Interdealer information in an augmented Taylor rule
-
A new hybrid approach to analyze exchange rates*

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Abstract

We construct a hybrid exchange rate model, augmenting a macroeconomic Taylor rule with information from the foreign exchange interdealer market. Conducting a comprehensive empirical assessment we show the significant impact of market order flow and a new microstructure measure, which is solely based on limit orders, on exchange rate dynamics. We document that hybrid models, which combine public macroeconomic and private information from FX trading platforms, provide a superior model fit and in-sample forecasting performance than a conventional Taylor rule specification and commonly estimated market microstructure models individually. The empirical evidence is based on the largest interdealer order flow data set explored up to know, covering nineteen US Dollar and Euro currency pairs over more than ten years of monthly data.

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1 Introduction

This paper incorporates market microstructure-based order flow measures from the foreign exchange interdealer market within a standard Taylor rule specification in order to examine exchange rate dynamics. Our analysis is motivated by recent findings from Chinn and Moore (2011), who provide first empirical evidence that a combination of market microstructure and macroeconomic information in one and the same approach improves exchange rate modelling. We build upon this novel result, applying a Taylor rule as main model base frame and utilizing a large set of FX interdealer information in form of market orders as well as limit orders. Covering more than ten years of monthly data, we assess nineteen US Dollar and Euro-based currency pairs from one of the largest FX interdealer datasets available up to now.

Combining approaches from the recent FX market microstructure literature (Evans and Lyons (2002)) with a conventional Taylor rule model (Engel and West (2005), Engel et al. (2008)), this paper assesses the following research questions: Do hybrid Taylor rule models fit exchange rate data more accurately than a conventional Taylor rule specification and market microstructure models? Is the newly constructed order flow measure, namely limit order flow, a significant driver of exchange rates in a hybrid framework and at a monthly frequency? What is the impact of cross-country interdependences on the exchange rate analysis?

With the new hybrid Taylor rule concept, we aim to contribute to the exchange rate literature in various dimensions. Firstly, this paper provides evidence that a hybrid Taylor rule produces a superior model fit and in-sample forecasts than its individual components separately. Building upon Chinn and Moore (2011) it shows the possible gains of combining modelling approaches in order to explain exchange rate dynamics. Secondly, we confirm recent results by Kozhan et al. (2015) that not only market orders but also limit order flows are drivers of exchange rate returns. We are the first to document their significant impact as part of a macroeconomic model and at a monthly frequency. Thirdly, we conduct seemingly unrelated regression analysis highlighting the importance of cross-country interdependences for the exchange rate analysis. Last but not least, all empirical evidence provided in this study is based on the largest available FX interdealer order flow dataset. We examine ten US Dollar and nine Euro currency pairs in the period January 2004 to February 2014. The broad coverage of Euro and US Dollar exchange rates over a period of more than ten years provides new insights into the linkage between currency prices and order flows in the foreign exchange market.

The paper is organized as follows. Section 2 reviews recent relevant developments in the exchange rate literature. Section 3 outlines our research methodology, Section 4 introduces the data and Section 5 presents our main findings. Section 6 discusses the impact of additional macroeconomic factors on exchange rate dynamics and presents a variety of robustness checks. Section 7 concludes the discussion.

2 Literature Review

The apparent disconnect between macroeconomic fundamentals and exchange rates is well documented in the literature (e.g. Obstfeld and Rogoff (2000)) and has witnessed increasing attention not last since the seminal paper by Meese and Rogoff (1983). Despite numerous empirical assessments, success in explaining exchange rates remains limited if solely macroeconomic characteristics are used as explanatory factors.[1]

An alternative angle to comprehend exchange rate patterns is provided by market microstructure models, which established themselves as new stream in the exchange rate literature within the last fifteen years or so. In their seminal paper Evans and Lyons (2002) present a portfolio shift model with a high goodness of fit measure if trading data from the FX market is used as explanatory variable. Several studies have subsequently confirmed this finding (e.g. Killeen et al. (2006)) and show that information incorporated in market microstructure variables is a crucial driver of exchange rate dynamics.[2]

Surprisingly, macroeconomic and market microstructure models have evolved largely separately from each other, even though both streams attempt to explain the same phenomenon: the dynamics of exchange rates. This segregation between macroeconomic and microstructure approaches indicates that mutual overlaps have not been entirely exploited yet, omitting benefits of a possible symbiosis between the two streams.[3]

One prominent exception is a study by Chinn and Moore (2011), in which the authors construct an ad-hoc hybrid version of the traditional money-income model by including an additional market order flow component. Fitting an error correction model to data for dol-

[1] For example see Cheung et al. (2005).

[2] Comprehensive surveys on the impact of order flow on exchange rates is provided by King et al. (2013) and Osler and Wang (2012).

[3] For example Evans (2010) and Rime et al. (2010) examine the disconnect puzzle from a market microstructure perspective, however, the authors do not incorporate order flow variables in a conventional macroeconomic model.

lar/euro and dollar/yen currency pairs, the authors provide evidence for a superior model fit when both classes of variables are taken into account in one and the same model. The improvement in explanatory power is driven by the fact that market order flow aggregates otherwise dispersed private information and makes them public to a larger group of FX traders. As a result, market participants benefit from a larger set of information, on which they can base their decisions.

Our paper builds upon these promising results, extending Chinn and Moore (2011) approach in a number of dimensions. Firstly, due to recent success of Taylor rule models to explain exchange rate patterns (Engel et al. (2008), Molodtsova and Papell (2009)), we estimate a hybrid model built on a Taylor rule as macroeconomic base frame. Taylor rules make use of the link between short-term interest rates - the central banks' main direct policy tool - and dynamics of important macroeconomic factors. For example, the Taylor rule model estimated in this paper comprises macroeconomic information on inflation, economic output, interest rate persistence and the real exchange rate. As outlined in the next section, we make use of the interest rate parity condition in order to link these variables with the change in currency prices. The mechanism driving exchange rate changes, therefore, differs fundamentally from Chinn and Moore (2011). While we examine the link between an explicit policy response function and the exchange rate, Chinn and Moore (2011) used a traditional money-income model, which is determined by monetary fundamentals, such as e.g. money supply.

Another crucial difference between our approach and Chinn and Moore (2011) is that we exploit information not from one but two finance market microstructure variables. Firstly, we utilize information incorporated in market order flow which is defined as the sum of net buyer-initiated and seller-initiated trades (Evans and Lyons (2002)). As argued in the literature (e.g. Chinn and Moore (2011)) market order flow aggregates dispersed information and drives revisions of dealers' quotes and changes about future prices of the exchange rate. Both can lead to an adjustment of currency prices. Secondly, we use a newly constructed transaction flow measure from the FX interdealer market, namely limit order flow, as additional explanatory variable. As outlined in detail in the data description, limit order flow is defined as the difference between executed and cancelled limit orders, which both can affect the price discovery process of exchange rates. Thus our analysis not only takes into account a subset of dealers' trades in form of market orders but considers all submitted orders in the FX market. Thereby we aim to capture all trading dynamics taking place at the interdealer platform which possibly have an impact on currency prices. This extension builds upon recent findings by Kozhan et al. (2015) who document the significant relevance of limit order flow on the price discovery process. Their study is based on daily observation. Up to now, limit orders have neither been assessed within the framework of a macroeconomic model nor have their explanatory power for exchange rate changes been confirmed at a monthly frequency. Our analysis aims to fill this gap.

Finally, the scope of our dataset allows for a comprehensive empirical assessment of hybrid models, which combine macroeconomic and market microstructure information. By far it exceeds the scope of Chinn and Moore (2011) study. In this paper, we analyze two balanced panels, with 9 Euro and 10 US Dollar exchange rate pairs, respectively. Due to the large coverage of exchange rate and transaction flow data, our results provide a broader understanding of dynamics in the foreign exchange market and of the price discovery process of currencies.

3 Methodology

We begin this section by briefly outlining the portfolio shift model by Evans and Lyons (2002) and its extension derived by Kozhan et al. (2015) which both include solely market microstructure variables as regressors to explain exchange rate dynamics. As part of the empirical assessment, we will replicate these models in order to show that both microstructure variables convey information about exchange rate returns. This preliminary step aims to forestall any scepticism that subsequent results of the hybrid models are driven by *"idiosyncratic aspects of our data set"* (Chinn and Moore (2011, p. 1604)).

3.1 Market Microstructure Model I: Evans & Lyons

The Evans and Lyons (2002) portfolio shift model estimated in this paper is given by

$$\Delta s_t = \gamma_0 + \gamma_1 mo_t + u_t \tag{1}$$

where Δs_t refers to the change in the log spot exchange rate between period $t-1$ and t, γ_0 is a constant and mo_t refers to market order flow in period t. The estimated parameter $\hat{\gamma}_1$ is expected to be positive because an increase in order flow is associated with a higher demand for the home currency. The positive net-demand for the base currency, then, leads to an increase in the exchange rate. In contrast to Evans and Lyons (2002), we omit the interest rate differential in Equation (1) because in most cases it is found to be insignificant.

Moreover, the primary aim is to identify the explanatory role of order flow variables.[4]

3.2 Market Microstructure Model II: Kozhan *et al.*

The second market microstructure exchange rate model, which serves as comparison for our hybrid Taylor rule, is developed by Kozhan et al. (2015). Similarly to the original portfolio shift model, it includes market orders as right-hand side variable, but it further accounts for trades initiated through limit orders. The additional transaction flow variable is denoted by lbo_t, such that Eq (1) can be re-written as

$$\Delta s_t = \gamma_0 + \gamma_1 mo_t + \gamma_2 lbo_t + u_t \tag{2}$$

where the exchange rate return (Δs_t) is determined by market order flows (mo_t) as well as limit order flows (lbo_t).[5] Kozhan et al. (2015) argue that limit order flow account for crucial dynamics in foreign exchange markets since they are an important supplier of liquidity. In addition, market participants may submit limit orders, instead of market orders, in order to exploit gains from trade. Precisely this trading behavior is captured in Equation (2).

In the model derived by Kozhan et al. (2015), we expect estimates of both order flow components to be positive. As previously argued for the original portfolio shift model, increasing market order flows capture growing net demand for the base currency. This leads to a higher exchange rate and is associated positively with an appreciation of the base currency. In similar way, limit orders may convey private interdealer information and are used by market participants to exploit gains from trade. The buying pressure resulting from limit order submissions works in the same direction as market orders, resulting in higher demand for the base currency. Therefore, $\hat{\gamma}_2$ is expected to be positive. However, as argued by Kozhan et al. (2015) traders may use either market or limit orders submissions to trade in the foreign exchange market, depending on their signal and strength of private information. As the informational signal transmitted via limit orders is argued to be smaller than information via market orders, we expect $\hat{\gamma}_1$ to be larger than $\hat{\gamma}_2$.

[4] In the original portfolio shift model, Evans and Lyons (2002) regress the change in log spot exchange rate (Δp_t) on the change in interest rate differentials ($\Delta(i_t - i_t^*)$) and market order flow (Δx_t), such that: $\Delta p_t = \beta_1 \Delta(i_t - i_t^*) + \beta_2 \Delta x_t + \eta_t$.

[5] Again, we omit the interest rate differential as right-hand side variable, which is originally included in the approach by Kozhan et al. (2015), in order to insulate the role of order flow variables on exchange rate developments.

3.3 Conventional macroeconomic Taylor rule

The macroeconomic base frame for the hybrid model is a conventional Taylor rule, which links short-term interest rates and macroeconomic fundamentals. In a first step, therefore, we document in detail the components of this conventional monetary policy rule. Subsequently, in a second step, we extend the Taylor rule with additional order flow components from the interdealer platform and introduce the new hybrid models.

The derivation of the conventional Taylor rule closely follows the approach outlined in Molodtsova and Papell (2009). The authors define a central bank's policy response function as

$$i_t^* = \pi_t + \phi(\pi_t - \pi^*) + \gamma y_t + r^* + \kappa q_t \tag{3}$$

where i_t^* is the central bank's target for the interest rate, π_t^* is the target level of inflation, π_t refers to the rate of inflation, y_t is the output gap, measured as the difference between potential and current output in period t, r^* is the equilibrium level of the real interest rate and q_t refers to the real exchange rate. The reasoning to include the latter variable is motivated by the work of Clarida et al. (1998) who argue that central banks take into account purchasing power parity condition and stable prices of their currency when setting the interest rate.[6]

Furthermore, one can combine the central bank's targets for inflation and interest rate in one parameter ($\mu = r^* - \phi\pi^*$) and re-write Equation (3) in the following form

$$i_t^* = \mu + \phi\pi_t + \gamma y_t + \kappa q_t \tag{4}$$

The intercept term μ captures differences between the short-term interest rate set by the central bank in period t and the target rates for inflation and interest, π^* and r^*, respectively.

Lastly, the specification allows to take into account interest rate inertia such that

$$i_t = (1 - \rho)i_t^* + \rho i_{t-1} + v_t \tag{5}$$

where i_t refers to the short-term interest rate and $\rho \in [0, 1]$ is a smoothing parameter. It takes into account the gradual adjustment of interest rates towards the target rate. Substituting

[6] Molodtsova and Papell (2009) only assess US-Dollar based currency pairs and include the real exchange rate only in the policy response function of the foreign country.

Eq. (4) into Eq. (5), we derive the following policy response functions

$$\hat{i}_t = (1-\rho)(\mu + \phi\hat{\pi}_t + \gamma\hat{y}_t + \kappa\hat{q}_t) + \rho\hat{i}_{t-1} + \hat{v}_t \tag{6}$$

where "ˆ" is added to denote foreign country variables. Similarly a policy response function for the home country is constructed, however, in line with Molodtsova and Papell (2009), the parameter on the real exchange rate is set equal to zero ($\kappa = 0$)

$$i_t = (1-\rho)(\mu + \phi\pi_t + \gamma y_t) + \rho i_{t-1} + v_t \tag{7}$$

such that the interest rate is solely determined by its own lag term, changes in inflation and output gap.

Assuming both, home and foreign central banks, set their interest rate according to Equation (7) and (6) then the interest rate differential between two countries can be written as

$$i_t - \hat{i}_t = \alpha + \beta_1(\pi_t - \hat{\pi}_t) + \beta_2(y_t - \hat{y}_t) + \beta_3(i_{t-1} - \hat{i}_{t-1}) + \beta_4 q_t + v_t - \hat{v}_t \tag{8}$$

where the policy response functions' parameters are summarized as $\alpha = (1-\rho)\mu$, $\beta_1 = (1-\rho)\phi$, $\beta_2 = (1-\rho)\gamma$, $\beta_3 = \rho$ and $\beta_4 = (1-\rho)\kappa$.

Finally, the linkage between the interest rate spread and changes in the spot exchange rate can be constructed using the uncovered interest parity (UIP) condition, as stated in Equation (9)

$$s_t - s_{t-1} = i_{t-1} - \hat{i}_{t-1} + \epsilon_t \tag{9}$$

where the change in the exchange rate between period t and $t-1$ is determined by the lagged interest rate differential between home and foreign country $(i_{t-1} - \hat{i}_{t-1})$ and a residual term, which is denoted by ϵ_t. Combining UIP with the baseline Taylor rule in Eq. (8), leads to

$$s_t - s_{t-1} = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y_{t-1} - \hat{y}_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + u_t \tag{10}$$

which we refer to as conventional macroeconomic Taylor rule.

