE, iDEM).$$

The model is estimated under the assumption of two cointegration vectors. See the appendix for more details. Sample: Jan. 1993-June 2002.

Restricted vector	**lSEK**	**Cust.**	**pSWE**	**pDEM**	**iSWE**	**iDEM**
alpha	-0.231	0	0.058	-0.028	0	0
st.errors	*0.062*		*0.014*	*0.008*		
beta	1	0.0069	-1	1	-1.88	1.88
st.errors		*0.001*				*0.004*

Table 5: Vector equilibrium correction model of d(log(SEK/EUR))

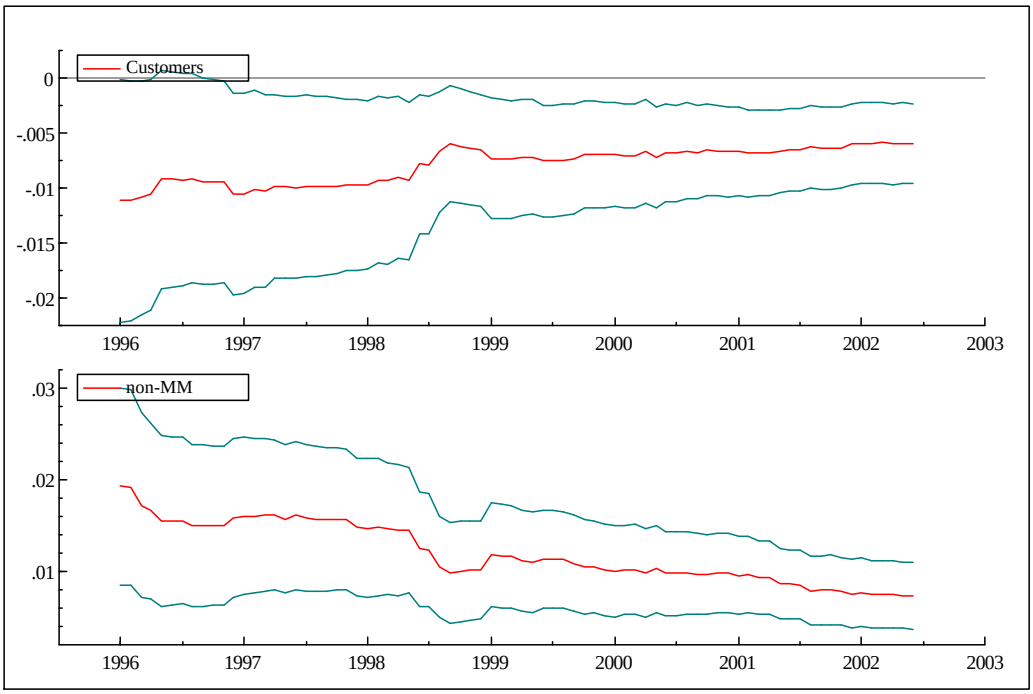
We estimate a VECM and reduce the included variables according to the general-to-specific procedure. CRVEC1(-1) is the first lag of the cointegration vector described in table 4. Volume variables are included as changes of accumulated net currency positions. Statistics are calculated with a White heteroscedasticity consistent covariance matrix. Sample: Jan. 1993-June 2002.

	Coef.	*t-stat.*		*Coef.*	*t-stat.*	
C	0.49	3.08	**	0.46	3.06	**
Cust.	-0.0064	-4.31	**			
non-MM				0.0060	3.98	**
D(SEK10Y)	3.60	5.54	**	3.29	5.81	**
D(DEM10Y)	-4.34	-4.06	**	-3.66	-3.55	**
CRVEC1(-1)	-0.21	-3.07	**	-0.20	-3.03	**
R^2-*adj.*	0.41			0.40		
DW	1.77			1.81		

accumulated currency positions and long-term interest rates. We reduce the system according to the rules of general-to-specific. We estimate separate equations where we use changes in non-financial customer and non-market maker positions respectively. Both variables are highly significant, and have about the same coefficient size, although with the opposite sign. The coefficient of customer position changes is as predicted negative. Both coefficients indicate an effect of 0.60 per cent per 10 billion SEK. The numbers can be compared with similar numbers reported by Evans and Lyons (2002). They find an effect of 0.44 per cent per one billion USD traded in the DEM/USD market.[9] As 1 USD was on average 8.21 SEK over this period, the equivalent effect here is 0.49 per cent per one billion USD.

We have above predicted that in the overnight market, change in (customer + non-market maker positions) should not be correlated with the exchange rate. This proposition is confirmed. We find this variable to be insignificant. The same insignificance is found when we regress changes in the exchange rate on the monthly aggregates of market makers' positions.

