



Exchange Rate Determination: Mixed Microstructural and Macroeconomic Approach

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ABSTRACT

This paper represents a new approach in the exchange rate determination by using microstructural and macroeconomic variables. We test a combination of fundamentals and microstructure variables in cointegrated relationship of the USD/JPY and USD/GBP currencies' pairs. The 'twofold' model includes interest rate, money supply and net foreign assets as fundamentals, and spread and high-low spread as a microstructure variable. Then we compare the different models of macroeconomic and twofold model with the random walk using an error-correction method. We find that the twofold model outperforms the random structural model in out-of-sample and in-sample forecast test for both exchange rates. Twofold model outperforms in out-of-sample forecast the random walk test for the USD/JPY.

Keywords: Exchange Rate, Spreads, Interest Rate, Money Supply, Net Foreign Assets, Twofold Model, Cointegration

JEL Classifications: G15, G17, G18, F31, F62

1. INTRODUCTION

Along the history of exchange rate determination, visions differ from the macroeconomic approach (Hinkle and Montiel, 1944; 1999) to the new theory of microstructural interference. The macroeconomic disconnect puzzle stands as a turning point in the evolution of structural models to include, as main microstructural factor, the order flow in valuing currency. Intuitively, the exchange rate has two dimensions every policymaker must consider. On one side, the exchange rate is a price relevant to the production and consumption of goods and services whose movements are correlated with the change of the competitiveness and the consumption inside the country. On the other side, it is also an asset price relevant to the national investment inside and outside the borders, which can respond to the news, rumors and even expectations. Any jump in the currency price disrupts the demand of the country's product, *ceteris paribus*, and the competitiveness of the economy. Similarly, the investment sentiment faces a refuge to the 'green' zone, less risky currency, leading to portfolio decomposition shifts when money can

flow from one to other securely as a medium of exchange (Kallianiotis, 2013).

Exchange rate is the main result of the whole nation in term of economic policy, society development and financial market stability (Jeffrey, 2015). Eventually, history is full of balances and counterbalances of power between the main nations (Barry et al., 2018) which make currency an up-to-date subject for journalists, researchers and analysts. And for a whole time, the interest rate indicator has stood as a fundamental instrument in explaining a wide range of the exchange rate variability. Empirical works prove that the foreign/domestic interest rate differential is twisted with other fundamentals to explain the expected appreciation of the domestic currency: the Uncovered Interest Parity (UIP) approach¹. Even with the wide diversification of the exchange rate regimes,

¹ The basic idea of the uncovered rate (UIP) is to relate the exchange rate to the interest rate showing that when the interest rate of the domestic country is higher (lower) than the foreign country by an amount equal to the expected depreciation (appreciation) of the exchange rate.

interest rate intervenes in the comparison of the de jure and de facto classification alongside nation's currencies (Reinhart and Rogoff, 2004). Unfortunately, the regime classification depends on other macro-economic factors and in risk reigned from volatilities and political decisions (Levy-Yeyati and Sturzenegger, 2005; 2010); (Bleaney et al., 2016).

The focus on the long-term real exchange rate depends on two factors according to previous literature: the productivity differential and the Net Foreign Assets. A decrease in asset holdings of the U.S citizens realizes a more current account deficits, ceteris paribus, more capital inflows, which appreciates the domestic currency "U.S. Dollar" to reasonable values or to an equilibrium point. In our model, we include NFA as explanatory parameter of exchange rate.

The money supply is another macroeconomic factor who resists for a long time to be included in many models. For decades, the money supply was of much importance in the exchange rate determination as many studies tract the amount of money flowing to predict the exchange rate (Levin, 1997; Cushman and Zha, 1997). In our model, we will use the M1 of money supply to stress the resistance of paper money in explaining the currency dynamic, especially with the new technology evolution.

After the relaxation of many theories based on fundamentals in the literature of the exchange rate determination (MEESE and ROGOFF, 1983), microstructure of currency market disposes a real new approach for the exchange rate determination. Generally, order flow is the sum of the initiated-buy orders and the initiated-sell orders carrying different signs in contrast with the volume of transactions. In currencies' markets, dealers (market makers) are the best informed as much as their orders flow can anticipate the returns better than individual traders do. Order flow has a strong correlation with macroeconomic fundamentals and a powerful predictor of the exchange rate fluctuations (Rime et al., 2010). To summarize, the microstructure foundation admits the heterogeneity of the market participants through that they have effects on the short-run currencies' price and the exchange rate volatility. But those influences differ from the long horizons to the very short runs.