With regard to sign and magnitude, we expect coefficient estimates β_1, β_2, β_3 and β_4 to be positive. An increase in the home country's inflation is associated with a contractionary monetary policy response. For example, responding to increasing price levels central banks may pursue a tighter monetary policy and increase the country's short term interest rate. This policy decision translates into an appreciation of the exchange rate, due to increasing returns ($\beta_1 > 0$). As pointed out by Molodtsova and Papell (2009), an increase in the level of inflation not only results in a contemporaneous rise in the home interest rate, it does also affect market participants' expectations about the long-lasting effects of the policy intervention. The revision of expectations can result in an additional appreciation of the home country's currency, accelerating the initial effect of the rise in inflation.

Further, β_2 captures the effect of output gap differences between home and foreign country. A positive output gap in the home country implies an increase in economic activity over potential output levels. The divergence between potential and realised output is likely to take place during economic booms and business cycle upswings, which are periods associated with rising prices and inflationary pressure. Following the same line of argument, the increase in prices ultimately is associated with a rise in the interest rate and an appreciation of the base currency compared to the foreign currency ($\beta_2 > 0$).

The effect of interest rate inertia is captured by the lagged interest rate differential. The associated coefficient is expected to be positive because an increase in interest rates in the home country is associated with an appreciation of the domestic currency. Since interest rates enter the Taylor rule specification with a lag, we account for the fact that changes in monetary policy are not incorporated immediately in prices of currencies ($\beta_3 > 0$).[7]

Lastly, the impact of a rise in the real exchange rate is associated with increasing returns. Since real exchange rates are determined by the sum of log nominal exchange rate and log price differential, an increase in the real exchange rate, *ceteris paribus*, is driven by lower price levels in the home country or higher price levels in the foreign country. The higher the domestic prices relative to foreign prices, the more distinct is the impact on exchange rate returns ($\beta_4 > 0$).

3.4 Hybrid Taylor Rule Model

After establishing the relationship between macroeconomic dynamics and exchange rate returns, the objective of the next step is to expand the conventional Taylor rule and to construct a hybrid model specification, which also accounts for market microstructure variables (Evans

[7]It is worth noting that the interest rate differential enters with a two-period delay due to the assumption of interest rate inertia in Equation (5).

and Lyons (2002), Kozhan et al. (2015)). The hybrid model is derived, following the methodology in Breedon et al. (2016) and applying their approach to the set-up of a conventional macroeconomic Taylor rule.

In principle, Breedon et al. (2016) argue that fluctuations in the exchange rate in Eq. (9) are not only driven by the interest rate spread between home and foreign country but also by an additional risk premium δ_t. Under this assumption the uncovered interest rate parity can be re-phrased as

$$s_t - s_{t-1} = i_{t-1} - \hat{i}_{t-1} + \delta_t + u_t \tag{11}$$

This risk premium, in turn, is directly impacted by investors' trading decisions and developments in the foreign exchange market. To be more concrete, two measures of uncertainty in the foreign exchange market are crucial. One is the size of market order flows in period t which is argued to be positively correlated with a higher risk premium. Hence, investors holding a larger proportion of foreign currencies in their portfolio are exposed to a larger degree of risk. The second measure of uncertainty is the volatility of the spot exchange rate itself which is - intuitively - also positively correlated with the risk premium. Hence, investors holding a currency in their portfolio which is likely to be characterized by distinct up- and downward swings would require a higher risk premium as compensation for potential losses. Given this relation between order flow, exchange rate and risk premium, Eq. (9) can be re-formulated as

$$s_t - s_{t-1} = i_{t-1} - \hat{i}_{t-1} + \gamma_1 mo_t + u_t \tag{12}$$

where $\gamma_1 mo_t$ is the market order flow and its respective coefficient.[8] Lastly, substituting Taylor rule fundamentals for the interest rate spread, which we derived in the previous section, the hybrid Taylor rule specification can be written as

$$s_t - s_{t-1} = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y_{t-1} - \hat{y}_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \gamma_1 mo_t + u_t \tag{13}$$

where the conventional Taylor rule is augmented by the additional market order flow component. Equation (12) accounts for dynamics of the standard portfolio-shift model as well as for macroeconomic dynamics, captured by a conventional Taylor rule.

[8]Eq. (12) simplifies the approach by Breedon et al. (2016) since I do not explicitly take into account the conditional variance of the spot rate. In their paper, the authors specify the augmented interest rate differential as $s_{t+1} - s_t = i_t - \hat{i}_t + \breve{o}_t$, where $\breve{o}_t$ is the modified order flow variable consisting of the product between conditional volatility of the spot exchange rate and market order flow $\breve{o}_t = \sigma_t^2 o_t$.

3.5 Hybrid Model with both order flow components

In a final step, we build upon the approach by Breedon et al. (2016) and construct a second hybrid model, in which the risk premium is influenced by both order flow components. As shown by Kozhan et al. (2015) not only market orders but also limit orders have an impact on the price discovery process of currencies. Consequently, uncertainty shocks to either of the two flow components are positively associated with a larger degree of risk and a higher risk premium. In this case, Equation (12) can be re-written as

$$s_t - s_{t-1} = i_{t-1} - \hat{i}_{t-1} + \gamma_1 mo_t + \gamma_2 lbo_t + u_t \tag{14}$$

where the risk premium is decomposed into a market order flow (mo_t) and a limit order flow (lbo_t) component. With regard to size and magnitude one would expect γ_1 to be larger than γ_2, following the argument of Kozhan et al. (2015) that the informational content transmitted via order flow has a larger impact than that of limit order flow. Ultimately, substituting Taylor rule fundamentals for the interest rate spread, the second hybrid model is given by

$$s_t - s_{t-1} = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y_{t-1} - \hat{y}_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \gamma_1 mo_t + \gamma_2 lbo_t + u_t \tag{15}$$

which combines conventional macroeconomic Taylor rule fundamentals with important drivers from the foreign exchange market in one and the same equation.

The next section introduces the data, which we use to estimate the five models described above: (1) Evans and Lyons (2002) portfolio shift model in Eq. (1), (2) Kozhan et al. (2015) model in Eq. (2), (3) a conventional macroeconomic Taylor rule as shown in Eq. (10), (4) the hybrid Taylor rule with market order flow in Eq. (13) and (5) the hybrid Taylor rule with market and limit order flow (15).

4 Data

For the empirical assessment, we use monthly data for more than ten years, covering the period January 2004 to February 2014 (122 observations). We analyze 19 exchange rate pairs in two separate panels, whereby Euro (EUR) and US-Dollar (USD) serve as base currency, respectively. The exchange rate return for each currency (Δs_t) is measured as the difference in the end-of-the-month log spot exchange rate between period t and $t-1$.

The Euro serves as *numeraire* currency for the following nine currency pairs: Swiss Franc (EUR/CHF), Czech Koruna (EUR/CZK), Pound Sterling (EUR/GBP), Hungarian Forint (EUR/HUF), Japanese Yen (EUR/JPY), Norwegian Krone (EUR/NOK), Polish Zloty (EUR/PLN), Swedish Krona (EUR/SEK) and US-Dollar (USD/EUR).[9]

With regard to currency pairs denominated in US-Dollar, we examine Canadian Dollar (USD/CAD), Swiss Franc (USD/CHF), British Pound (USD/GBP)[10], Israeli Shekel (USD/ILS), Indian Rupee (USD/INR), Japanese Yen (USD/JPY), Mexican Peso (USD/MXN), Polish Zloty (USD/PLN), Singapore Dollar (USD/SGD) and South African Rand (USD/ZAR).

For all nineteen currency pairs, we analyze the impact of two interdealer transaction flow variables from the foreign exchange market: market order and limit order flows. The data is obtained from Reuters Dealing 3000 and is the largest FX interdealer dataset so far analyzed in the FX market microstructure literature. The currency pairs covered in this empirical analysis account for approximately 73% of foreign exchange market's global turnover in April 2013 (BIS (2013)). Even though Reuters Dealing 3000 is not the main trading platform for all exchange rate pairs, the dataset provides a broad coverage of trading dynamics in the global foreign exchange market.

For the empirical analysis, we aggregate all market orders for each currency pair to the monthly frequency since relevant macroeconomic information is only available at this level. While we do not possess data about the exact trading volume of each transaction order, we measure market order flow as the number of buy orders minus the number of sell orders. The implicit assumption of this proxy is that all orders are of equal size. As shown by previous research the significant impact of transaction flow data exists, independently if order flow is measured by number of trades or trade size (Rime et al. (2010)).[11] We denote the measure of market order flow in month t as mo_t.

In addition to market order flow, we employ a new microstructure-based measure, which we call limit order flow. In line with Kozhan et al. (2015), it is constructed by subtracting bid from offer order submissions and bid from offer order cancellations at the best price. Then, limit order flow is defined as the daily difference between these net limit orders and net can-

[9]The exchange rate pair USD/EUR is measured as US Dollar per Euro, such that the price is expressed in US Dollar and quantity in Euro.

[10]The exchange rate between British Pound and US-Dollar is traditionally denominated in pound

[11]Market orders are quoted by dealers and are immediately executed at the current market price. Our proxy of order flow is in line with Evans and Lyons (2002), who defined market order flow as the sum of net buyer-initiated and seller-initiated trades.

cellations. This new proxy takes into account that the price discovery process of currencies is not only influenced by the execution of market orders, but that there exist an information transmission effect through the submission and cancellation of limit orders. Importantly, net limit orders explicitly account for submitted and cancelled limit orders because both actions of dealers can affect the price path of currencies. Since our analysis is conducted at the monthly frequency, we aggregate the net limit order measure to a monthly frequency and denote the variable as lbo_t. While our measure captures all actions of dealers at the top of the order book, one shortcoming of our proxy is that it cannot capture quotes that are not submitted or cancelled at the current best price.

The average monthly numbers of market and net limit orders are summarized in Table (1).

[Insert Table (1)]

As displayed, the average number of trades as well as the degree of liquidity vary largely across currency pairs. On the one hand, the large dispersion of trades can be explained by the fact that certain currencies, e.g. EUR/USD, are simply more frequently traded than others, e.g. EUR/CHF. On the other hand, the comparably small number for market orders and limit order for some currency pairs can be explained by the fact that Reuters Dealing 3000 platform is not the main trading venue for all exchange rates. For instance, this is the case for EUR/JPY. While it is the third most frequently traded currency pair in the world by turnover (BIS (2013)), the average number of market orders in our dataset is comparably low. The large variation in number of trades indicates that market orders are also submitted on alternative trading platforms, such as Electronic Brooking System (EBS). However, as argued by Breedon and Vitale (2010), transaction dynamics between the two main trading platforms EBS and Reuters are closely linked. Even though Reuters is not the dominant trading platform for all currency pairs, strong correlations between trading venues ensure that results are representative of the total dynamics in the FX market.

We present the correlation coefficients between order flow variables and the log spot exchange rate in Table (2). Focusing on significant coefficients at the 10% level or higher, the correlation between market order flow and the change in log spot exchange rates are in line with our expectations outlined in the previous section. All significant coefficients, with the exception of USD/MXN, are larger than zero. The positive correlation coefficients resemble buying pressure on the home currency and an appreciation of the exchange rate due to the changing demand for Euro or US-Dollar, respectively. The correlations are significantly different from zero for seventeen out of nineteen currency pairs.

Similarly to market orders, limit orders are positively correlated with changes in the exchange rate, focusing on coefficients significantly different from zero. The positive coefficients indicate that limit orders are used by foreign exchange traders to exploit gains from trade. Further, the positive linkage between the two variables points towards the importance of limit orders on the price discovery process.

In line with our expectations the signal of limit order on the changes in returns is lower in comparison to market order flows. Out of nineteen currency pairs the correlation between limit orders and exchange rate return is only statistically significant for five currency pairs. [12] We conclude that the linear relationship between limit orders and exchange rates is less strong at a monthly level than for market orders. Finally, the correlation between order flow variables is negative which is in line with Kozhan et al. (2015) . For twelve currency pairs the correlation coefficient is statistically significant at 10% or higher.

[Insert Table (2)]

In addition to the foreign exchange microstructure data, we construct a dataset of macroeconomic variables. The main source is *IMF's International Financial Statistics* database accessed via *Datastream*. The price level is measured by monthly consumer price index (CPI) and inflation is constructed by using the 12-month difference of CPI. Since gross domestic product is announced only at the quarterly domain, for the majority of countries we use industrial production index as monthly proxy for output.[13] The output gap is calculated using Hodrick-Prescott filter (Molodtsova and Papell (2009)).[14] As a proxy for the short-term interest rate, we use money market rates.

5 Results

The results from the empirical analysis are discussed following a two-fold strategy. Firstly, we present findings from standard time-series regressions documenting the superior model

[12] This finding contrasts Kozhan et al. (2015), who find significant correlations between market orders, limit orders and the exchange rate across all currency pairs if daily data is used.

[13] For Switzerland retail trade index as proxy for output, since industrial production index is not available at a monthly frequency.

[14] In line with previous studies the HP-parameter is set to 14400 since the data frequency is monthly.

fit of hybrid models. Secondly, we use seemingly unrelated regression (SUR) estimator and allow for cross-equation correlation of the error term within a system of equations. In order to compare models' performance, we calculate adjusted R^2 to evaluate the goodness of fit of each model and, moreover, conduct an in-sample forecasting exercise.

5.1 Results from a new class of hybrid models

Time series regression results for all nineteen exchange rates are presented in Table (3) and (4). The specifications refer to the five models introduced in the previous section, beginning with Evans and Lyons' model (Specification 1) and concluding with the hybrid model, which combines a conventional Taylor rule with the approach by Kozhan et al. (2015) (Specification 5).

[Insert Table (3) and (4)]

Several points in Table (3) and (4) are worth noting. Firstly, market order flows are a significant driver of changes in exchange rates. For Euro-based currency pairs, the coefficient of market order flow is significant at the 10% level or higher for eight out of nine currency pairs. Only for EUR/CHF the market order flow coefficient ($\hat{\gamma}_1$) is not significant at a relevant statistical level. Similarly, in seven out of ten US-Dollar based currency pairs market orders play a significant role.[15] With regard to limit orders, the inference is more ambiguous. In only 9 out of 19 exchange rate pairs, estimates corresponding to limit order flows ($\hat{\gamma}_2$) are significant at the 10% level or higher. For these nine currency pairs, however, the impact of limit orders on the explanatory power can be very prevalent. For instance, in case of the currency pair USD/SGD the goodness of fit measure increases dramatically from 0.09 to 0.37 once limit order flow enters the hybrid model.

As expected *a priori* all significant order flow estimates have a positive sign ($\gamma_1, \gamma_2 > 0$). This finding resembles a higher demand and buying pressure for the home currency, resulting in an increase of the exchange rate. Furthermore, we find that the magnitude of market order flows' coefficient estimates is larger than that of limit orders ($\gamma_1 > \gamma_2$). This finding confirms the argument by Kozhan et al. (2015) that limit orders transmit less information about exchange rate returns than market orders. The only exception to the latter finding appears to be the exchange rate pair USD/SGD, for which the coefficient of limit order flow exceeds that of market orders. Also, coinciding with the findings by Kozhan et al. (2015) the coefficient on market order flow (γ_1) tends to increase when limit orders are considered

[15] For USD/CHF, USD/INR and USD/MXN order flow coefficients are insignificant.

as additional regressor.[16] The change in magnitude is driven by the partial effect of limit orders on the exchange rate and by the fact that market and limit order are correlated with each other.