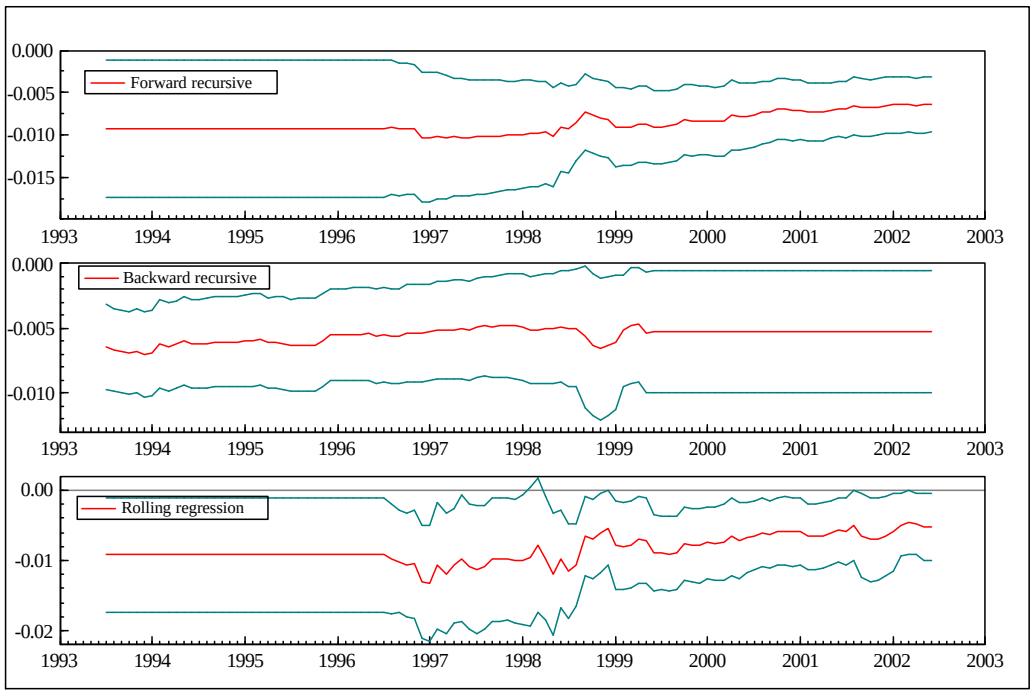
Figure 2: Recursive estimations of the coefficient (+/-2SE) on change in net positions
Upper panel shows coefficient (+/- 2SE) in regression on *customers* and lower panel shows coefficient (+/- 2SE) in regression $non - MM$.



[9]Note however that the result reported in Evans and Lyons (2002) is on daily data.

Figure 3: Recursive estimations of the coefficient (+/-2SE) on change in customer position

Upper figure shows forward estimation, mid figure shows backward estimation, while lower panel shows the result of a rolling regression with a 36-month window. The regression is the same as reported in table 5.



A notable feature of our results is a remarkable stability for the coefficient values on the flow variables in the estimations reported. Figure 2 reports results on forward recursive estimation on the coefficient in of the flow variable in each of the two regressions reported in table 5. Figure 3 reports different stability tests on the coefficient on on customer flows. Both figures show that the coefficient values are stable over the whole sample under investigation.

4.2 Regressing exchange rate changes on changes in currency positions and changes in interest rates

We have daily data. It might be interesting to see the correlation between price changes and trading on a number of different horisons. To do this we apply a standard GMM procedure to account for the fact that we have overlapping observations. As macro variables we use the three month interbank interest rate and the 10 year government bond rate. We include the differential between Swedish and German rates in the regression. The exchange rate is the log of the rate measured at close of the Swedish market.[10]

As stated above, we look at series of accumulated currency risk. We run regressions on non-financial customers, non-market making banks and market makers. Table 6 reports results on estimation on horisons from 1 to 180 days where the flow variables of each group are included separately. As is clear, the sign of non-market makers is positive and significant in all regressions reported. The maximum impact is about 1.0 per cent per 10 billion SEK (0.8 per cent per USD 1 billion) at a horison of 180 days. At horisons beyond 180 days the effect falls of. However, the variable will remain significant at horisons up to 360 days (not reported).

The non-financial customer flow is not significant when we look at changes from close to close. It becomes significant as the horision extends beyond three days. At horisons beyond three days the variable is *negative*. The impact increases to a maximum of -1.0 per cent per 10 billion SEK at a horison of 180 days. Further, at horisons beyond 10 days the coefficient of customers is almost exact the opposite of the coefficient on non-MM.

Above we predicted that market makers should have no impact on the exchange rate beyond one day. However, this hypothesis does not hold in the data when we look at overlapping samples. We see that market makers

[10]We operate with two series for the exchange rate. Both series are collected from Datastream. However, we can only document that the series SWEKRO and DEMKRO are collected at the close of the Swedish market, i.e. GMT 15. These series are only available starting in January 1994. The exact timing of the collection is more important on daily than on monthly data. Regressions here reported are therefore estimated on a slightly shorter sample than in the previous section.