Many models in the literature try to capture the exchange rate using its relationship with three decisive elements in the international financial markets, which are the central bank decisions, investors' risk bearing capacity and governments' decisions. These policy makers and financial intervenants are among the most influential elements in exchange rate determination and forecast literature, and their actions on the international markets are very tractable by many research papers in order to make the currency weaker or stronger and create costs and benefits, ceteris paribus, losers and winners.

After dealing with the most common trends and the different issues of exchange rate, we find that governments must face many important decisions in their path for installing an effective exchange rate policy. Additionally, monetary authorities always keep attention to different economic parameters and social stability in varying its monetary tools like interest rate. Investors

are the catalyzer of the market by absorbing the information and interpreting current and future announcements, then their decisions relate on different variables on long and short-run where they reflect their attitude in rebalancing their portfolios. Numerous models try to link the different variables affecting the exchange rate. Monetary models represent the central banks reaction in dealing with different settled targets of currency's value. Furthermore, macroeconomics variables focus on households and governments interaction on the international market leading to exchange rate adjustments. With the emergence of the microstructure approach, theorists find more sense in highlighting the investors' interpretations role in pushing up or down the currency's price. We suppose that a combination between the macroeconomic fundamentals and microstructural variables can lead to get better forecast of the future exchange rate. Spreads and order flow may impose a more crucial role in installing a more adequate equation for determining the currency value. To verify those assumption, we will use a cointegration relationship to verify the long run and short run effects in an error correction model.

The remainder of this paper will be structured as follows. Section 2 presents the theoretical framework to build our model. Section 3 describes the data and the methodology. Sections 4 and 5 present the results for USD/JPY and USD/GBP exchange rates, respectively, and Section 6 concludes.

2. THEORETICAL MOTIVATION

2.1. Structural Models: Monetary Models

The exchange rate and the interest rate differential are positively (negatively) correlated in the long (short) horizons (Chinn and Zhang, 2018) which make the UIP more powerful to predict the exchange rate at long horizons. It seems that the interest rate parity holds mostly in long horizons because of the fictions in the market when the UIP is a form of efficiency in the market. Chinn and Zhang (2018) using a New Keynesian dynamic stochastic general equilibrium model, prove the poor evidence of interest differential to exchange rate on long run and especially on short run. Most of the earliest empirical works prove the useless of the interest rate in predicting the exchange rate (MEESE and ROGOFF, 1983). Instead, other empirical results find the strong relation of the interest rate parity and the uncovered interest rate in long and short horizons by introducing the risk premium (Meredith and Chinn, 1998; Alexius, 2001). Their model discusses the short run and long run effect of monetary variables on the G-7 countries using a cointegration test to verify the effect of interest rate and other fundamentals on exchange rate.

Groen (2001) analyzed a large data panel of the Euro-exchange rate with Canada, Japan and the U.S. the author found that monetary fundamentals behave more effective on long horizons than on short horizons using an out-of-sample and in-sample model. He found an important forecast factor for fundamentals of exchange rate in comparison of the classical random walk model in regard of the RMSE criterion. Cerra and Saxena (2010) used a larger data panel of 96 countries in order to study the prediction power of fundamentals in determining the exchange rate variability. They found a strong cointegration evidence between exchange rate and

fundamentals and better forecast of monetary model ahead of the random walk model.

The earliest models trying to find a more equilibrate exchange rate, such as the NATREX and the BEER, do not prove a strong possibility of cointegration (MEESE and ROGOFF, 1983). None of those models outperform the random walk using a mean squared error, instead, certain structural model outperform the random walk in term of direction of change (Cheung et al., 2005). Overall, a currency model with some specifications can do well in a defined period under a performance metric indeed of another currency model with different specifications.

Balancing between the monetary instruments in one hand, including net foreign assets and interest rates of the authorities, construct an important role to predict the exchange rate shifts and to determine the currency excess return (Della Corte et al., 2016).

In the asset-pricing model, portfolio balance models try to explain the exchange rate in term of the risk exposure (BRANSON, et al., 1977). This shift toward an exchange risk premium measured in term of government bonds or swaps leads to many failures in the literature. Frankel and Engel (1984) studied six major currency by testing the classical CAPM model with likelihood estimation of the mean variance components. They found poor evidence about the exchange rate portfolio-balancing model and the risk exchange premium.