Secondly, the conventional Taylor rule provides less convincing results than simple market microstructure models. In general, the goodness of fit measure (adjusted R^2) is smaller than that of market microstructure models.[17] Furthermore, in most cases, coefficients of macroeconomic variables are not significant at a relevant statistical level and coefficients' signs often do not coincide with economic theory. For example, for USD/CAD the coefficient of the inflation differential is negative even though we would expect the opposite. These results are indicative for the disconnect between macroeconomic fundamentals and exchange rate dynamics. Our analysis suggests that the explanatory power of models solely using macroeconomic variables is very low (Obstfeld and Rogoff (2000)).

Thirdly, focusing on Specifications (4) and (5) it becomes clear that hybrid models show an improvement of the goodness of fit measure over macroeconomic and finance microstructure models separately. For example, in case of EUR/USD explanatory power of the hybrid model with both order flow components (Specification (5)) accounts for 0.32. The individual model only achieve values of 0.11 and 0.26, respectively. In case of GBP/USD adjusted R^2 increases from 0.14 in the Kozhan et al. (2015) model to 0.23 when its hybrid version is considered. It is worth noting that these findings are not consistent across all exchange rates. For example, for the pair EUR/CZK microstructure approaches reveal a slightly higher R^2 than the hybrid models. One explanation for this result could be the differences in exchange rates regimes and the possibility that currencies are closely pegged to the base currency. Overall, in 14 out of 19 exchange rate pairs, hybrid models perform at least as good as the microstructure model on its own and nearly in all cases, the performance is superior to the conventional Taylor rule. In rare cases, in which hybrid models perform worse than market microstructure models, the difference between adjusted R^2 is marginal.

While adjusted R^2 already indicates the superior performance of hybrid models, we conduct an in-sample forecasting exercise in order to obtain an additional measure for comparison. We calculate the mean square error (MSE) for each of the models and use the conventional Taylor rule as base line specification. The relative measures of the four models for all currency pairs are displayed in Table (5). Since the MSE of the conventional Taylor

[16] In 17 out of 19 exchange rate pairs, this finding is confirmed at a monthly frequency. Exceptions are EUR/USD, EUR/SEK.

[17] An exception to this is the USD/CHF and EUR/CHF currency pairs.

rule is set equal 1, any value lower than 1 means the model outperforms the macroeconomic Taylor rule. The closer the value to zero, the better is the model's fit to the data. As shown in Table (5) the hybrid Taylor rule with both order flow specifications (denoted as Hybrid (2)) produces always the best model fit, as indicated by the bold relative mean square errors

[Insert Table (5)]

5.2 Cross-country dependence in currency markets: SUR analysis

The large dimension of our dataset allows for an additional analysis, examining the impact of cross-country interdependences on exchange rates. In addition to individual time-series, therefore, we conduct seemingly unrelated regression (SUR) analysis in two sets of equations with EUR and USD as base currency, respectively (**??**). From an economic point of view, there are various justifications for estimating exchange rates in a system of equations as opposed to individual time series regressions. For example, it is reasonable to assume that changes in one exchange rate are likely to affect the value of other currency pairs, which share the same base currency. If exchange rates are analyzed individually, interdependences across currencies are not taken into account, affecting the efficiency of obtained coefficient estimates.

To begin with interdependences across currency prices can be highlighted by certain data patterns. The most obvious indicator is the correlation coefficients between residuals from individual time-series regressions. In Table (6) and (7) we display residual correlation coefficients of the hybrid Taylor, which accounts for market and limit order flows (Specification (5)). As shown, the correlation reaches substantial magnitudes of 0.51 in case of Euro and 0.60 in case of US-Dollar exchange rates. This cross-country interdependence is not taken into account by standard time series regressions and motivates to re-estimate the hybrid model in a simultaneous set of equations.

[Insert Table (6) and (7)]

For the SUR estimation, we set up two systems of seemingly unrelated regressions for Euro and US-dollar based currencies, respectively. Each system is of the form

$$\boldsymbol{S_t} = \boldsymbol{B}\boldsymbol{X}_t + \boldsymbol{U}_t \tag{16}$$

where $\boldsymbol{S}_t$ is a $k \times 1$ vector containing the dependent variable spot exchange rate (Δs_t^j) as dependent variable. For example, for EUR currency pairs, let j = *US, CHF, CZK, GBP,* *HUF, JPY, NOK, PLN, SEK*, then $\boldsymbol{S}_t = (\Delta s_t^{US}, ..., \Delta s_t^{SEK})$, $\boldsymbol{B}$ is a matrix of coefficients and $\boldsymbol{X}_t$ contains the explanatory variables for each of the five models.

The results for all five models are displayed in Table (8) and (9). Again, specifications (1) to (5) refer to the Evans and Lyons (2002) model, Kozhan et al. (2015), conventional macroeconomic Taylor rule, Hybrid model I and Hybrid model II, respectively.

[Table (8) and Table (9)]

Similarly to individual country time-series regression, the role of order flow on changes in exchange rates is prominent. In eight out of nine Euro and seven out of nine US-dollar pairs, market order flow is a significant driver of exchange rate returns. Also similar, limit orders are significant at the ten percent level or higher in six out of the eighteen currency pairs. Again these findings emphasize the important - albeit subordinate - role of limit orders in the foreign exchange market.

Furthermore, in comparison to the individual country regression the change in standard errors is worth noting. By taking into account cross-equation correlation residuals' standard errors of coefficient estimates decrease, leading to more efficient regression outcomes. The improvement in the estimates precision is quite significant, as can be seen by the coefficients' high t-statistics. Improvements in the magnitude of standard errors can be observed across nearly all currency pairs.

The significant interdependences across countries can further be presented by assessing the variance-covariance matrices of the two systems of equations. If there were no cross-country correlations, the off-diagonal entries of these matrices would be zero. In this case SUR estimation leads to identical results than ordinary least square. We test the diagonality condition by calculating the Breusch and Pagan (1980) test statistic.[18] Under the null hypothesis of diagonality, the test statistic follows a $\chi^2_{M(M-1)/2}$ distribution, with $M = 9$ denoting the number of equations in each system. The 5% critical value is $\chi^2_{45} = 61.656$.

[Insert Table(10)]

As clearly displayed in Table (10), the high values of the Breusch-Pagan test suggest the rejection of the null hypothesis, consistently across all five models, at the 1% level. The

[18] The test statistic is calculated by $\lambda_{LM} = T \sum_{i=2}^{M} \sum_{j=1}^{i-1} r_{ij}^2$ where M refers to the number of equations and i and j are the number of rows and columns, respectively. Further r_{ij}^2 is the sample correlation coefficients, which is calculated based on the sample standard covariances, such that $r_{ij}^2 = \frac{s_{ij}}{\sqrt{s_{ii} s_{jj}}}$.

test highlights the significant cross-country correlations in our exchange rate analysis and underlines the importance of conducting exchange rate analysis in a system of equations.

Furthermore, we calculate the system-wide goodness of fit measure for seemingly unrelated regressions introduced by McElroy (1977) and, analogously to standard regression analysis, we construct an ad-hoc adjusted system-wide measure, which takes into account the overall number of parameters employed in the system.[19] The results for all five models and both systems of equations are displayed in Table (11).

[Insert Table (11)]

For EUR-based currency pairs, adjusted system-wide $\bar{R}^2_{SUR}$ shows the highest value for the hybrid models (0.09) that incorporates both order flow variables within the framework of a conventional Taylor rule. In comparison, the conventional Taylor rule, solely based on macroeconomic variables, achieves an adjusted system-wide $\bar{R}^2_{SUR}$ of 0.00. Similarly for US-Dollar denominated exchange rates, we find the best model fit is achieved by the hybrid model which accounts for both order flow variables. The $\bar{R}^2_{SUR}$ rises to 0.101, outperforming all other models.

Lastly and in similar fashion to individual time-series regressions, we conduct an in-sample forecasting exercise estimating all five models and calculate the relative mean square error for each of the models. The results are shown in Table (12). Again, the mean square error of the conventional Taylor rule serves as benchmark model. Values lower than unity, therefore, indicate a comparably better model finds. Similar to the time series regression, the two hybrid models, outperform the conventional macroeconomic and market microstructure models.

[Insert Table(12)]

Overall, seemingly unrelated regression analysis supports our approach that hybrid models combining streams from the finance microstructure and macroeconomic literature results in a superior model fit and forecasting performance. Moreover, the analysis underlines the significant impact of cross-country correlations across exchange rates in the foreign exchange market. The significant country interdependences among currency pairs affects the estimates'

[19] The system-wide measure for the goodness of fit, is calculated by $R^2_{SUR} = 1 - \frac{M}{tr(\Sigma^{-1}S_{yy})}$ where M denotes the number of equations, Σ is a variance-covariance matrix and S_{yy} is the mean deviation cross product matrix. The ad-hoc measure which accounts for the number of parameters is given by $\bar{R}^2_{SUR} = 1 - \frac{(1-R^2_{SUR})(N-1)}{N-p-1}$ where N denotes the total sample size, p the number of explanatory variables across M equations and R^2_{SUR} refers to the original system-wide measure of fit.

coefficients, the goodness of fit measure and parameters' standard deviation. Last but not least, we have presented additional evidence that hybrid and market microstructure models outperform the conventional macroeconomic Taylor rule.

6 Alternative Macroeconomic Factors and Robustness Checks

In line with Clarida et al. (1998), this section discusses alternative macroeconomic factors which could be driving exchange rate changes but are not included in the conventional macroeconomic Taylor rule. For example, similar to the classical money-income model, we take into account different measures of money supply and monetary aggregates and control for their impact on currency prices. Given the sample period of our empirical analysis, alternative impact factors are of particular interest since interest rates are deliberately kept at low levels and central banks may not only take into account variables present in a conventional Taylor rule. Since interest rates are kept close to zero in a various countries or are not characterized by a large degree of variations, this analysis assesses if other monetary policy instruments or macroeconomic variables have an impact on the exchange rate. In order to take these possibilities into account, we construct two augmented macroeconomic Taylor rule specifications. Firstly, the change in the exchange rate is given by

$$s_t - s_{t-1} = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y_{t-1} - \hat{y}_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \delta_1\beta_5(m_{t-1} - \hat{m}_{t-1}) + u_t \tag{17}$$

where $(m_{t-1} - \hat{m}_{t-1})$ denotes the difference in the growth rate of money between home and foreign country. Money supply is measured by M2 and depending on data availability we use M3. Secondly, the augmented Taylor rule is formulated as

$$s_t - s_{t-1} = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y_{t-1} - \hat{y}_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \delta_1\beta_5(mb_{t-1} - \hat{mb}_{t-1}) + u_t \tag{18}$$

where mb_{t-1} and $\hat{mb}_{t-1}$ denote the log of the monetary aggregate for home and foreign country, respectively.

Tables (13) and (14) show the results if the Taylor rule is augmented by measures of the monetary base, while (15) and (16) refer to the case when monetary aggregates are used. To preserve space, we focus only on the conventional Taylor rule specification and both hybrid models.

[Insert Table (13) and (14)]

[Insert Table (15) and (16)]

Overall our findings are consistent across different model specifications. While the model fit improves slightly for some exchange rate when a measure of money is included, hybrid models continue to outperform pure macroeconomic approaches. These findings underline the importance to include variables of interdealer knowledge in a conventional Taylor rule.

As a last step, we conduct several robustness checks in order to confirm the stability of the results. Firstly, we divide the sample in two sub-samples: January 2004 - January 2009 and February 2009 to February 2014. Since both periods contain only about 60 observations, however, results should be considered with caution. Tables (17) and (18) show the adjusted $\bar{R}^2$ for all five models. In general, it appears that both hybrid models as well as the market microstructure model by Kozhan *et al.* provide the best model fit, revealing the highest adjusted R^2. The conventional Taylor rule performs comparably poorly across both sub-sample periods and across currencies.

[Insert Table (17) and (18)]

Secondly, we use quarterly observations to control if the results are stable at a lower frequency.[20] The results are shown in Table (19), which summarizes adjusted $\bar{R}^2$ measures for all currencies and across models. Overall, hybrid model continue to outperform other model specifications. It is worth noting, that for Euro pairs, the hybrid model with only market order flow presents the highest goodness of fit measures while the hybrid model with both order flow components shows higher R^2-values for currency pairs with the US-Dollar as base currency. Similarly to the sub-sample analysis, the results may suffer from small sample properties since only 40 observations are at hand.

[Insert Table (19)]

Lastly, we relax the assumption of a symmetric Taylor rule in Equation (8) and allow for heterogeneous Taylor rule coefficients across countries (Molodtsova and Papell (2009)). In this case, Equation (10) can be re-formulated as

$$s_t - s_{t-1} = \alpha + \beta_{1,H}\pi_{t-1} + \beta_{1,F}\hat{\pi}_{t-1} + \beta_{2,H}y_{t-1} + \beta_{2,F}\hat{y}_{t-1} + \beta_{3,H}i_{t-2} + \beta_{3,F}\hat{i}_{t-2} + \beta_4 q_{t-1} + u_t \quad (19)$$

[20]Quarterly observations are constructed by taking the average over 3-month period

where the subscripts H, F denote parameters for home and foreign country, respectively. The results in form of $\bar{R}^2$ are summarized in Table (20) and resemble earlier findings.

[Insert Table (20)]

Last but not least, results are robust to the choice of measurement of inflation and output gap. For example, constructing inflation based on the wholesale price index and output gap from countries' sales index instead of industrial production does not change the results. The hybrid model continues to explain changes in exchange rate most accurately and provides the best fit to the data.[21]

7 Conclusion

This paper incorporates market microstructure variables within the framework of a conventional Taylor rule model in order to explain exchange rate dynamics. The findings are based on the largest FX interdealer order flow dataset, covering nineteen Euro and US-dollar based currency pairs for more than ten years. The results can be summarized as follows.

Firstly, we find that a hybrid Taylor rule specifications - combining market microstructure variables within a conventional macroeconomic framework - have a better model fit than its individual components. We document a higher goodness-of-fit measure and superior in-sample predictive power of hybrid models. These results hold in standard time-series models as well as in our seemingly unrelated regression analysis. They are also robust to alternative Taylor rule specifications and varies robustness checks.

Secondly, we show that a new microstructure measure, which is purely based on limit order flow, transmits information about changes in the exchange rate even at a monthly frequency. Compared to market order flows, however, limit orders play a subordinate role. Only for 8 out nineteen currencies, limit order flows are a significant driver of exchange rate returns.

Thirdly, we use seemingly unrelated regression analysis in order to highlight the importance of cross-country dependences in the exchange rates analysis. Taking into account the significant correlation across exchange rates sharing the same base currency, we obtain more efficient estimates and provide additional evidence in favor of hybrid models.

[21] Results based on different macroeconomic measures are unreported to preserve space but are available on request.

Overall, our broad empirical evidence highlights the advantages from combining market microstructure approaches with conventional macroeconomic models. We suggest future research may further focus on hybrid models in order to uncover yet unexplored gains in the exchange rate literature and possibly other areas in international finance.