Table 6: Flows and returns. Sample: 1.1994-6.2002

The table shows a GMM regression on $(log(SEK/EUR)_t - log(SEK/EUR_{t-x})$. "non-MM" is accumulated currency risk positions of non-market making banks while "Cust." is accumulated currency risk positions of non-bank customers. "MM" is the accumulated positions of market makers. Flows are measured in 10 billion SEK. All regressions include a three month and a ten year interest rate differential to Germany (not reported).
R^2-base is the R^2-adjusted from a regression including only the interest rate differentials. R^2-add is the the difference between the regression including the flow variables and this base-regression.
All variables are measured as (t-(t-x)), where x is 1, 2, 3 ... . The regression are estimated with a fixed band width of x-1 and an instrument list including all exogenous variables.

	1-1			**1-5**			**1-30**			**1-90**			**1-180**		
	Coef.	*t-stat*		*Coef.*	*t-stat*		*Coef.*	*t-stat*		*Coef.*	*t-stat*		*Coef.*	*t-stat*	
non-MM	0.0017	2.05	*	0.0041	4.96	**	0.0064	5.79	**	0.0086	4.90	**	0.0094	4.45	**
R^2-add	*0.002*			*0.022*			*0.098*			*0.193*			*0.262*		
Cust.	0.0011	1.46		-0.0032	-3.77	**	-0.0061	-5.63	**	-0.0084	-5.95	**	-0.0101	-6.67	**
R^2-add	*0.001*			*0.013*			*0.083*			*0.168*			*0.277*		
MM	-0.0049	-4.48	**	-0.0042	-3.32	**	-0.0043	-2.37	*	-0.0079	-2.88	**	-0.0115	-3.64	**
R^2-add	*0.017*			*0.012*			*0.019*			*0.066*			*0.124*		
R^2-base	*0.14*			*0.26*			*0.32*			*0.40*			*0.35*		
Obs.	2215			2211			2186			2126			2036		

have the predicted negative sign, and is significant at all horisons up to 180 days. However, unlike the two variables discussed above, the t-statistic for MM does not increase as we increase the horison.

The difference between market makers and the two other groups is further emphasised if we look at the measure of R^2. The table reports the R^2-adjusted from a regression on only interest rate differentials, and the difference between this measure of R^2 and the R^2-adjusted when we include the flow variable. We see that for regressions on up to five days the ability of changes in positions to add to the R^2 is limited. This is common for all groups. We also notice that on short horisons the explanatory power is higher for the regression on market maker flow than for the other kinds of flow. If horisons go beyond two days this change however. We now find that flow of customers, both non-market making banks and non-financial, has more explanatory power than flow of market makers.

To conclude, in line with previous literature on this subject, we do find a positive correlation between the traded net flow of financial customers and changes in the exchange rate. On horisons beyond one day this correlation is matched by a negative correlation between traded net flow of non-financial customers and changes in the exchange rate. However, we also find that market makers do provide liquidity beyond a horison of one day, although their importance seem to diminish as the horison increases.

4.3 Identifying "passive side": Granger causality—flows on flows

We continue by using the Granger causality test to identify "liquidity providers". The Granger causality test indicates the forecast ability of one series on another. If the trading of non-financial customers forecasts the flow of non-market making banks, we can hardly say that they are on the passive side.

In this analysis we include the trading of the central bank, and the change in the net positions of the market making banks. Results from the Granger causality test are reported in table 7.

We can not reject the hypothesis that flows of customers do *not* Granger cause the other flows. However, we can reject the opposite hypotheses, namely that other groups do not cause the flows of customers. This leads us to conclude that customers are on the passive side of the trading. Further, we can not reject the hypothesis that no other group cause the change in the positions of non-market making banks—pointing to non-market making banks as a first mover.

Combining the results of tables 6, 5 and 7 might therefore indicate that

Table 7: Granger causality with 2 lags. Daily observations. Sample: 1.1993-6.2002. Only probabilities are reported.

Table presents the probabilities from Granger causality tests. The question asked is whether the variable in the left column do not cause the variable in the upper row. We see that this hypothesis can only be rejected in two cases. We can reject that a change in non-market makes positions do not cause a change in customer positions. We can also reject that a change in market makers positions do not cause a change in customers positions.

Does not cause:	**MM**	**non-MM**	**Cust.**
MM	na.	0.54	0.00
non-MM	0.28	na.	0.00
Cust.	0.78	0.71	na.

we here have identified two groups acting as respectively "aggressors" and "liquidity providers" in aggregate.

4.4 Flows and asset prices

As a liquidity provider we should expect that the trading of non-financial customers should match the trading of non-market making banks in the case of a shock. This can be analyzed within a VAR.