The analysis of the exchange rate forecasts undergoes a dramatic change after the emergence of the cointegrating vector in testifying the long run relationship between exchange rate and fundamentals. Introduction of error correction term in cointegrated equation can measure the altitude of re-equilibrium of exchange.

Money supply is the sum of the currency and other liquid instruments (saving accounts, coins, cash...) circulating in the economy for a specified period. For decades, the money supply was of much importance in the exchange rate determination as many studies tract the amount of money flowing to predict the exchange rate (Levin, 1997; Cushman and Zha, 1997).

Recent studies shows that even the announcements by the monetary authorities and their anticipation affect the exchange rate and the investors' returns, and the currency excess returns is high in the announcements day opposing to the interest rate differential (Mueller et al., 2017).

2.2. Structural Models: Macroeconomic and Disconnect Puzzle

Transfer effects play a central role in many open economy macroeconomics models to shed the light on the role of the NFAs positions as a state variable that can illustrate the temporary shocks in the governments' policy shifts and investors' behavior on the asset prices (Obstfeld and Rogoff, 1995; Lane and Milesi-Ferretti, 2001). An increase in the government spending induces a depreciation of real exchange rate and a higher private consumption. Real exchange rate co-moves positively with a private consumption shock, and holds a strong relation with

non-traded goods in response to the government spending shocks (Monacelli and Perotti, 2010).

Ricci et al. (2008) studied the long-term determinants of the real effective exchange rate over 1980-2004 in a panel of 48 countries (combining advanced economies and emerging market economies) and found that government consumption is highly significant. Moreover, the estimated coefficient is economically large: A 1 percentage point increase in the ratio of government consumption to GDP is associated with 3 percentage points' appreciation of the real effective exchange rate.

To follow more the nature of this relationship, (Gagnon 1996) studied an annual data panel of 20 countries from 1960 through 1995 using the Phillips-Loretan estimator in a cointegrated model. He used leads and lags regression to examine the Deutsche Mark variability relation with Balassa-Samuelson productivity effect and, government consumption and Net Foreign Asset. Net Foreign Asset is calculated as the combination of exports and imports adjusted by the income where an increase in NFA induces an appreciation of the imports and exports summation. Gagnon (1996) found that an increase of NFA generates an appreciation of exchange rate for about 20% in short run and 10% in long run. Net foreign assets are significant for countries that face external constraints and low savings, and for countries with high trade-balance (Chinn and Ito, 2008; Christopoulos et al., 2012). Cavallo and Ghironi, (2002) extend the (Obstfeld and Rogoff, 1995) model by emphasizing the exchange rate determination and its relationship with net foreign assets. They found that the today's value of the currency depends on the accumulated net foreign assets in the previous period, and a capital inflow (net foreign debt) lead in general to exchange rate appreciation.

Sachs and Wyplosz (1984) stress the impact of the net foreign assets and the public spending on the real exchange rate. They found that even the composition of the spending and the taxation policy make a real influence. The 'transfer problem established earlier by John Maynard Keynes in 1929 is an essential factor in explaining the relationship of the Real Exchange Rate (RER) and NFAs (Lane and Milesi-Ferretti, 2004). For countries whose exports denominated mainly in their domestic currencies, the terms of trade become reasonably exogenous to the nominal exchange rate. Recently, many analyses who focus on the developed countries and take the cumulative current account as an approximation of NFA, found that a higher NFA are associated with a depreciated currency in the long run (Lane and Milesi-Ferretti, 2004).

The counterpart of the currency-NFA influence channel is that an observed ratio about net exports to net assets holds information about the future exchange rate changes. Gourinchas and Rey (2005) found a predictable power of the NFA (a ratio of net exports to net foreign assets) in exchange rate movements. Using a cointegration model, a sample data is able to predict the variance of the exchange rate more significantly on the long horizons. Even the out-of-sample has a powerful forecast in determining the exchange rate at all horizons, and it can beat the random walk model.

Transfer effects play a central role in many open-economy macroeconomics models to shed the light on the role of the NFAs positions as a state variable that can illustrate the temporary shocks in the governments' policy shifts and investors' behavior on the asset prices (Obstfeld and Rogoff, 1995; Lane and Milesi-Ferretti, 2001).

In empirical analysis of exchange rate, many structural models based on the macroeconomic fundamentals face difficulties in terms of models' ability to fit the data and to forecast (in sample and out-of-sample analyzes). Data differs from a country to another because of the different structural specification (exchange regimes, fiscal policy...) and the different stage of development for each one of them. This problem is among the most challenging difficulties in the international macro-puzzles (Obstfeld and Rogoff, 2000). We speak generally of a disconnect problem which means a lack or a break of correlation between macroeconomic variables and exchange rate variation.