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8 Appendix

Table 1: Monthly Average Number of Trades

Table displays average number of trades for market order flows (*mo*) and net limit order flows (*lbo*). The sample period is January 2004 to February 2014 (122 observations).

	mo	*lbo*		*mo*	*lbo*
EUR/USD	29,829	359,106	USD/CAD	145,386	171,365
EUR/CHF	426	59,440	USD/CHF	338	130,375
EUR/CZK	6,860	22,242	GBP/USD	189,749	322,253
EUR/GBP	92,423	356,597	USD/ILS	4,435	18,474
EUR/HUF	11,516	34,150	USD/INR	31,810	47,412
EUR/JPY	265	200,627	USD/JPY	3,231	180,895
EUR/NOK	26,952	101,711	USD/MXN	68,469	201,141
EUR/PLN	19,288	65,861	USD/PLN	926	124,702
EUR/SEK	29,735	100,374	USD/SGD	30,459	52,775
			USD/ZAR	32,028	127,122

Table 2: Correlation: Returns and Order Flows

Table displays correlation coefficients between market order (Δmo) and limit order flows (Δlbo) and with the change in the log spot exchange rate (Δs_t). Sample period is January 2004 to February 2014 (122 observations). *, **,*** denote the 10%, 5% and 1% level of significance, respectively.

Euro exchange rates										
	EUR/USD		EUR/CHF		EUR/CZK		EUR/GBP			
	Δs_t	Δmo	Δs_t	Δmo	Δs_t	Δmo	Δs_t	Δmo		
Δmo	0.47***		0.05		0.36***		0.37***			
Δlbo	0.24***	0.03	-0.003	-0.32***	0.25***	-0.05	-0.06	-0.45***		
	EUR/HUF		EUR/JPY		EUR/NOK		EUR/PLN		EUR/SEK	
	Δs_t	Δmo	Δs_t	Δmo	Δs_t	Δmo	Δs_t	Δmo	Δs_t	Δmo
Δmo	0.31***		0.10***		0.42***		0.37***		0.28***	
Δlbo	-0.02	-0.21**	0.20**	-0.02	0.02	-0.03	-0.05	-0.28***	-0.06	-0.02
US-Dollar exchange rates										
	USD/CAD		USD/CHF		GBP/USD		USD/ISL		USD/INR	
	Δs_t	Δmo	Δs_t	Δmo	Δs_t	Δmo	Δs_t	Δmo	Δs_t	Δmo
Δmo	0.58***		0.02		0.30***		0.33***		0.16*	
Δlbo	-0.10	-0.47***	0.08	-0.16*	0.06	-0.52***	-0.03	-0.31***	-0.14	-0.86***
	USD/JPY		USD/MXN		USD/PLN		USD/SGD		USD/ZAR	
	Δs_t	Δmo	Δs_t	Δmo	Δs_t	Δmo	Δs_t	Δmo	Δs_t	Δmo
Δmo	0.25***		-0.17*		0.29***		0.33***		0.41***	
Δlbo	0.30***	-0.24**	0.13	-0.33***	0.04	-0.05	0.31***	-0.50***	0.09	-0.12

Table 3: Model Comparison: Euro Pairs

Estimates are obtained using ordinary least square estimator, testing the following five model specifications **(1)** Evans & Lyons (2002) portfolio shift model:$\Delta s_t = \gamma_0 + \gamma_1 mo_t + u_t$, **(2)** Kozhan, Moore & Payne (2015) model: $\Delta s_t = \gamma_0 + \gamma_1 mo_t + \gamma_2 lbo_t + u_t$, **(3)** Conventional Taylor rule: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + u_t$, **(4)** Taylor rule incl. market order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \gamma_1 mo_t + u_t$ and **(5)** Taylor rule incl. FX order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \gamma_1 mo_t + \gamma_2 lbo_t + u_t$. Numbers in parentheses present respective HAC-adjusted t-statistics. Estimates of intercept terms are not reported to preserve space. ***, ** and * refer to level of statistical significance of 1%, 5% and 10%, respectively. Sample period is January 2004 to February 2014 (122 observations).

	Spec	$\pi_{t-1} - \pi^*_{t-1}$	$y^G_{t-1} - y^{G^*}_{t-1}$	$i_{t-2} - i^*_{t-2}$	q_{t-1}	mo_t	lbo_t	R^2
EUR/USD	(1)					177.85***		0.22
						(6.80)		
	(2)					174.90***	76.69***	0.26
						(7.65)	(4.53)	
	(3)	122.30***	-259.72	-74.53***				0.11
		(4.19)	(-0.17)	(-3.69)				
	(4)	109.76***	-690.97	-28.75		171.42***		0.29
		(3.08)	(-0.45)	(-0.90)		(5.14)		
	(5)	101.09***	-690.44	-25.12		170.13***	66.77***	0.32
		(2.81)	(-0.48)	(-0.78)		(5.44)	(3.32)	
EUR/CHF	(1)					153.03		-0.01
						(0.47)		
	(2)					167.08	7.95	-0.01
						(0.48)	(0.32)	
	(3)	14.92	-42.11	10.48	-274.59			-0.02
		(0.70)	(-0.28)	(0.47)	(-0.89)			
	(4)	9.96	-27.26	13.72	-325.52	211.63		-0.03
		(0.40)	(-0.17)	(0.51)	(-1.10)	(0.48)		
	(5)	11.62	-27.07	14.81	-317.20	230.23	12.99	-0.03
		(0.46)	(-0.17)	(0.52)	(-1.05)	(0.49)	(0.44)	
EUR/CZK	(1)					243.61***		0.12
						(4.37)		
	(2)					251.41***	90.22***	0.19
						(4.70)	(3.41)	
	(3)	9.55	-114.15	-11.70	126.62			-0.03
		(0.37)	(-0.47)	(-0.51)	(0.44)			
	(4)	19.07	-220.58	-6.52	-182.71	274.99***		0.12
		(0.90)	(-1.07)	(-0.31)	(-0.69)	(4.78)		
	(5)	12.17	-246.03	-6.66	-168.29	275.20***	84.32***	0.17
		(0.55)	(-1.28)	(-0.31)	(-0.63)	(4.54)	(3.21)	
EUR/GBP	(1)					55.26***		0.13
						(8.02)		
	(2)					64.61***	31.23**	0.14
						(7.29)	(2.36)	
	(3)	-21.52	720.76*	-33.39	-229.11			-0.01
		(-0.39)	(1.90)	(-0.77)	(-0.54)			
	(4)	-15.14	542.94	20.96	-468.41	62.49***		0.13
		(-0.28)	(1.61)	(0.47)	(-1.09)	(6.32)		
	(5)	-12.56	455.42	14.92	-482.70	67.50***	23.45	0.13
		(-0.23)	(1.39)	(0.34)	(-1.10)	(6.64)	(1.58)	
EUR/HUF	(1)					182.21***		0.09
						(3.54)		
	(2)					190.27***	29.08	0.09
						(3.90)	(0.67)	
	(3)	23.70*	333.55	0.41	305.27			0.00
		(1.75)	(0.95)	(0.02)	(0.57)			

	(4)	15.54	281.70	-0.25	23.68	167.37***		0.07
		(1.09)	(0.86)	(-0.01)	(0.05)	(3.13)		
	(5)	14.63	286.88	-0.19	54.07	173.16***	21.25	0.07
		(1.00)	(0.88)	(-0.01)	(0.12)	(3.42)	(0.52)	
EUR/JPY	(1)					2680.77***		0.15
						(5.90)		
	(2)					2703.54***	116.34**	0.19
						(5.43)	(1.96)	
	(3)	-20.93	736.89	-21.74	-1371.92			0.05
		(-0.61)	(1.40)	(-0.66)	(-2.27)			
	(4)	-70.97**	706.04	16.66	-1139.15**	2838.30***		0.19
		(-2.13)	(1.37)	(0.67)	(-2.11)	(5.74)		
	(5)	-64.87*	564.73	-5.69	-1066.89	2683.00***	111.36*	0.22
		(-1.92)	(1.08)	(-0.23)	(-1.72)	(4.94)	(1.95)	
EUR/NOK	(1)					146.81***		0.17
						(5.24)		
	(2)					146.99***	1.61	0.16
						(5.21)	(0.34)	
	(3)	-21.13	628.40**	-64.04	-308.11			0.03
		(-1.16)	(2.51)	(-1.60)	(-0.93)			
	(4)	-21.86	435.06	-7.93	-508.60	147.38***		0.19
		(-1.42)	(2.12)	(-0.18)	(-1.56)	(4.80)		
	(5)	-22.87	461.78**	-9.38	-516.89	147.43***	5.44	0.18
		(-1.44)	(2.19)	(-0.22)	(-1.56)	(4.77)	(1.14)	
EUR/PLN	(1)					123.82***		0.13
						(3.84)		
	(2)					129.55***	16.76	0.12
						(4.37)	(0.74)	
	(3)	11.59	1111.71**	-5.03	297.57			0.02
		(0.50)	(2.45)	(-0.26)	(0.51)			
	(4)	-25.93	1043.15***	38.38	-374.53	145.95***		0.16
		(-0.87)	(2.61)	(1.29)	(-0.60)	(3.21)		
	(5)	-25.18	1057.53***	38.11	-378.54	151.59***	17.76	0.16
		(-0.82)	(2.63)	(1.26)	(-0.60)	(3.52)	(0.82)	
EUR/SEK	(1)					101.61***		0.07
						(2.92)		
	(2)					101.30***	-3.96	0.06
						(2.90)	(-0.75)	
	(3)	-23.82	86.33	-12.75	-48.89			-0.02
		(-0.62)	(0.67)	(-0.60)	(-0.12)			
	(4)	-36.16	113.25	4.43	-38.00	117.83***		0.07
		(-0.92)	(0.97)	(0.21)	(-0.09)	(3.25)		
	(5)	-35.00	112.95	4.72	-20.67	117.46***	-3.31	0.06
		(-0.87)	(0.96)	(0.22)	(-0.05)	(3.22)	(-0.62)	

Table 4: Model Comparison: US-Dollar Pairs

Estimates are obtained using ordinary least square estimator, testing the following five model specifications **(1)** Evans & Lyons (2002) portfolio shift model:$\Delta s_t = \gamma_0 + \gamma_1 mo_t + u_t$, **(2)** Kozhan, Moore & Payne (2015) model: $\Delta s_t = \gamma_0 + \gamma_1 mo_t + \gamma_2 lbo_t + u_t$, **(3)** Conventional Taylor rule: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + u_t$, **(4)** Taylor rule incl. market order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \gamma_1 mo_t + u_t$ and **(5)** Taylor rule incl. FX order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \gamma_1 mo_t + \gamma_2 lbo_t + u_t$. Numbers in parentheses present respective HAC-adjusted t-statistics. Estimates of intercept terms are not reported to preserve space. ***, ** and * refer to level of statistical significance of 1%, 5% and 10%, respectively. Sample period is January 2004 to February 2014 (122 observations).

	Spec	$\pi_{t-1} - \pi^*_{t-1}$	$y^G_{t-1} - y^{G^*}_{t-1}$	$i_{t-2} - i^*_{t-2}$	q_{t-1}	mo_t	lbo_t	R^2
USD/CAD	(1)					91.83***		0.34
						(6.74)		
	(2)					108.51***	90.82*	0.37
						(10.93)	(1.79)	
	(3)	88.24***	-527.44	-66.83*	-565.16***			0.09
		(2.98)	(-0.73)	(-1.94)	(-2.99)			
	(4)	23.64	-242.06	-74.18**	-610.09 ***	93.18***		0.41
		(0.75)	(-0.38)	(-2.11)	(-2.70)	(8.19)		
	(5)	26.20	-290.35	-74.54**	-470.37	103.32 ***	59.06	0.42
		(0.84)	(-0.44)	(-2.31)	(-1.54)	(12.80)	(1.02)	
USD/CHF	(1)					79.02		-0.01
						(0.51)		
	(2)					126.01	66.51	-0.01
						(0.74)	(0.63)	
	(3)	91.99***	-357.91	-32.23	256.74			0.04
		(3.71)	(-1.03)	(-1.58)	(0.87)			
	(4)	91.87***	-364.84	-37.63*	267.14	168.29		0.04
		(3.70)	(-1.05)	(-1.65)	(0.88)	(0.90)		
	(5)	88.52***	-348.56	-40.08*	285.17	209.16	39.98	0.03
		(3.27)	(-1.02)	(-1.72)	(0.94)	(1.05)	(0.42)	
GBP/USD	(1)					41.81 ***		0.08
						(3.08)		
	(2)					63.72***	73.34***	0.14
						(4.51)	(4.01)	
	(3)	-0.18	393.31	-99.27**	657.02**			0.11
		(-0.01)	(0.77)	(-2.53)	(2.39)			
	(4)	10.59	513.32	-97.08**	309.75	50.50***		0.21
		(0.52)	(1.03)	(-1.96)	(0.92)	(3.08)		
	(5)	2.33	395.38	-92.15**	329.19	61.70***	48.39**	0.23
		(0.11)	(0.81)	(-1.97)	(1.05)	(4.01)	(2.50)	
USD/ILS	(1)					397.16***		0.10
						(3.01)		
	(2)					427.17***	36.19	0.10
						(3.02)	(0.91)	
	(3)	9.87	14.55	-45.96**	-84.41			0.01
		(0.74)	(0.05)	(-2.31)	(-0.32)			
	(4)	11.86	-42.91	-47.51***	-117.52	407.63***		0.12
		(0.93)	(-0.13)	(-2.83)	(-0.47)	(3.06)		
	(5)	11.33	-51.15	-46.12***	-96.02	427.70***	24.62	0.11
		(0.88)	(-0.16)	(-2.74)	(-0.38)	(3.08)	(0.68)	
USD/INR	(1)					21.46		0.02
						(0.92)		
	(2)					18.57	-7.20	0.01
						(0.41)	(-0.10)	
	(3)	9.87*	554.77	-19.40*	-339.98			0.06
		(1.87)	(0.97)	(-1.82)	(-1.50)			