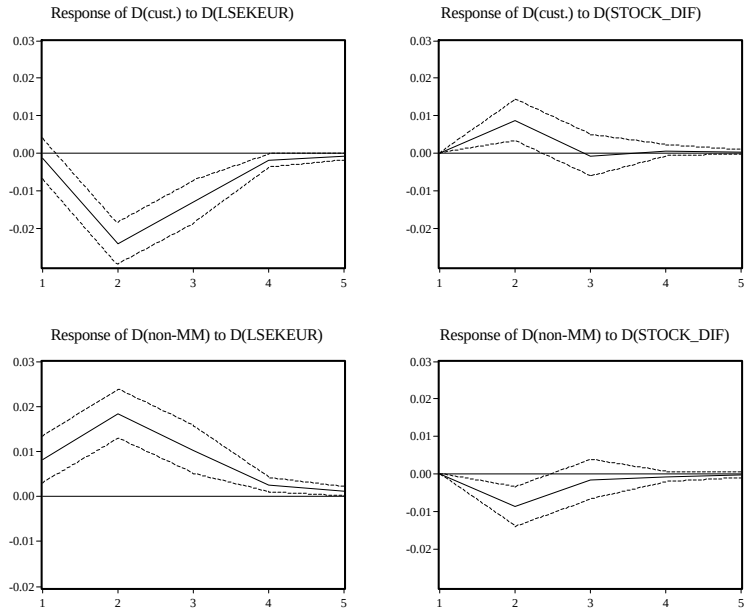
The question asked is how do customer positions react to a price shock. We estimate a VAR that include both the change in the exchange rate and the relative stock return between Sweden and Europe and net flow of the two groups, i.e. non-financial customers and non-market making banks. The assumption is that if the positions of one group reacts to price shock, the other group must take the opposite position.

Figure 4 presents the impulse responses of non-financial customers and non-market makers to a shock to the exchange rate and the relative stock return.

As can be seen in figure 4 the two flow variables both react to a shock in asset prices. A shock of one standard deviation in the exchange rate causes a purchase of SEK 200 and 300 million by non-financial customers, and a comparable sale of SEK by non-market making banks. The response to a shock in the relative stock price is about half this size, but still significant. In both situations we find that a positive shock to a Swedish asset induces a purchase of Swedish assets by non-market making banks and a sale of Swedish assets by non-financial customers.

One should also point out here that it is by no means obvious that the liquidity provider, i.e. the non-financial customer, is "irrational". Notice that the liquidity providers are here consistently behaving as *profit takers*. This of course leaves the question of the trading strategies of the non-market making banks. It is not impossible to interpret them as feedback traders.

Figure 4: Impulse response to a one SD exchange rate shock +/- 2 S.E.
D(cust.) is change in net position of customers, and D(non-MM) is change in net position of non-market making banks. $stock_dif$: the difference in return between the Swedish stock index and a European index (ex. Sweden), measured in local currencies (both series from MSCI). Estimated VAR includes 5 lags. Note that a negative value indicates that the group is buying SEK, e.g. as can be seen in the lower right panel, non-MM responds to a positive shock Swedish stock prices over European stock prices buy buying Swedish currency assets, while customers respond by selling Swedish currency assets.



However, buying an assert that has increased in price does not necessarily imply feedback trading. Other strategies might also fit this kind of trading.

5 Correlation with real variables

In theoretical models the liquidity provider is either modelled as someone who makes transactions in the currency market for other purposes than speculation or someone that is in general uniformed. However, it does seem odd to believe that a group making up more than 20 per cent of total gross trading in SEK/EUR could be caraterised as uninformed?

When we look at the foreign exchange market it might be reasonable to assume that market participants taking positions based on exports and imports fill this role. Carlson and Osler (2000) discuss a model with current account traders and rational speculators. They assume that these current account traders' "demands for currency are [...] determined predominantly by the level of the exchange rate and by factors unconnected to the exchange rate which appear random to the rest of the market."

Another possible hypothesis could be that the liquidity provider is the "uninformed party" in any deal. In asset markets the uninformed party tends to react more to public information than informed traders. If it is correct to assume that the liquidity providers are uninformed, we should expect a stronger correlation between the positions of the liquidity provider and real variables than what we see for the opposing party, i.e. the non-market making banks.

Table 8 shows the correlation between changes in net flows of the groups and two variables; the Swedish current account and the quarterly change in the Swedish GDP. Swedish variables are the relevant reference points here, as trading in SEK/EUR reflects a large share of Swedish trading, but of course only a very small share of all trade in the EMU.

Table 8: Correlation between flows and real variables

Correlation between changes in accumulated net currency positions and Swedish real variables, i.e. CA-current account, TB-trade balance, and GDP (measured in volume). *-indicates significance at 5 per cent. Non-MM: Non-market making banks, Cust.: Customers. We use quarterly observation from 1993:1 to 2002:2.

Quarterly		**CA**		**TB**		**GDP**
1993-2002	**Cust.**	-0.41	*	-0.36	*	0.01
	non-MM	0.01		0.05		-0.18

For the sample as a whole, we find a significant negative correlation between changes in net positions of customers and the current account, indicating that the trading of customers in this data set is related to the current

account. The correlation is negative, as an increase in the current account surplus comes together with increased demand for SEK. For non-market making banks we find no correlation with either the current account nor the trade balance. This might suggests that customers and non-market making banks do not share the same motives for trading. If trading motives are similar there is a zero-sum game between the groups and liquidity provision would be more risky.

6 Conclusion

The provision of liquidity is important for well functioning asset markets. Still, the liquidity of the foreign exchange market, maybe the most important financial market, is a black box. When it comes to fixed exchange rates we know that central banks act as liquidity providers, and that market makers provide liquidity in the intraday market when exchange rates are floating. This paper addresses who provides liquidity *overnight* in the foreign exchange market.

To this end we use a unique data set from the Swedish foreign exchange market covering the trading of several distinct groups over a long time span, the beginning of 1993 up to the summer of 2002. The distinct groups we analyze are (*i*) Market-making banks; (*ii*) the central bank; (*iii*) Non-market making banks; and (*iv*) customers (non-banks). We argue that market making banks and the central bank do not fill the role of liquidity providers overnight in the Swedish market. This assumption also seems to hold in our data.

This leaves us with customers and non-market banks as potential liquidity providers. We use the theory of market making to characterize what to expect of a liquidity providing group of market participants, if one exists. There are in particular two characteristics of a liquidity provider: (*a*) The net currency position of the liquidity provider will be negatively correlated with the value of the currency; and (*b*) The liquidity provider will be matching others' demand and supply passively.

We have three main findings supporting the proposition that non-financial customers are the main liquidity providers in the Swedish market. First, we confirm that there is a positive correlation between the net purchases made by non-market making banks and the exchange rate. The correlation is weak when we correlate daily change with daily returns, but becomes stronger as we lower the frequency from day to week to month to quarter. This is in line with Froot and Ramadorai (2002), who find that net flows and returns in the given currency are positively related, and that the correlation increases

as one increases the horizon from one to seventy trading days.

Second, we find that the positive correlation between net purchases of non-market making banks and the exchange rate is matched by a negative correlation between the net purchases of the customers and the exchange rate. The coefficient is not only similar to the one of non-market making banks in absolute value, but also very stable. These findings lead us to conclude that the customers we observe fulfill requirement (a) above, while non-market making banks do not.

Third, we also find that requirement (b), that the liquidity providers passively match changes in the demand and supply of others, to be supported for the customers. We find that the trading of non-market making banks tends to forecast the changes in net holdings of customers. We interpret this as evidence that the customer group is not the one in the active end of trading. Furthermore, we find that in response to a shock to the exchange rate the purchases of non-market making banks are closely matched by the selling of customers. That the customers primarily consist of non-financial customers is supported by a strong correlation with the Swedish current account, which is not seen for the non-market making banks.

This paper is a first attempt to address the question of liquidity provision overnight in the foreign exchange market. To what extent can we expect these findings to be generalized to other currencies? The SEK is the eight largest currency according to the latest BIS survey of the foreign exchange market. We believe it can be expected that many smaller and similar sized currencies, e.g. smaller currencies in Europe and emerging market currencies, can have the same market structure as the Swedish market. Hence, the results suggested here might be relevant for these currencies. Liquidity issues may be particularly important for these markets, lacking the vehicle flows of larger currencies that add to liquidity. For the larger markets the financial customer flows are so large, and often going in both directions, that it becomes more difficult to discuss the relevance. There is also a problem with lack of data. We do believe, however, that also for the larger markets this is an important question that needs to be addressed.

Appendix 1: Cointegration

To find the long-term relationship in the vector equilibrium model we estimate a cointegration vector. We define the vector stochastic process as

$$X_t = (log(SEK/EUR), acc.positions, pSWE, pDEM, iSWE, iDEM).$$

$pSWE$ is the log of the Sweedish CPI, while $pDEM$ is the log of the German CPI. $iSWE$ is the 10 year Swedish bond rate, while $iDEM$ is the ten year German bond rate. The flow variable is either the accumulated currency position of non-financial customers or of non-market making banks. All variables in this vector are first order stationary according to the Dickey-Fuller test of stationarity.

To take account of non-stationary endogenous variables we need to use a multivariate model. I will follow the procedures used by Johansen (1995) and Johansen and Juselius (1992).[11] The multivariate framework implies that I conduct joint modelling of all endogenous variables.

The cointegration analysis presumes that X can be parameterised as a vector equilibrium correction model, on the form

$$\Delta X_t = \alpha_1 \beta' X_{t-1} + \sum_{i=1}^{p-1} \Gamma_{1,i} \Delta X_{t-i} + \delta_1 + \varepsilon_{1,t},$$

where δ_1 is a vector of deterministic variables, including a constant and dummy variables. ε is assumed to be white noise.