	(4)	8.08	600.91	-16.44	-325.61	11.99		0.06
		(1.18)	(1.00)	(-1.36)	(-1.41)	(0.50)		
	(5)	7.91	580.67	-18.82	-366.97	29.40	45.76	0.05
		(1.19)	(1.01)	(-1.63)	(-1.56)	(0.65)	(0.56)	
USD/JPY	(1)					220.36**		0.06
						(2.25)		
	(2)					300.60***	223.94***	0.19
						(3.35)	(4.86)	
	(3)	17.42	851.24*	-8.20	-6.33			0.01
		(0.78)	(1.64)	(-0.63)	(-0.03)			
	(4)	15.81	858.37*	-7.24	64.48	220.99		0.07
		(0.68)	(1.71)	(-0.57)	(0.27)	(2.20)		
	(5)	22.70	878.62	-16.82	-14.43	299.51***	236.22***	0.22
		(1.43)	(1.81)	(-1.16)	(-0.07)	(3.47)	(5.42)	
USD/MXN	(1)					-46.37*		0.02
						(-1.65)		
	(2)					-38.93	15.02	0.02
						(-1.44)	(0.82)	
	(3)	25.86*	-1978.36**	-28.24	-309.07			0.02
		(1.65)	(-2.08)	(-0.91)	(-1.13)			
	(4)	26.29*	-1883.49*	-17.30	-199.67	-41.19		0.03
		(1.76)	(-1.95)	(-0.54)	(-0.82)	(-1.53)		
	(5)	26.50*	-1863.33*	-15.41	-128.26	-36.04	12.96	0.02
		(1.80)	(-1.89)	(-0.50)	(-0.52)	(-1.33)	(0.75)	
USD/PLN	(1)					1460.28***		0.08
						(2.62)		
	(2)					1470.25***	36.41	0.07
						(2.63)	(0.49)	
	(3)	51.76***	1194.05*	-64.90***	-548.28			0.06
		(2.69)	(1.69)	(-2.43)	(-1.51)			
	(4)	40.84*	1352.17*	-44.53	-688.17*	1373.33***		0.12
		(2.12)	(1.90)	(-1.55)	(-1.77)	(3.50)		
	(5)	40.76**	1329.39*	-44.15	-688.52	1379.27***	14.63	0.12
		(2.11)	(1.83)	(-1.53)	(-1.76)	(3.48)	(0.22)	
USD/SGD	(1)					81.68***		0.10
						(3.30)		
	(2)					157.95***	221.28***	0.39
						(6.50)	(5.50)	
	(3)	8.84	-354.11	-18.40	-168.64			-0.02
		(1.01)	(-0.77)	(-1.26)	(-0.99)			
	(4)	7.63	-402.86	-13.41	95.77	91.60		0.09
		(0.84)	(-0.98)	(-0.77)	(0.56)	(3.40)		
	(5)	-2.32	-35.53	-8.82	69.85	159.85***	221.39***	0.37
		(-0.34)	(-0.11)	(-0.77)	(0.44)	(6.30)	(5.17)	
USD/ZAR	(1)					210.59***		0.16
						(4.61)		
	(2)					219.15***	27.29**	0.18
						(5.06)	(2.19)	
	(3)	24.73	891.44	-7.89	-1146.96***			0.02
		(1.48)	(0.41)	(-0.29)	(-2.81)			
	(4)	8.17	2041.44	46.13*	708.83	288.63***		0.19
		(0.45)	(1.04)	(1.90)	(1.18)	(3.87)		
	(5)	9.59	1932.61	41.88*	697.18	294.24***	23.79*	0.20
		(0.52)	(0.98)	(1.64)	(1.14)	(4.15)	(1.71)	

Table 5: In-Sample Prediction: Comparison of Mean Square Errors

Table shows the mean square errors (MSE) of market microstructure and hybrid models, relative to a conventional Taylor from a one-horizon in-sample prediction. A MSE lower than unity indicates a better model fit than the conventional Taylor rule. The closer the MSE to zero, the better the overall model fit. For each currency pair the lowest value is marked as bold. Hybrid (1) refers to a hybrid Taylor rule model, including market order flows. Hybrid (2) refers to a hybrid Taylor rule model, which includes market order as well as limit order flows as additional regressors. Sample period is January 2004 to February 2014.

	Euro Pairs					US-Dollar Pairs			
	Evans & Lyons	Kozhan et al	Hybrid (1)	Hybrid (2)		Evans & Lyons	Kozhan et al	Hybrid (1)	Hybrid (2)
EUR/USD	0.83	0.83	0.79	**0.74**	USD/CAD	0.70	0.67	0.64	**0.63**
EUR/CHF	1.01	0.998	0.996	**0.995**	USD/CHF	1.07	1.07	1.00	**0.99**
EUR/CZK	0.81	0.80	0.85	**0.79**	GBP/USD	0.99	0.99	0.88	**0.85**
EUR/GBP	0.87	0.86	0.86	**0.85**	USD/ILS	0.93	0.93	0.882	**0.879**
EUR/HUF	0.93	0.93	0.92	**0.918**	USD/INR	1.07	1.04	0.99	**0.986**
EUR/JPY	0.87	0.84	0.84	**0.81**	USD/JPY	0.83	0.83	0.93	**0.78**
EUR/NOK	0.88	0.87	0.83	**0.828**	USD/MXN	1.01	1.01	0.98	**0.97**
EUR/PLN	0.90	0.90	0.85	**0.84**	USD/PLN	1.01	0.98	0.924	**0.9240**
EUR/SEK	0.93	0.93	0.91	**0.90**	USD/SGD	0.61	0.61	0.88	**0.608**
					USD/ZAR	0.86	0.86	0.82	**0.80**

Table 6: Residual Correlation of Euro currency pairs

Table displays cross-equation correlation of residuals obtained from a Hybrid model, which includes market and limit order flows. Sample period is January 2004 to February 2014.

	EUR/USD	EUR/CHF	EUR/CZK	EUR/GBP	EUR/HUF	EUR/JPY	EUR/NOK	EUR/PLN	EUR/SEK
EUR/USD	1.00								
EUR/CHF	0.12	1.00							
EUR/CZK	-0.09	0.05	1.00						
EUR/GBP	0.51	0.07	0.08	1.00					
EUR/HUF	-0.28	-0.12	0.27	-0.13	1.00				
EUR/JPY	0.47	0.41	-0.08	0.32	-0.20	1.00			
EUR/NOK	0.23	0.06	0.01	0.38	-0.10	0.05	1.00		
EUR/PLN	-0.15	0.08	0.44	0.08	0.47	-0.12	0.18	1.00	
EUR/SEK	0.02	0.08	0.23	0.31	-0.02	0.07	0.43	0.35	1.00

Table 7: Residual Correlation of US Dollar currency pairs

Table displays cross-equation correlation of residuals obtained from a Hybrid model, which includes market and limit order flows. Sample period is January 2004 to February 2014.

	USD/CAD	USD/CHF	GBP/USD	USD/ILS	USD/INR	USD/JPY	USD/MXN	USD/PLN	USD/SGD	USD/ZAR
USD/CAD	1.00									
USD/CHF	0.29	1.00								
GBP/USD	-0.44	-0.48	1.00							
USD/ILS	0.39	0.56	-0.38	1.00						
USD/INR	0.37	0.43	-0.30	0.35	1.00					
USD/JPY	0.08	0.23	-0.06	0.07	0.09	1.00				
USD/MXN	0.43	0.43	-0.53	0.42	0.58	-0.20	1.00			
USD/PLN	0.45	0.60	-0.59	0.48	0.47	-0.01	0.68	1.00		
USD/SGD	0.29	0.52	-0.28	0.34	0.33	0.07	0.44	0.49	1.00	
USD/ZAR	0.40	0.38	-0.41	0.33	0.37	0.03	0.47	0.50	0.45	1.00

Table 8: SUR - Model Comparison: Euro pairs

Estimation is conducted for five different systems of seemingly unrelated regressions. The individual systems include the following model specifications **(1)** Evans & Lyons (2002) portfolio shift model:$\Delta s_t = \gamma_0 + \gamma_1 mo_t + u_t$, **(2)** Kozhan, Moore & Payne (2015) model: $\Delta s_t = \gamma_0 + \gamma_1 mo_t + \gamma_2 lbo_t + u_t$, **(3)** Conventional Taylor rule: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + u_t$, **(4)** Taylor rule incl. market order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \gamma_1 mo_t + u_t$ and **(5)** Taylor rule incl. FX order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \gamma_1 mo_t + \gamma_2 lbo_t + u_t$.Numbers in parentheses present respective t-statistics. Estimates of intercept terms are not reported to preserve space. ***, ** and * refer to level of statistical significance of 1%, 5% and 10%, respectively. Sample period is January 2004 to February 2014 (120 observations). Number of equations per system: M=9.

	Spec	$\pi_{t-1} - \hat{\pi}_{t-1}$	$y^G_{t-1} - \hat{y}^G_{t-1}$	$i_{t-2} - \hat{i}_{t-2}$	q_{t-1}	mo_t	lbo_t	R^2
EUR/USD	(1)					112.41***		0.19
						(5.90)		
	(2)					119.60***	44.26***	0.23
						(6.26)	(2.63)	
	(3)	81.80***	-88.71	-39.98**				0.09
		(3.74)	(-0.09)	(-2.42)				
	(4)	77.69***	-546.87	-37.65**		102.84***		0.25
		(3.64)	(-0.60)	(-2.25)		(4.98)		
	(5)	73.25***	-646.08	-31.52*		111.81***	36.57**	0.28
		(3.37)	(-0.70)	(-1.86)		(5.39)	(2.14)	
EUR/CHF	(1)					212.81		-0.01
						(0.93)		
	(2)					211.85	-9.33	-0.02
						(0.87)	(-0.21)	
	(3)	9.54	-109.45	11.39	-194.32			-0.02
		(0.46)	(-0.67)	(0.49)	(-1.09)			
	(4)	0.91	-45.61	15.65	-312.34	269.97		-0.03
		(0.04)	(-0.28)	(0.67)	(-1.09)	(1.06)		
	(5)	-1.28	-64.29	18.08	-309.52	318.85	2.43	-0.04
		(-0.06)	(-0.40)	(0.76)	(-1.08)	(1.21)	(0.05)	
EUR/CZK	(1)					157.78***		0.11
						(3.10)		
	(2)					163.90***	89.87***	0.17
						(3.38)	(3.72)	
	(3)	14.20	-390.98	-9.11	25.97			-0.04
		(1.13)	(-1.71)	(-0.47)	(-0.27)			
	(4)	22.19*	-404.20*	-13.41	-73.78	173.74***		0.09
		(1.74)	(-1.79)	(-0.71)	(-0.27)	(3.32)		
	(5)	14.54	-442.05**	-13.83	-76.21	174.36***	83.75***	0.14
		(1.18)	(-2.04)	(-0.76)	(-0.29)	(3.49)	(3.54)	
EUR/GBP	(1)					47.68***		0.13
						(4.97)		
	(2)					52.22***	8.86	0.13
						(4.86)	(0.55)	
	(3)	-28.85	623.44	-34.56	214.73			-0.02
		(-0.97)	(1.59)	(-1.14)	(-0.36)			
	(4)	-23.74	451.94	3.96	-108.06	53.29***		0.12
		(-0.86)	(1.24)	(0.13)	(-0.36)	(5.05)		
	(5)	-20.93	465.16	8.66	-83.99	53.51***	-5.64	0.11
		(-0.75)	(1.26)	(0.29)	(-0.28)	(4.79)	(-0.33)	
EUR/HUF	(1)					70.32*		0.05
						(1.77)		
	(2)					85.65**	46.96	0.05
						(2.11)	(1.60)	
	(3)	0.63	123.18	7.53	-149.56			-0.03
		(0.06)	(0.40)	(0.68)	(-0.36)			

	(4)	1.22	156.78	7.39	-136.89	75.75*		0.03
		(0.11)	(0.50)	(0.66)	(-0.36)	(1.81)		
	(5)	0.03	130.15	6.62	-104.31	90.33**	39.99	0.02
		(0.00)	(0.42)	(0.59)	(-0.27)	(2.12)	(1.30)	
EUR/JPY	(1)					1727.95***		0.13
						(4.50)		
	(2)					1713.24***	74.46**	0.16
						(4.45)	(2.39)	
	(3)	-3.66	635.57	-41.68**	-569.80*			0.03
		(-0.13)	(1.76)	(-2.15)	(-1.86)			
	(4)	-51.92*	497.97	0.49	-787.49*	1940.83***		0.17
		(-1.76)	(1.42)	(0.02)	(-1.86)	(4.49)		
	(5)	-54.41*	457.52	-10.45	-733.62*	1885.48***	76.36**	0.20
		(-1.84)	(1.29)	(-0.49)	(-1.73)	(4.34)	(2.26)	
EUR/NOK	(1)					122.22***		0.16
						(5.02)		
	(2)					121.92***	3.68	0.16
						(5.03)	(0.53)	
	(3)	-21.73*	407.29*	-35.67	-160.40			0.02
		(-1.88)	(1.90)	(-0.89)	(-1.32)			
	(4)	-21.98**	231.71	15.76	-350.11	130.01***		0.18
		(-2.06)	(1.16)	(0.42)	(-1.32)	(5.20)		
	(5)	-23.50**	261.49	9.71	-341.55	127.01***	6.28	0.17
		(-2.20)	(1.29)	(0.26)	(-1.29)	(5.12)	(0.91)	
EUR/PLN	(1)					57.56***		0.09
						(2.88)		
	(2)					65.15***	-1.69	0.09
						(3.15)	(-0.11)	
	(3)	-7.74	531.49	15.48	-201.20			-0.01
		(-0.55)	(1.51)	(1.03)	(-0.89)			
	(4)	-25.97*	642.66*	27.83*	-365.21	75.54***		0.11
		(-1.69)	(1.83)	(1.68)	(-0.89)	(3.38)		
	(5)	-22.47	568.84	21.54	-295.94	79.14***	-3.11	0.11
		(-1.47)	(1.62)	(1.30)	(-0.72)	(3.49)	(-0.20)	
EUR/SEK	(1)					95.99***		0.07
						(3.75)		
	(2)					98.66***	-1.34	0.06
						(3.86)	(-0.26)	
	(3)	4.95	67.43	10.35	206.42			-0.04
		(0.28)	(0.48)	(0.54)	(0.57)			
	(4)	-13.22	97.23	22.76	162.06	114.33***		0.05
		(-0.75)	(0.70)	(1.21)	(0.57)	(4.25)		
	(5)	-12.22	84.63	21.41	162.69	116.34***	-0.63	0.05
		(-0.69)	(0.61)	(1.14)	(0.57)	(4.35)	(-0.12)	

Table 9: SUR - Model Comparison: US-Dollar pairs

Estimation is conducted for five different systems of seemingly unrelated regressions. The individual systems include the following model specifications **(1)** Evans & Lyons (2002) portfolio shift model:$\Delta s_t = \gamma_0 + \gamma_1 mo_t + u_t$, **(2)** Kozhan, Moore & Payne (2015) model: $\Delta s_t = \gamma_0 + \gamma_1 mo_t + \gamma_2 lbo_t + u_t$, **(3)** Conventional Taylor rule: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + u_t$, **(4)** Taylor rule incl. market order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \gamma_1 mo_t + u_t$ and **(5)** Taylor rule incl. FX order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \gamma_1 mo_t + \gamma_2 lbo_t + u_t$. Numbers in parentheses present respective t-statistics. Estimates of intercept terms are not reported to preserve space. ***, ** and * refer to level of statistical significance of 1%, 5% and 10%, respectively. Sample period is January 2004 to February 2014 (122 observations). Number of equations per system: M=10.