α and β are $5 \cdot r$ matrices, where r is the rank, or number of cointegration relationships in the system. α contains the loading parameters of the system, and will tell us something about how the variable adjust back to the long term equilibrium rate. A test of weak exogeneity in the cointegration relationship would be to test whether the parameter of α is zero. $\beta' X_t$ will comprise the cointegration relationships in the system.

Given X we can test for specific hypotheses. E.g. a test of pure PPP would imply a stable cointegration relationship given by the vector β constrained as $(1, 0, -1, 1, 0, 0)$, where the positions refer to the vector X. This follows as pure PPP implies that the exchange rate, ϵ, when defined as the price of foreign currency in local currency, is given as

$$\epsilon = \frac{P}{P^*}, \tag{3}$$

where P is the local price level, and P^* is the foreign price level. A test of UIP would imply a test of a stable interest rate differential, or a β-vector constrained as $(0, 0, 0, 0, 1, -1, 0, 0)$.

Should accumulated flow be included in the cointegration vector, and if so, what kind of accumulated flow?

We focus on two series of aggregate currency positions; non-market making banks and non-financial customers. We have stated that on higher aggre-

[11] A good introduction to the topic is found in Harris (1995).

Figure 5: Cointegration vectors under different assumptions of X

The figure shows estimated cointegration vectors from an estimation on the vector X=(log(SEK/EUR), volume, $log(CPI_{SWE})$, $log(CPI_{DEM})$, $i10y_{SWE}$, $i10y_{DEM}$). In the upper panel we exclude the all volume variables. in the second panel we include the accumulated positions of non-market making banks. In the lower panel we include the aggregated positions of non-financial customers.

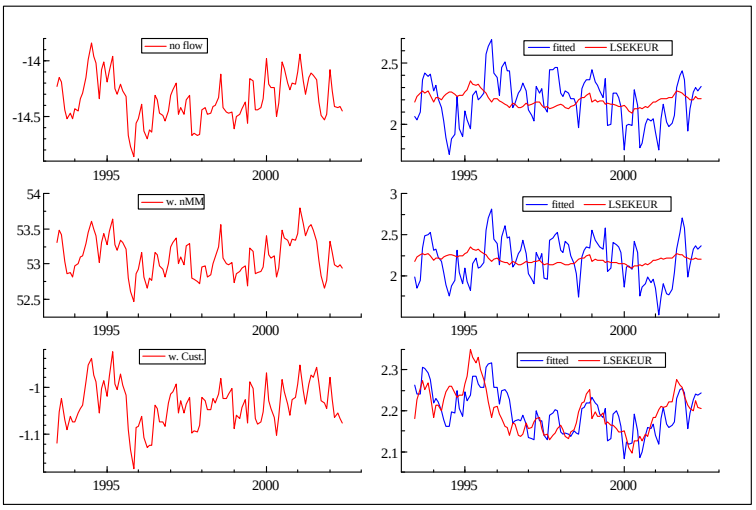


Table 9: Testing for cointegration

Results of a Johansen test on cointegration, using the vector stochastic process X as described in the text, and including aggregate currency positions of non-financial customers.

Ho:rank=p	**trace**		**adj.**		**95 %**
p == 0	137.8	**	99.88	*	94.2
p $\leq$ 1	89.64	**	64.96		68.5
p $\leq$ 2	50.94	*	36.92		47.2
p $\leq$ 3	25		18.12		29.7
p $\leq$ 4	8.61		6.24		15.4
p $\leq$ 5	0.45		0.32		3.8
Tests	**System**				
AR 1-7	0.92				
X_i^2	14.14				
Normality (χ^2)	0.11				

gates one should expect these to be strongly negatively correlated. So we can not include both series at once. Three opportunities exist: estimate a cointegration vector with no flow variable, estimating with the aggregate holdings of non-market making banks and estimating with aggregate holdings of non-financial customers. The first two estimations return one cointegration vector, the last regression return evidence of two cointegration vectors (see table 9).

Figure 5 show that including a flow variables does make a difference. In the upper panel we show the cointegration vector with only macro variables. In the second panel we include the accumulated flow of non-market making banks. In the lower panel we include the aggregate positions of non-financial customers. We see that the cointegration vector has better fit in the lower panel than in the two upper panels. The aggregate position of non-market making banks does not seem to influence the cointegration relationship.

Testing for restrictions on the on the cointegration vector

Table 9 can be interpreted as evidence of two cointegration vectors. When estimating restrictions on the cointegration framework we therefore use two vectors. However, we impose the restrictions on the second vector. We set both α and β values for $log(SEK/EUR)$ and the accumulated currency position equal to zero. This restriction can not be rejected. We interpret this as evidence that the exchange rate and the volume variable are not included in the second cointegration vector. As our focus is on these two variables, we ignore the second cointegration vector in the following discussion.[12]

Table 10 reports the results as we impose a number of specific restrictions on the cointegration vector. As expected, we can reject both PPP and UIP in the data, although we can not reject augmented PPP or augmented UIP.

Of importance in this analysis is the finding that accumulated currency positions of non-financial customers can (i)) not be excluded from the β vector, and (ii) can be excluded from the α vector. The last finding indicates that we can threat accumulated currency positions as weakly exogenous on monthly data. As a result we can include the same period value of accumulated positions as we estimate the short term relationship in the VECM.

[12] All results reported are estimated with the joint assumption that α and β values for $log(SEK/EUR)$ and the accumulated currency position are set equal to zero.

Table 10: Testing for restrictions on the cointegration vector

Testing for restrictions on the cointegration vector. The vector stochastic process is defined as:

$$X_t = (log(SEK/EUR), volume, pSWE, pDEM, iSWE, iDEM).$$

In the lower part of the table we report both restricted and unrestricted cointegration vectors. All restrictions are estimated under the assumption of two cointegration vectors. We impose the restriction (0,0,*,*,*,*) on the β vector in the second cointegration vector, and the restriction (0,0,*,*,*,*) on the α vector. These restrictions can not be rejected, and are imposed when we test the restrictions reported below. As our focus is on the exchange rate, the second cointegration vector is not reported.

a.	**beta**	**assuming**	**Beta restrictions**	**LR prob.**
	I	No Cust.	(1,0,*,*,*,*)	15.28**
	II	Pure PPP	(1,0,-1,1,0,0)	31.94**
	III	Augmented PPP	(1,*,-1,1,*,*)	3.84
	IV	Pure UIP	(0,0,0,0,1,-1)	40.94**
	V	Augmented UIP	(1,*,*,*,a,-a)	3.64
	VI	Augmented PPP and UIP	(1,*,-1,1,a,-a)	3.84

b.	**alpha**	**weak exogeneity of**	**Alpha restrictions**	
	A	LC	(*,0,*,*,*,*)	4.72
	B	pSWE	(*,*,0,*,*,*)	7.13
	C	pDEM	(*,*,*,0,*,*)	10.86*
	D	iSWE	(*,*,*,*,0,*)	4.07
	E	iDEM	(*,*,*,*,*,0)	3.99
	F	LC, iSWE, iDEM	(*,0,*,*,0,0)	5.80

c.	**Joint**	**VI + F**		
	beta	Augmented PPP and UIP	(1,*,-1,1,a,-a,*)	
	alpha	Cust., iSWE, iDEM	(*,0,*,*,0,0)	6.91

unrestricted	**lSEK**	**Cust.**	**pSWE**	**pDEM**	**iSWE**	**iDEM**
alpha	-0.055	-6.376	0.067	-0.017	-0.459	-0.771
beta	1	0.0066	-5.48	4.70	-0.46	3.65

VII+I	**lSEK**	**Cust.**	**pSWE**	**pDEM**	**iSWE**	**iDEM**
alpha	-0.231	0	0.058	-0.028	0	0
st.errors	*0.062*		*0.014*	*0.008*		
beta	1	0.0069	-1	1	-1.88	1.88
st.errors		*0.001*				*0.004*

Appendix 2:Interaction between different types of counterparties

An important question not addressed in table 6 is the possibility of interaction between the change in currency positions of different groups. The liquidity provider part of non-financial customer will be negatively correlated with the active part of non-market making banks. However, non-financial customers are, intra day, only one of the liquidity providers for non-market makers. The liquidity provider part of non-financial customers will be a negatively correlated sub-group of the active part of non-market makers. This is of course also valid the other way around; the liquidity provider part of non-market maker will be a negatively correlated sub-group of the active part of non-financial customer trading.

When we include both non-market makers and non-financial customers in the same regression, non-market maker volume will wash out the liquidity provider part of non-financial customer trading, while non-financial customer trading will wash out the liquidity provider part of non-market maker trading. As a result a common regression will strengthen the aggressor part of both series—and the coefficient value of both series should increase compared to the regression with only volume series. This is observed in table 11.

Market makers is a group dominated by liquidity providers at short horisons. This we know with a high degree of certainty. However, the volume of the main liquidity provider will be negatively correlated with the volume of the active side. As each customer group, i.e. both non-market makers and non-financial customers, are both active in the short term, the active part of the customer groups' volume become sub-groups of market maker volume. The part of customer volume that retains its impact is the liquidity provider part of volume.

However, in the case of non-market makers the part that reflect liquidity provider volume is limited. As a result the coefficient becomes insignificant and very small. In the case of non-financial customers the liquidity trader part of customer volume is stronger than the liquidity trader part of non-market maker volume. For non-financial customers we get a negative parameter in this regression.

On horisons beyond one day, non-financial customers become a more and more important as liquidity providers. The negative coefficient becomes larger, and more significant. But there is still a small part of active trading in total non-financial customer trading. As a result the coefficient of non-financial customer trading is still stronger when we include market maker trading than when we only estimate regressions on customer trading.