	Spec	$\pi_{t-1} - \hat{\pi}_{t-1}$	$y^G_{t-1} - \hat{y}^G_{t-1}$	$i_{t-2} - \hat{i}_{t-2}$	q_{t-1}	mo_t	lbo_t	R^2
USD/CAD	(1)					61.76***		0.30
						(6.87)		
	(2)					78.20***	93.48***	0.33
						(8.13)	(3.82)	
	(3)	58.53***	-513.89	-21.60	-621.61***			0.08
		(2.63)	(-0.92)	(-0.83)	(-3.06)			
	(4)	18.21	-252.49	-46.72**	-624.26***	64.38***		0.37
		(0.87)	(-0.50)	(-2.01)	(-3.06)	(7.13)		
	(5)	21.53	-257.01	-44.55*	-467.54**	74.22***	65.95***	0.38
		(1.05)	(-0.52)	(-1.97)	(-2.21)	(7.59)	(2.57)	
USD/CHF	(1)					68.31		-0.01
						(0.42)		
	(2)					104.05	10.70	-0.01
						(0.60)	(0.27)	
	(3)	38.74**	-82.41	-5.04	38.77			0.01
		(1.97)	(-0.45)	(-0.27)	(0.18)			
	(4)	35.36*	-57.42	-10.11	53.27	45.17		0.00
		(1.77)	(-0.31)	(-0.51)	(0.18)	(0.25)		
	(5)	39.36*	-116.13	-13.46	72.84	79.82	5.85	0.00
		(1.87)	(-0.60)	(-0.66)	(0.24)	(0.42)	(0.14)	
USD/ILS	(1)					259.70***		0.09
						(3.36)		
	(2)					261.06***	-6.18	0.08
						(3.23)	(-0.21)	
	(3)	2.46	171.82	-27.73*	-4.15			0.00
		(0.25)	(0.61)	(-1.72)	(-0.05)			
	(4)	1.34	100.27	-29.83*	-11.04	252.87***		0.09
		(0.14)	(0.37)	(-1.92)	(-0.05)	(3.31)		
	(5)	3.94	117.23	-32.22**	-35.94	253.49***	-5.92	0.09
		(0.42)	(0.43)	(-2.05)	(-0.16)	(3.16)	(-0.19)	
USD/INR	(1)					8.53		0.01
						(0.97)		
	(2)					-10.24	-51.33	-0.00
						(-0.60)	(-1.40)	
	(3)	7.36	247.72	-7.53	-468.36			0.04
		(1.41)	(0.72)	(-0.91)	(-1.70)			
	(4)	6.35	225.52	-8.41	-439.18	0.65		0.04
		(1.17)	(0.65)	(-0.98)	(-1.70)	(0.07)		
	(5)	6.90	359.25	-8.73	-403.71	-7.14	-21.55	0.03
		(1.25)	(1.04)	(-0.98)	(-1.55)	(-0.41)	(-0.54)	
USD/JPY	(1)					164.37***		0.05
						(2.55)		
	(2)					249.97***	198.94***	0.19
						(3.93)	(4.69)	
	(3)	1.72	456.92	-3.72	7.06			-0.00
		(0.09)	(1.42)	(-0.26)	(0.18)			

	(4)	1.72	570.01*	-0.93	44.17	181.05***		0.06
		(0.09)	(1.80)	(-0.07)	(0.18)	(2.79)		
	(5)	8.71	759.40**	-8.68	-47.09	266.66***	218.33***	0.21
		(0.47)	(2.56)	(-0.68)	(-0.21)	(4.26)	(5.16)	
USD/MXN	(1)					-22.47*		0.01
						(-1.74)		
	(2)					-27.81**	1.87	0.01
						(-2.03)	(0.21)	
	(3)	4.08	-282.59	11.57	-126.76			-0.03
		(0.39)	(-0.45)	(0.87)	(-0.12)			
	(4)	-0.37	-161.11	23.35	-34.73	-35.31**		-0.03
		(-0.04)	(-0.26)	(1.75)	(-0.12)	(-2.52)		
	(5)	-0.67	-290.81	28.21**	39.80	-36.43**	10.12	-0.03
		(-0.06)	(-0.47)	(2.11)	(0.14)	(-2.52)	(1.09)	
USD/PLN	(1)					417.57*		0.03
						(1.70)		
	(2)					376.79	-16.22	0.02
						(1.53)	(-0.45)	
	(3)	11.08	820.80*	-17.52	-521.11			0.03
		(0.73)	(1.90)	(-1.13)	(-1.43)			
	(4)	6.23	934.22**	-16.80	-560.41	409.95*		0.06
		(0.40)	(2.13)	(-1.04)	(-1.43)	(1.68)		
	(5)	4.21	896.43**	-16.03	-556.10	389.79	-26.36	0.04
		(0.27)	(2.03)	(-0.98)	(-1.42)	(1.60)	(-0.76)	
USD/SGD	(1)					24.27**		0.05
						(2.19)		
	(2)					80.88***	129.12***	0.30
						(6.16)	(6.87)	
	(3)	2.73	86.03	-6.99	-94.62			-0.03
		(0.52)	(0.35)	(-0.65)	(-0.18)			
	(4)	3.82	19.85	-10.77	-30.19	27.81**		0.03
		(0.72)	(0.08)	(-0.99)	(-0.18)	(2.25)		
	(5)	-1.67	131.66	-10.88	-17.08	81.96***	133.40***	0.29
		(-0.31)	(0.52)	(-1.04)	(-0.12)	(5.85)	(6.76)	
USD/ZAR	(1)					89.56***		0.10
						(2.83)		
	(2)					95.84***	11.27	0.11
						(3.01)	(0.97)	
	(3)	2.54	2674.85*	37.36	-824.34			-0.00
		(0.16)	(1.89)	(1.81)	(-0.11)			
	(4)	-0.68	2824.01**	48.79**	-56.96	129.24***		0.12
		(-0.04)	(2.00)	(2.23)	(-0.11)	(3.15)		
	(5)	-3.16	2845.23**	49.03**	-8.13	134.63***	8.44	0.13
		(-0.19)	(2.01)	(2.24)	(-0.02)	(3.27)	(0.76)	

Table 10: Breusch-Pagan-Test for Diagonality

Table displays Breusch and Pagan (1980) test statistic λ_{LM}:

$$\lambda_{LM} = T \sum_{i=2}^{M} \sum_{j=1}^{i-1} r_{ij}^2$$

where M refers to the number of equations and i and j are the number of rows and columns, respectively. Further r_{ij}^2 is the sample correlation coefficients, which is calculated based on the sample standard covariances, such that $r_{ij}^2 = \frac{s_{ij}}{\sqrt{s_{ii}s_{jj}}}$. Under the null hypothesis λ_{LM} has an asymptotic χ^2_{45} distribution.

	EvLy	*KMP*	Macro	*Hybrid/EvLy*	*Hybrid/KMP*
EUR	344.4	346.0	409.6	352.9	352.5
USD	1077.6	1037.8	1185.2	1086.1	1041.1

Table 11: System-wide R^2: Model Comparison

Table displays McElroy's system-wide measure of fit R^2_{SUR} of form

$$R^2_{SUR} = 1 - \frac{M}{tr(\Sigma^{-1}\hat{S}_{yy})}$$

where M denotes the number of equations, Σ^{-1} is the residual cross product and S_{yy} is the mean deviation cross product matrix. The adjusted R^2_{SUR} is calculated from

$$\bar{R}^2_{SUR} = 1 - \frac{(1 - R^2_{SUR})(N-1)}{N-p-1}$$

		EvLy	*KMP*	*Macro*	*Hybrid/EvLy*	*Hybrid/KMP*
R^2_{SUR}	EUR	0.089	0.11	0.046	0.129	0.147
	USD	0.052	0.100	0.050	0.108	0.153
$\bar{R}^2_{SUR}$	EUR	0.074	0.087	0.00	0.083	0.094
	USD	0.035	0.077	0.010	0.061	0.101

Table 12: In-Sample Prediction: SUR Estimation

Table shows the mean square errors (MSE) of market microstructure and hybrid models, relative to a conventional Taylor from a one-horizon in-sample prediction. A MSE lower than unity indicates a better model fit than the conventional Taylor rule. The closer the MSE to zero, the better the overall model fit. For each currency pair the lowest value is marked as bold. Hybrid (1) refers to a hybrid Taylor rule model, including market order flows. Hybrid (2) refers to a hybrid Taylor rule model, which includes market order as well as limit order flows as additional regressors. Sample period is January 2004 to February 2014.

	Evans & Lyons	Kozhan et al	Hybrid 1	Hybrid 2		Evans & Lyons	Kozhan	Hybrid 1	Hybrid 2
EUR/USD	0.91	0.85	0.81	**0.77**	USD/CAD	0.78	0.74	0.67	**0.66**
EUR/CHF	1.01	1.01	**0.99**	1.00	USD/CHF	1.05	1.04	1.00	**0.99**
EUR/CZK	0.88	0.82	0.87	**0.81**	USD/ILS	0.94	0.94	0.901	0.898
EUR/GBP	0.88	0.87	**0.856**	0.86	USD/INR	1.06	1.07	**1.00**	**1.00**
EUR/HUF	0.94	0.94	0.934	**0.932**	USD/JPY	0.97	0.83	0.93	**0.77**
EUR/JPY	0.92	0.88	0.85	**0.81**	USD/MXN	0.98	**0.97**	0.99	0.98
EUR/NOK	0.88	0.88	0.84	**0.83**	USD/PLN	1.02	1.02	**0.96**	0.97
EUR/PLN	0.92	0.92	0.873	**0.869**	USD/SGD	0.95	0.69	0.94	**0.68**
EUR/SEK	0.92	0.92	0.902	**0.901**	USD/ZAR	0.92	0.90	0.87	**0.86**

Table 13: Model Comparison incl. Money Base: Euro Pairs

Estimates are obtained using ordinary least square estimator, testing the following five model specifications **(3)** Conventional Taylor rule: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \beta_5(M_{t-1} - M^*_{t-1}) + u_t$, **(4)** Taylor rule incl. market order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \beta_5(M_{t-1} - M^*_{t-1}) + \gamma_1 mo_t + u_t$ and **(5)** Taylor rule incl. FX order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \beta_5(M_{t-1} - M^*_{t-1}) + \gamma_1 mo_t + \gamma_2 lbo_t + u_t$. Numbers in parentheses present respective HAC-adjusted t-statistics. Estimates of intercept terms are not reported to preserve space. ***, ** and * refer to level of statistical significance of 1%, 5% and 10%, respectively. Sample period is January 2004 to December 2010 (120 observations). $M_{t-1} - M^*_{t-1}$ refers to the log difference in money base.

	Spec	$\pi_{t-1} - \pi^*_{t-1}$	$y^G_{t-1} - y^{G^*}_{t-1}$	$i_{t-2} - i^*_{t-2}$	q_{t-1}	$M_{t-1} - M^*_{t-1}$	mo_t	lbo_t	R^2
EUR/USD	(3)	148.76***	-555.37***	-70.87		119.55*			0.12
		(5.12)	(-0.34)	(-3.20)		(1.68)			
	(4)	90.20**	-624.88	-27.22		-89.62	188.30***		0.30
		(2.49)	(-0.42)	(-0.90)		(-1.41)	(5.46)		
	(5)	70.98*	-547.69	-22.50		-131.82**	194.75***	72.77***	0.34
		(1.88)	(-0.40)	(-0.75)		(-2.02)	(6.57)	(3.59)	
EUR/CHF	(3)	7.15	-20.34	41.29	-249.20	-55.06			-0.02
		(0.34)	(-0.13)	(0.92)	(-0.85)	(-1.14)			
	(4)	1.71	-6.11	45.08	-301.28	-56.10	220.36		-0.02
		(0.06)	(-0.04)	(0.86)	(-1.10)	(-1.09)	(0.48)		
	(5)	1.50	-5.88	45.14	-302.02	-56.41	218.51	-1.30	-0.03
		(0.05)	(-0.03)	(0.86)	(-1.07)	(-1.08)	(0.46)	(-0.05)	
EUR/CZK	(3)	0.48	-111.82	8.92	-10.73	165.32			-0.02
		(0.02)	(-0.48)	(0.30)	(-0.04)	(1.63)			
	(4)	20.36	-237.56	-8.55	-184.48	-16.55	280.15***		0.11
		(0.91)	(-1.11)	(-0.32)	(-0.69)	(-0.17)	(4.57)		
	(5)	16.83	-290.49	-17.77	-139.47	-90.38	297.60***	94.26***	0.18
		(0.76)	(-1.40)	(-0.61)	(-0.53)	(-0.90)	(4.67)	(3.26)	
EUR/GBP	(3)	-22.76	724.35	-45.85	-193.17	-22.07			-0.01
		(-0.42)	(1.92)	(-0.96)	(-0.44)	(-0.46)			
	(4)	-15.74	534.43	7.78	-444.06	-24.32	63.34***		0.12
		(-0.29)	(1.62)	(0.17)	(-0.99)	(-0.59)	(6.09)		
	(5)	-13.17	435.61	-4.34	-448.77	-34.46	69.01***	25.77*	0.12
		(-0.24)	(1.35)	(-0.09)	(-0.97)	(-0.74)	(6.34)	(1.66)	
EUR/HUF	(3)	22.40	270.46	-0.14	264.69	4.93			-0.02
		(1.55)	(0.77)	(-0.01)	(0.43)	(0.03)			
	(4)	14.89	214.42	-4.01	82.42	-98.71	173.16***		0.06
		(1.01)	(0.65)	(-0.18)	(0.15)	(-0.54)	(2.56)		
	(5)	14.35	234.45	-3.81	153.13	-113.85	186.39**	36.85	0.05
		(0.98)	(0.70)	(-0.17)	(0.28)	(-0.65)	(2.94)	(0.78)	
EUR/JPY	(3)	-36.35	666.17	-30.76	-1205.51	-78.94			0.04
		(-0.66)	(1.33)	(-0.73)	(-1.45)	(-0.26)			
	(4)	-110.46**	738.21	22.08	-1374.60*	169.94	2879.87***		0.18
		(-2.51)	(1.47)	(0.86)	(-1.82)	(0.80)	(5.44)		
	(5)	-106.43**	652.55	9.04	-1487.40*	281.37	2796.38***	110.03*	0.21
		(-2.35)	(1.30)	(0.35)	(-1.82)	(1.30)	(4.77)	(1.94)	
EUR/NOK	(3)	-16.32	615.52**	-71.81	-416.09	-136.86			0.03
		(-0.94)	(2.41)	(-1.61)	(-1.23)	(-1.23)			
	(4)	-20.64	408.25	-12.81	-572.13*	-76.75	149.89***		0.19
		(-1.34)	(1.92)	(-0.27)	(-1.70)	(-0.68)	(4.95)		
	(5)	-21.66	439.22**	-14.20	-580.91*	-74.95	149.32***	5.95	0.19
		(-1.36)	(2.01)	(-0.30)	(-1.71)	(-0.67)	(4.89)	(1.19)	
EUR/PLN	(3)	21.49	1101.31**	-19.60	174.41	-312.59			0.04
		(1.11)	(2.39)	(-1.41)	(0.29)	(-1.39)			
	(4)	-15.52	1067.80**	24.79	-411.52	-235.73	139.11***		0.17
		(-0.67)	(2.59)	(1.02)	(-0.65)	(-1.32)	(3.38)		
	(5)	-14.53	1095.47**	24.55	-414.98	-240.01	147.77***	21.15	0.17

		(-0.61)	(2.64)	(1.00)	(-0.65)	(-1.32)	(3.79)	(0.97)	
EUR/SEK	(3)	-15.88	106.62	-38.74	-73.13	47.99			-0.02
		(-0.46)	(0.81)	(-1.21)	(-0.17)	(1.28)			
	(4)	-23.25	159.57	-42.41	-83.48	92.20**	140.95***		0.10
		(-0.70)	(1.37)	(-1.32)	(-0.20)	(2.16)	(3.49)		
	(5)	-20.25	150.28	-40.83	-37.52	92.35**	137.99***	-8.64	0.10
		(-0.56)	(1.31)	(-1.24)	(-0.08)	(2.21)	(3.31)	(-0.71)	

Table 14: Model Comparison incl. Money Base: US-Dollar Pairs

Estimates are obtained using ordinary least square estimator, testing the following five model specifications **(3)** Conventional Taylor rule: **(3)** Conventional Taylor rule: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \beta_5(M_{t-1} - M^*_{t-1}) + u_t$, **(4)** Taylor rule incl. market order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \beta_5(M_{t-1} - M^*_{t-1}) + \gamma_1 mo_t + u_t$ and **(5)** Taylor rule incl. FX order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \beta_5(M_{t-1} - M^*_{t-1}) + \gamma_1 mo_t + \gamma_2 lbo_t + u_t$. Numbers in parentheses present respective HAC-adjusted t-statistics. Estimates of intercept terms are not reported to preserve space. ***, ** and * refer to level of statistical significance of 1%, 5% and 10%, respectively. Sample period is January 2004 to December 2010 (120 observations). $M_{t-1} - M^*_{t-1}$ refers to the log difference in monetary base.

	Spec	$\pi_{t-1} - \pi^*_{t-1}$	$y^G_{t-1} - y^{G*}_{t-1}$	$i_{t-2} - i^*_{t-2}$	q_{t-1}	$M_{t-1} - M^*_{t-1}$	mo_t	lbo_t	R^2
USD/CAD	(3)	66.97**	-618.89*	-85.77**	-758.44	-126.11			0.10
		(2.27)	(-0.86)	(-1.84)	(-2.44)	(-0.98)			
	(4)	45.22	-179.33	-48.12	-382.71	141.07	98.75***		0.41
		(1.39)	(-0.27)	(-1.22)	(-1.15)	(1.07)	(8.81)		
	(5)	43.79	-226.01	-52.62	-303.06	117.96	106.44***	49.50	0.41
		(1.33)	(-0.34)	(-1.43)	(-0.78)	(0.92)	(11.19)	(0.86)	
USD/CHF	(3)	94.35***	-303.71	-35.61	260.97	46.45			0.04
		(3.53)	(-0.83)	(-1.58)	(0.84)	(0.46)			
	(4)	94.33***	-312.23	-40.87	270.07	48.35	161.81		0.03
		(3.52)	(-0.86)	(-1.62)	(0.85)	(0.47)	(0.85)		
	(5)	91.41***	-302.83	-42.69*	284.82	44.69	195.20	32.49	0.02
		(3.11)	(-0.85)	(-1.68)	(0.88)	(0.43)	(0.97)	(0.34)	
GBP/USD	(3)	1.07	376.05	-99.09**	617.21*	-17.80			0.10
		(0.06)	(0.74)	(-2.54)	(1.76)	(-0.17)			
	(4)	14.85	479.28	-97.73**	175.57	-64.47	51.01***		0.20
		(0.63)	(0.99)	(-1.99)	(0.41)	(-0.65)	(3.10)		
	(5)	6.22	362.28	-92.74**	203.80	-59.99	62.23***	48.74***	0.22
		(0.25)	(0.76)	(-2.00)	(0.47)	(-0.54)	(3.97)	(2.47)	
USD/ILS	(3)	5.81	84.27	-56.21**	-192.81	-60.26			0.01
		(0.35)	(0.28)	(-2.03)	(-0.55)	(-0.57)			
	(4)	12.66	28.45	-49.43**	-99.91	6.77	442.12***		0.13
		(0.81)	(0.09)	(-2.03)	(-0.29)	(0.07)	(3.58)		
	(5)	12.37	19.90	-47.52*	-72.17	10.31	462.10***	23.95	0.12
		(0.79)	(0.06)	(-1.91)	(-0.20)	(0.10)	(3.58)	(0.65)	
USD/INR	(3)	6.58	399.26	-27.69*	-174.94	-119.93			0.06
		(0.97)	(0.65)	(-1.91)	(-0.58)	(-0.65)			
	(4)	5.65	463.35	-23.78	-189.74	-98.68	10.45		0.05
		(0.77)	(0.68)	(-1.37)	(-0.63)	(-0.51)	(0.42)		
	(5)	6.05	468.27	-24.39	-248.55	-78.40	24.78	36.91	0.05
		(0.88)	(0.69)	(-1.47)	(-0.84)	(-0.42)	(0.53)	(0.45)	
USD/JPY	(3)	18.45	789.30	3.41	188.56	81.34			0.00
		(0.65)	(1.53)	(0.17)	(0.46)	(0.63)			
	(4)	19.22	785.76	8.71	336.22	111.65	225.73		0.06
		(0.66)	(1.58)	(0.49)	(0.91)	(1.01)	(2.25)		
	(5)	31.46*	726.29	16.76	574.20*	245.82**	321.27***	271.96***	0.25
		(1.65)	(1.55)	(0.86)	(1.68)	(2.13)	(3.82)	(5.58)	
USD/MXN	(3)	20.42	-2378.31**	-37.84	-538.18	-176.91			0.02
		(1.34)	(-2.08)	(-1.04)	(-1.19)	(-0.85)			
	(4)	15.38	-2520.81**	-25.57	-548.43	-327.91	-70.56*		0.07
		(1.18)	(-2.24)	(-0.81)	(-1.30)	(-1.39)	(-1.92)		
	(5)	14.86	-2551.25**	-22.16	-415.77	-362.77	-62.60*	29.68	0.08
		(1.16)	(-2.26)	(-0.76)	(-1.07)	(-1.56)	(-1.80)	(1.51)	
USD/PLN	(3)	52.52***	1058.87	-83.79	-802.95	-209.01			0.07
		(2.97)	(1.40)	(-2.01)	(-1.57)	(-0.78)			
	(4)	41.70***	1219.81	-63.52	-945.2*	-210.16	1375.58***		0.13
		(2.38)	(1.57)	(-1.44)	(-1.71)	(-0.76)	(3.39)		

	(5)	41.69**	1214.46	-63.38	-944.80*	-209.63	1377.24***	4.00	0.12
		(2.37)	(1.55)	(-1.42)	(-1.70)	(-0.74)	(3.36)	(0.06)	
USD/SGD	(3)	10.73	-372.12*	-65.21	-439.24	-204.89			-0.01
		(1.21)	(-0.83)	(-1.79)	(-1.57)	(-1.26)			
	(4)	8.43	-413.44	-36.39	-49.44	-101.50	86.71***		0.09
		(0.93)	(-1.00)	(-1.07)	(-0.20)	(-0.71)	(3.41)		
	(5)	-1.28	-19.19	-22.09	-15.30	-50.49	158.03***	224.59***	0.37
		(-0.18)	(-0.06)	(-0.93)	(-0.08)	(-0.48)	(6.10)	(5.06)	
USD/ZAR	(3)	47.06**	-685.43	-30.65***	-1776.27	-328.10			0.04
		(2.24)	(-0.31)	(-0.90)	(-3.06)	(-1.59)			
	(4)	24.90	914.86	27.30	190.96	-229.34	276.34***		0.20
		(1.30)	(0.45)	(1.11)	(0.32)	(-1.45)	(3.88)		
	(5)	27.61	730.24	21.52	146.41	-244.39	282.09***	25.16*	0.21
		(1.47)	(0.36)	(0.84)	(0.24)	(-1.53)	(4.21)	(1.82)	

Table 15: Model Comparison incl. Monetary Aggregate: Euro Pairs

Estimates are obtained using ordinary least square estimator, testing the following five model specifications **(3)** Conventional Taylor rule: **(3)** Conventional Taylor rule: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \beta_5(M_{t-1} - M^*_{t-1}) + u_t$, **(4)** Taylor rule incl. market order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \beta_5(M_{t-1} - M^*_{t-1}) + \gamma_1 mo_t + u_t$ and **(5)** Taylor rule incl. FX order flow: $\Delta s_t = \alpha + \beta_1(\pi_{t-1} - \hat{\pi}_{t-1}) + \beta_2(y^G_{t-1} - \hat{y}^G_{t-1}) + \beta_3(i_{t-2} - \hat{i}_{t-2}) + \beta_4 q_{t-1} + \beta_5(M_{t-1} - M^*_{t-1}) + \gamma_1 mo_t + \gamma_2 lbo_t + u_t$. Numbers in parentheses present respective HAC-adjusted t-statistics. Estimates of intercept terms are not reported to preserve space. ***, ** and * refer to level of statistical significance of 1%, 5% and 10%, respectively. Sample period is January 2004 to December 2010 (120 observations). $M_{t-1} - M^*_{t-1}$ refers to the log difference in monetary aggregates.

	Spec	$\pi_{t-1} - \pi^*_{t-1}$	$y^G_{t-1} - y^{G^*}_{t-1}$	$i_{t-2} - i^*_{t-2}$	q_{t-1}	$M_{t-1} - M^*_{t-1}$	mo_t	lbo_t	R^2
EUR/USD	(3)	131.50***	-223.18	-67.04***		-503.77			0.11
		(4.69)	(-0.14)	(-2.99)		(-0.89)			
	(4)	103.64**	-848.23	-33.15		392.68	177.69***		0.29
		(2.60)	(-0.56)	(-1.06)		(0.87)	(4.80)		
	(5)	92.09**	-868.98	-31.08		539.85	178.65***	67.80***	0.33
		(2.24)	(-0.62)	(-0.98)		(1.09)	(5.21)	(3.14)	
EUR/CHF	(3)	12.72	-46.35	-15.10	-6.84	-375.65**			-0.01
		(0.66)	(-0.30)	(-0.73)	(-0.02)	(-1.89)			
	(4)	1.91	-22.00	-17.38	-19.45	-498.19**	419.75		-0.00
		(0.08)	(-0.13)	(-0.88)	(-0.06)	(-2.29)	(0.90)		
	(5)	-0.63	-20.32	-20.26	-16.38	-521.20**	405.15	-16.59	-0.01
		(-0.03)	(-0.12)	(-0.93)	(-0.05)	(-2.38)	(0.85)	(-0.71)	
EUR/CZK	(3)	3.84	-118.82	7.53	-34.26	-523.55			-0.02
		(0.15)	(-0.50)	(0.31)	(-0.10)	(-1.49)			
	(4)	19.96	-236.37	-8.33	-181.59	49.79	279.00***		0.11
		(0.85)	(-1.10)	(-0.38)	(-0.58)	(0.14)	(4.52)		
	(5)	13.46	-279.78	-12.61	-151.48	160.98	286.32***	90.62***	0.17
		(0.55)	(-1.36)	(-0.56)	(-0.49)	(0.52)	(4.43)	(3.18)	
EUR/GBP	(3)	-24.84	691.17*	-50.96	-211.49	-229.32			-0.01
		(-0.44)	(1.77)	(-0.86)	(-0.50)	(-0.50)			
	(4)	-20.05	466.01	-10.21	-462.54	-429.57	64.47***		0.12
		(-0.36)	(1.53)	(-0.19)	(-1.05)	(-1.19)	(6.05)		
	(5)	-16.42	413.16	-6.20	-478.24	-306.79	68.42***	19.55	0.12
		(-0.29)	(1.33)	(-0.11)	(-1.08)	(-0.74)	(6.22)	(1.13)	
EUR/HUF	(3)	22.12	260.25	-1.66	206.14	-152.33			-0.01
		(1.59)	(0.74)	(-0.09)	(0.37)	(-0.39)			
	(4)	15.05	259.19	2.86	142.38	395.83	180.48***		0.06
		(0.98)	(0.77)	(0.15)	(0.27)	(1.02)	(3.19)		
	(5)	14.50	288.29	4.27	230.61	470.22	196.27***	39.20	0.05
		(0.93)	(0.85)	(0.21)	(0.45)	(1.20)	(3.77)	(0.73)	
EUR/JPY	(3)	-43.51	695.88	-31.56	-1259.82	-58.40			0.04
		(-1.06)	(1.35)	(-0.51)	(-1.63)	(-0.14)			
	(4)	-95.35**	675.25	57.36*	-1656.53**	463.70*	3080.31***		0.19
		(-2.51)	(1.34)	(1.80)	(-2.61)	(1.79)	(6.04)		
	(5)	-80.02**	536.87	52.91	-1797.30**	639.13**	3038.14***	119.57**	0.23
		(-2.07)	(1.04)	(1.60)	(-2.53)	(2.15)	(5.40)	(2.08)	
EUR/NOK	(3)	-20.45	579.03**	-27.12	-387.63	-449.22			0.03
		(-1.14)	(2.50)	(-0.35)	(-0.99)	(-0.64)			
	(4)	-23.18	391.48**	7.20	-547.51	-184.21	151.15***		0.19
		(-1.54)	(2.04)	(0.09)	(-1.43)	(-0.27)	(4.93)		
	(5)	-24.22	424.60	3.25	-552.94	-153.64	150.67***	5.91	0.19
		(-1.57)	(2.17)	(0.04)	(-1.43)	(-0.22)	(4.88)	(1.16)	
EUR/PLN	(3)	6.41	1160.37**	9.32	71.91	-222.69			0.02
		(0.27)	(2.49)	(0.40)	(0.12)	(-1.48)			
	(4)	-24.21	1063.41***	36.02	-326.70	45.03	148.51***		0.15
		(-0.81)	(2.56)	(1.24)	(-0.54)	(0.23)	(2.83)		

	(5)	-23.44	1089.03**	35.99	-328.69	45.48	156.67***	19.58	0.15
		(-0.77)	(2.62)	(1.23)	(-0.54)	(0.24)	(3.17)	(0.81)	
EUR/SEK	(3)	-24.28	86.91	-15.12	-28.37	65.03			-0.03
		(-0.66)	(0.67)	(-0.60)	(-0.05)	(0.12)			
	(4)	-39.33	119.76	-7.64	69.43	359.44	124.72***		0.06
		(-1.01)	(1.01)	(-0.28)	(0.13)	(0.61)	(3.13)		
	(5)	-36.55	111.64	-4.95	94.49	317.90	121.53***	-7.00	0.06
		(-0.88)	(0.96)	(-0.17)	(0.17)	(0.53)	(2.90)	(-0.49)	

Table 16: Model Comparison incl. Monetary Aggregate: US-Dollar Pairs

Estimates are obtained using ordinary least square estimator, testing the following five model specifications **(3)** Conventional Taylor rule: $\Delta s_t = \alpha+\beta_1(\pi_{t-1}-\hat{\pi}_{t-1})+\beta_2(y^G_{t-1}-\hat{y}^G_{t-1})+\beta_3(i_{t-2}-\hat{i}_{t-2})+\beta_4 q_{t-1}+\beta_5(M_{t-1}-M^*_{t-1})+u_t$, **(4)** Taylor rule incl. market order flow: $\Delta s_t = \alpha+\beta_1(\pi_{t-1}-\hat{\pi}_{t-1})+\beta_2(y^G_{t-1}-\hat{y}^G_{t-1})+\beta_3(i_{t-2}-\hat{i}_{t-2})+\beta_4 q_{t-1}+\beta_5(M_{t-1}-M^*_{t-1})+\gamma_1 mo_t+u_t$ and **(5)** Taylor rule incl. FX order flow: $\Delta s_t = \alpha+\beta_1(\pi_{t-1}-\hat{\pi}_{t-1})+\beta_2(y^G_{t-1}-\hat{y}^G_{t-1})+\beta_3(i_{t-2}-\hat{i}_{t-2})+\beta_4 q_{t-1}+\beta_5(M_{t-1}-M^*_{t-1})+\gamma_1 mo_t+\gamma_2 lbo_t+u_t$. Numbers in parentheses present respective HAC-adjusted t-statistics. Estimates of intercept terms are not reported to preserve space. ***, ** and * refer to level of statistical significance of 1%, 5% and 10%, respectively. Sample period is January 2004 to December 2010 (120 observations). $M_{t-1}-M^*_{t-1}$ refers to the log difference in monetary aggregates.