Table 11: Flows and returns. Sample: 1.1993-6.2002

The table shows a GMM regression on $(log(SEK/EUR)_t - log(SEK/EUR_{t-x})$. "non-MM" is accumulated currency risk positions of non-market making banks while "Cust." is accumulated currency risk positions of non-bank customers. "MM" is the accumulated positions of market makers. Flows are measured in 10 billion SEK. All regressions include a three month and a ten year interest rate differential to Germany (not reported).

For each variable we report three different regressions. The regressions are; non-MM, 1: only non-MM, 2: non-MM and Cust., 3: non-MM and MM; Cust: 1: only Cust., 2: Cust. and non-MM, 3: Cust. and MM; MM: 1: only MM, 2: MM and non-MM, 3: MM and Cust.

All variables are measured as (t-(t-x)), where x is 1, 5, 10 and 15. The regression are estimated with a fixed band width of x-1 and an instrument list including all exogenous variables.

	1-1			**1-5**			**1-10**		
	Coef.	*t-stat*		*Coef.*	*t-stat*		*Coef.*	*t-stat*	
non-MM									
1	0.0017	2.05	*	0.0041	4.96	**	0.0048	5.34	**
2	0.0041	3.42	**	0.0039	3.05	**	0.0044	3.22	**
3	0.0004	0.51		0.0035	3.94	**	0.0044	4.35	**
Cust.									
1	0.0011	1.46		-0.0032	-3.77	**	-0.0040	-4.02	**
2	0.0036	3.16	**	-0.0003	-0.24		-0.0005	-0.36	
3	-0.0009	-1.12		-0.0044	-5.00	**	-0.0048	-4.84	**
MM									
1	-0.0049	-4.48	**	-0.0042	-3.32	**	-0.0041	-2.89	**
2	-0.0048	-4.12	**	-0.0025	-1.86		-0.0017	-1.11	
3	-0.0054	-4.92	**	-0.0059	-4.68	**	-0.0056	-4.12	**

For non-market makers however, there is no gain from including other volume variables at horisons beyond one day. This is because at these horisons non-market makers are the dominant aggressors in the market, and the liquidity part of non-market maker volume is so small that including e.g. customer volume does not wash out noise—it only adds multicolinearity, as the two are strongly negatively correlated.

References

Bank of International Settlements (2002). "Foreign exchange and derivatives market activity in 2001." Triennial central bank survey, BIS.

BIS (2002). *Central Bank Survey of Foreign Exchange and Derivative Market Activity. 2001.* Bank for International Settlements, Monetary and Economic Department, Basle.

Bjønnes, G. and D. Rime (2001). "Fx trading ... live! Dealer behaviour and trading systems in foreign exchange markets."

Bjønnes, G. H. and D. Rime (2000). "FX trading ... LIVE! dealer behavior and trading systems in foreign exchange markets." Memorandum 29/2000, Department of Economics, University of Oslo, Norway.

Bjønnes, G. H., D. Rime and H. O. A. Solheim (2002). "Volume and volatility in the fx-market: does it matter who you are?" Working Paper 786, CESifo.

Carlson, J. A. and C. L. Osler (2000). "Rational speculators and exchange rate volatility." *European Economic Review*, **44**, 231–53.

Evans, M. D. and R. K. Lyons (2002). "Order flow and exchange rate dynamics." *Journal of Political Economy*, **110**, 170–180.

Fan, M. and R. K. Lyons (2003). "Customer trades and extreme events in foreign exchange." In P. Mizen, ed., *Monetary History, Exchange Rates and Financial Markets: Essays in Honor of Charles Goodhart*, pp. 160–179. Edward Elgar, Northampton, MA. Forthcoming.

Froot, K. A. and T. Ramadorai (2002). "Currency returns, insitutional investor flows, and exchange rate fundamentals." Tech. Rep. 9080, NBER.

Harris, R. (1995). *Using cointegration analysis in econometric modelling.* Prentice Hall/Harvester Wheatsheaf.

Johansen, S. (1995). *Likelihood based inference in cointegrated vector autoregressive models*. Oxford University Press.

Johansen, S. and C. Juselius (1992). "Testing structural hypotheses in a multivariate cointegration analysis of the PPP and UIP for UK." *Journal of Econometrics*, **53**, 211–214.

Lyons, R. K. (1995). "Tests of microstructural hypothesis in the foreign exchange market." *Journal of Financial Economics*, **39**, 321–51.

Lyons, R. K. (2001). *The Microstructure Approach to Exchange Rates*. MIT Press, Cambridge, Mass.

Rime, D. (2001). "U.S. exchange rates and currency flows." Working paper 4, Stockholm Insititute of Financial Research, Stockholm, Sweden.

Yao, J. M. (1998). "Market making the interbank foreign exchange market." Tech. Rep. S-98-3, Stern School of Business, N.Y.U.