	Spec	$\pi_{t-1}-\pi^*_{t-1}$	$y^G_{t-1}-y^{G*}_{t-1}$	$i_{t-2}-i^*_{t-2}$	q_{t-1}	$M_{t-1}-M^*_{t-1}$	mo_t	lbo_t	R^2
USD/CAD	(3)	87.62**	-588.76**	-65.37	-602.45	108.73			0.09
		(2.38)	(-0.88)	(-2.05)	(-1.31)	(0.11)			
	(4)	21.40	-288.29	-76.54*	-713.56*	250.96	91.96***		0.40
		(0.60)	(-0.45)	(-1.96)	(-1.86)	(0.30)	(7.74)		
	(5)	23.12	-332.18	-77.66**	-591.32	279.95	102.21***	57.39	0.41
		(0.63)	(-0.52)	(-2.21)	(-1.31)	(0.32)	(12.29)	(0.97)	
USD/CHF	(3)	86.89***	-317.59	-40.47	169.23	-357.02			0.03
		(3.42)	(-0.86)	(-1.28)	(0.41)	(-0.32)			
	(4)	86.49***	-326.59	-45.91	172.60	-377.66	157.66		0.03
		(3.42)	(-0.88)	(-1.32)	(0.43)	(-0.34)	(0.83)		
	(5)	83.23***	-316.16	-48.46	183.49	-393.73	195.39	36.03	0.02
		(3.09)	(-0.87)	(-1.39)	(0.46)	(-0.36)	(0.96)	(0.38)	
GBP/USD	(3)	14.11	398.19	-93.93**	385.36	-349.03			0.11
		(0.60)	(0.77)	(-2.35)	(0.87)	(-0.84)			
	(4)	1.32	497.14	-99.78**	476.71	244.38	52.70***		0.20
		(0.07)	(1.01)	(-2.01)	(1.27)	(0.60)	(2.78)		
	(5)	-14.80	363.75	-96.87**	625.20	426.52	66.67***	53.17***	0.22
		(-0.75)	(0.76)	(-2.04)	(1.79)	(1.13)	(3.68)	(2.61)	
USD/ILS	(3)	8.80	71.76	-47.23**	-107.81	65.95			0.00
		(0.57)	(0.23)	(-2.29)	(-0.26)	(0.12)			
	(4)	20.35	15.67	-49.18***	114.25	-499.26	458.63***		0.13
		(1.44)	(0.05)	(-3.05)	(0.28)	(-0.97)	(3.50)		
	(5)	19.72	8.62	-47.89***	130.67	-491.23	476.52***	22.84	0.12
		(1.39)	(0.03)	(-2.95)	(0.32)	(-0.96)	(3.48)	(0.62)	
USD/INR	(3)	4.65	540.21	-29.32	-489.59	157.49			0.05
		(0.31)	(0.92)	(-1.15)	(-1.09)	(0.40)			
	(4)	4.60	578.74	-24.03	-430.14	112.31	10.89		0.05
		(0.30)	(0.94)	(-0.95)	(-0.97)	(0.29)	(0.46)		
	(5)	6.10	556.09	-23.14	-413.29	62.01	26.37	39.52	0.05
		(0.41)	(0.95)	(-0.93)	(-0.95)	(0.16)	(0.58)	(0.47)	
USD/JPY	(3)	39.38*	746.29	24.30	892.00*	1080.40*			0.03
		(1.66)	(1.39)	(1.25)	(1.67)	(1.82)			
	(4)	38.01*	755.93	24.99	954.75**	1071.25**	219.66**		0.08
		(1.64)	(1.45)	(1.43)	(2.01)	(2.14)	(2.20)		
	(5)	33.15*	777.11	5.14	587.01	735.85	299.36***	242.21***	0.24
		(1.73)	(1.57)	(0.28)	(1.44)	(1.59)	(3.54)	(5.00)	
USD/MXN	(3)	19.74	-2082.10**	-31.83	-678.74	241.43			0.01
		(1.36)	(-2.16)	(-0.98)	(-1.38)	(1.07)			
	(4)	15.48	-2005.10**	-19.39	-784.72	397.58	-50.75*		0.04
		(1.13)	(-2.07)	(-0.59)	(-1.54)	(1.44)	(-1.74)		
	(5)	10.55	-2013.68**	-15.21	-885.74*	598.08*	-42.37	34.52*	0.05
		(0.79)	(-2.02)	(-0.49)	(-1.71)	(1.85)	(-1.50)	(1.69)	
USD/PLN	(3)	48.13**	1160.65	-69.92**	-820.12	223.87			0.05
		(2.41)	(1.59)	(-2.19)	(-0.96)	(0.38)			
	(4)	36.80**	1321.04*	-50.03	-991.64	248.05	1377.11***		0.12
		(1.99)	(1.78)	(-1.57)	(-1.12)	(0.47)	(3.41)		

	(5)	36.90**	1315.43*	-49.82	-985.02	242.61	1378.79***	4.19	0.11
		(1.98)	(1.76)	(-1.55)	(-1.10)	(0.45)	(3.38)	(0.06)	
USD/SGD	(3)	8.93	-363.80	-17.30	-148.30	-16.39			-0.03
		(0.82)	(-0.78)	(-1.16)	(-0.56)	(-0.07)			
	(4)	7.70	-408.16	-12.15	113.98	-17.04	90.92***		0.08
		(0.63)	(-0.95)	(-0.73)	(0.52)	(-0.08)	(3.35)		
	(5)	-6.13	-74.78	-15.41	-76.99	168.40	161.09***	227.77***	0.37
		(-0.68)	(-0.23)	(-1.19)	(-0.38)	(0.85)	(6.33)	(5.36)	
USD/ZAR	(3)	-7.75	-401.13	-28.65***	-2829.39	1326.98*			0.04
		(-0.30)	(-0.19)	(-0.92)	(-3.13)	(1.92)			
	(4)	-19.21	908.34	26.17	-801.41	1154.52*	281.89***		0.20
		(-0.72)	(0.49)	(1.02)	(-0.83)	(1.95)	(3.77)		
	(5)	-18.15	782.40	21.36	-839.23	1175.76**	288.02***	24.34*	0.21
		(-0.68)	(0.42)	(0.79)	(-0.86)	(1.98)	(4.05)	(1.80)	

Table 17: Model Comparison in Sub-samples: Euro Pairs

Table shows adjusted $\bar{R}^2$ for all five model specifications for two different Sub-samples (Sample: January 2004 - January 2009 & February 2009 - February 2014). For each currency pair the highest adjusted $\bar{R}^2$ (best goodness of fit) is marked as bold. Hybrid (1) refers to a hybrid Taylor rule model, including market order flows. Hybrid (2) refers to a hybrid Taylor rule model, which includes market order as well as limit order flows as additional regressors.

	Sample: January 2004 - January 2009						Sample: February 2009 - February 2014				
	Evans & Lyons	Kozhan et al	Taylor Rule	Hybrid 1	Hybrid 2		Evans & Lyons	Kozhan et al	Taylor Rule	Hybrid 1	Hybrid 2
EUR/USD	0.05	0.22	0.11	**0.24**	**0.24**	EUR/USD	0.00	**0.57**	0.10	0.46	0.55
EUR/CHF	0.00	0.00	**0.02**	0.01	0.00	EUR/CHF	0.00	0.00	0.00	0.00	0.00
EUR/CZK	0.00	0.23	0.00	0.12	**0.29**	EUR/CZK	0.01	0.28	0.02	0.20	**0.27**
EUR/GBP	0.00	0.00	0.00	0.00	0.00	EUR/GBP	0.18	0.17	**0.19**	**0.19**	0.17
EUR/HUF	0.00	0.00	0.00	0.00	0.00	EUR/HUF	0.00	0.42	0.03	0.38	**0.42**
EUR/JPY	0.00	0.14	0.04	0.16	**0.18**	EUR/JPY	0.00	0.15	0.05	0.18	**0.19**
EUR/NOK	0.02	**0.31**	0.01	**0.31**	0.29	EUR/NOK	0.07	**0.24**	0.04	0.06	0.22
EUR/PLN	0.00	**0.27**	0.03	0.23	0.26	EUR/PLN	0.00	0.09	0.11	**0.17**	0.16
EUR/SEK	0.00	**0.39**	-0.02	0.37	0.36	EUR/SEK	0.01	0.11	0.14	0.15	**0.16**

Table 18: Model Comparison in Sub-samples: US-Dollar Pairs

Table shows adjusted $\bar{R}^2$ for all five model specifications for two different Sub-samples (Sample: January 2004 - January 2009 & February 2009 - February 2014). For each currency pair the highest adjusted $\bar{R}^2$ (best goodness of fit) is marked as bold. Hybrid (1) refers to a hybrid Taylor rule model, including market order flows. Hybrid (2) refers to a hybrid Taylor rule model, which includes market order as well as limit order flows as additional regressors.

	Sample: January 2004 - January 2009						Sample: February 2009 - February 2014				
	Evans & Lyons	Kozhan et al	Taylor Rule	Hybrid 1	Hybrid 2		Evans & Lyons	Kozhanet al	Taylor Rule	Hybrid 1	Hybrid 2
USD/CAD	0.04	0.41	0.14	0.43	**0.48**	USD/CAD	0.24	0.54	0.24	**0.58**	0.57
USD/CHF	0.00	0.02	0.05	0.04	**0.14**	USD/CHF	0.03	0.02	0.02	0.02	0.01
GBP/USD	0.00	0.01	0.16	0.18	**0.20**	GBP/USD	0.13	0.47	0.11	**0.50**	0.49
USD/ILS	0.00	0.12	0.00	**0.13**	0.11	USD/ILS	0.12	**0.17**	0.08	0.16	0.15
USD/INR	0.03	0.28	0.16	0.34	**0.35**	USD/INR	0.08	0.05	0.05	0.03	0.01
USD/JPY	0.00	0.29	0.04	0.20	**0.36**	USD/JPY	0.02	**0.25**	0.02	0.09	0.22
USD/MXN	0.00	**0.27**	0.07	0.06	**0.27**	USD/MXN	0.08	0.15	0.05	**0.19**	0.17
USD/PLN	0.00	0.06	0.06	**0.13**	0.12	USD/PLN	0.17	**0.24**	0.14	0.23	0.22
USD/SGD	0.00	**0.48**	0.03	0.23	0.46	USD/SGD	0.08	**0.43**	0.09	0.17	0.40
USD/ZAR	0.02	0.33	0.01	0.35	**0.37**	USD/ZAR	0.23	**0.31**	0.22	0.26	0.30

Table 19: Model Comparison: Quarterly Frequency

Table shows adjusted $\bar{R}^2$ for all five model specifications. Data frequency is at the quarterly domain, whereby quarterly values represent the average value of three consecutive months. For each currency pair the highest adjusted $\bar{R}^2$ (best goodness of fit) is marked as bold. Hybrid (1) refers to a hybrid Taylor rule model, including market order flows. Hybrid (2) refers to a hybrid Taylor rule model, which includes market order as well as limit order flows as additional regressors. Sample period covers January 2004 to February 2014. (40 quarterly observations)

	Evans & Lyons	Kozhan et al	Taylor Rule	Hybrid 1	Hybrid 2
			Euro Pairs		
EUR/USD	0.00	**0.13**	0.00	0.03	0.11
EUR/CHF	**0.09**	0.07	0.04	0.05	0.03
EUR/CZK	0.03	0.12	0.05	**0.19**	0.18
EUR/GBP	0.00	**0.09**	0.00	0.00	0.02
EUR/HUF	0.00	0.00	0.04	**0.06**	0.03
EUR/JPY	0.14	0.12	**0.14**	**0.14**	0.12
EUR/NOK	0.00	0.08	0.02	**0.14**	0.12
EUR/PLN	0.05	0.16	0.17	**0.22**	0.20
EUR/SEK	0.00	0.00	0.00	0.00	0.00
			US Dollar Pairs		
	Evans & Lyons	Kozhan et al	Taylor Rule	Hybrid 1	Hybrid 2
USD/CAD	0.13	0.25	0.27	0.37	**0.41**
USD/CHF	0.00	0.00	0.00	0.00	0.00
GBP/USD	0.00	0.12	0.24	0.22	**0.25**
USD/ILS	0.00	0.20	0.03	**0.24**	0.22
USD/INR	0.01	0.00	0.00	0.00	**0.02**
USD/JPY	0.00	0.06	0.00	0.03	**0.14**
USD/MXN	0.00	0.00	0.00	**0.01**	0.00
USD/PLN	0.04	0.04	0.23	**0.28**	0.26
USD/SGD	0.00	0.00	0.00	0.00	0.00
USD/ZAR	0.02	0.13	0.17	0.27	**0.32**

Table 20: Model Comparison: Heterogenous Taylor Rule Components

Table shows adjusted $\bar{R}^2$ for all five model specifications, whereby we allow for heterogenous Taylor rule specifications. Data frequency is at the monthly domain. For each currency pair the highest adjusted $\bar{R}^2$ (best goodness of fit) is marked as bold. Hybrid (1) refers to a hybrid Taylor rule model, including market order flows. Hybrid (2) refers to a hybrid Taylor rule model, which includes market order as well as limit order flows as additional regressors. Sample period covers January 2004 to February 2014.

	Evans & Lyons	Kozhan et al	Taylor Rule	Hybrid 1	Hybrid 2
			Euro Pairs		
EUR/USD	0.02	0.26	0.11	0.29	**0.32**
EUR/CHF	0.00	0.00	0.00	0.00	0.00
EUR/CZK	0.00	**0.18**	0.00	0.12	0.17
EUR/GBP	0.00	**0.14**	0.00	0.13	0.13
EUR/HUF	0.00	**0.08**	0.00	0.07	0.07
EUR/JPY	0.05	0.21	0.05	0.19	**0.22**
EUR/NOK	0.00	0.17	0.03	**0.19**	0.18
EUR/PLN	0.00	0.12	0.02	**0.16**	**0.16**
EUR/SEK	0.00	0.06	0.00	**0.07**	0.06
			US Dollar Pairs		
	Evans & Lyons	Kozhan et al	Taylor Rule	Hybrid 1	Hybrid 2
USD/CAD	0.04	0.40	0.09	0.41	**0.42**
USD/CHF	0.00	0.00	**0.04**	**0.04**	0.03
GBP/USD	0.00	0.13	0.11	0.21	**0.23**
USD/ILS	0.00	0.09	0.01	**0.12**	0.11
USD/INR	0.03	0.03	**0.06**	**0.06**	0.05
USD/JPY	0.00	0.18	0.01	0.07	**0.22**
USD/MXN	0.00	0.01	0.02	**0.03**	0.02
USD/PLN	0.00	0.08	0.06	**0.12**	**0.12**
USD/SGD	0.00	0.38	0.00	0.09	**0.37**
USD/ZAR	0.03	0.17	0.02	0.19	**0.20**