The market exchange rate is more volatile than its macroeconomic variables. The disconnection between exchange rate and macroeconomics is considerably proved in many empirical models. The fundamentals variables are not always observable, then estimating their measurements may contain potentially large errors.

After a massive debate about the exchange rate and its relation with fundamentals, some authors have tried to prove the incorrectness in measuring fundamentals as the reason of the disconnect puzzle (Cheung et al., 2005; Engel and West, 2005). Nowadays, with many other measurements used to tract an exchange-fundamentals relation, many authors conclude that the disconnect puzzle is a robust phenomenon. This phenomenon needs to be explained, not to be denied. The main idea of the Purchase Power Parity (PPP) puzzle is to highlight the weak relationship between exchange rate and national prices.

2.3. Micro-foundation Models: Spreads and Order Flow

Discussing the microstructure approach stresses two variables that represent the new hallmarks in the exchange rate analysis. These variables are widely discussed in fragmenting the financial market into some micro-components. Order flow and spreads show a strong explanatory power to many financial market's frictions. In our approach, we try to find the spread role as one of the exchange rate determinants after failing in gathering data about order flow. Spread can be the best solution to replace the order flow because of three main reasons: historical, scientific and practical (Lyons, 2001).

Historically, spread is a subject of many micro-based models tending to separate the classical point of view in which investors have rational expectations. Tightness or wideness of spread can clarify the environment inside the market and the information "war." The scientific reason lies in an easily collection of ask and bid prices of different assets and their readiness to test hypotheses, except for exchange rate where spread positivity does not give a complete information. Practically, managing risk and costs is

a common interest for market participants by which research course must keep attention to these interactions and the message transmitted to the asset values such as currency.

Earliest literature does not show the real effect of many microstructure variables, other than the order flow, on exchange rate. They assume their little effect. In order to focus on altering trading mechanism on the value of currency, we discuss the transaction cost spread effect on the exchange rate, directly and combined with high low difference. Tightness of spread/exchange rate relationship leads many researches to ignore it in favor of other variables. Order flow is a better informative instrument because it shows the symmetric information between investors and the frequency of intervention in foreign exchange market.

The importance of exchange rate spreads lays in the mechanism of determination, three main costs faced by dealers. The most important cost is whose results are the fruit of dealing with asymmetric information. Dealers know that customers are sometimes more informed than they expect, which lead to a money loss. If dealers can identify easily the best-informed investors, asymmetric information will not be a big problem in setting the spread. Moreover, dealers must care the market risk and the big-players interventions on the market by increasing the width of the quoted spread. Identifying risk and its significance still so difficult, so dealers need an element of remuneration by using the ask-bid spread. Dealers like customers set the spread on the historical market movement and events. If informed and uninformed investors separation in the market is easily identified, dealers can set different spread incorporating their adverse selection components (Easley and O'Hara, 1987).

For empirical findings, many results show that adverse selection is important in determining spreads on the foreign exchange market. (Lyons, 1995) in a daily analysis of DM/\$ exchange rate found that the dealers analyze the data coming from order flow frequency and volume to modify their exchange rate spread. Yao (1998) tracts the spread in the interbank foreign exchange market spread decomposition of the intraday \$/DM exchange rate spread. He found that dealers construct their spreads in accordance with the adverse selection component. Dealer bears about one-third of the total adverse selection model due to the risk sharing among interdealers trade market. The adverse component accounts only for about 17% of the total quoted spread, which reflect the weak private information in the currency market.

Naranjo and Nimalendran (2000) highlighted the effect of spread variability following a government's intervention on the FX market. They chose a monthly dataset from January 1976 to December 1994 of the Deutsche Mark and American dollar exchange rate. Results support the hypothesis of spread change accordingly to unexpected intervention trades. After decomposing interventions across the FX market into expected and unexpected, they find strong evidence about spread reaction toward expected intervention, unexpected intervention alike.

The ask-bid spread embeds in the multivariate informative tools to many assets in the financial market. Spreads do not carry only

the investor and dealer behavioral, but they support a strong relation with the volatility inside the market. Market makers face the risk of a volatility shock by increasing the width of the quoted spread as a compensation of their future possible losses. The relationship between spread and volatility can be adjusted with other microstructure factors such the number of trades or the volume of transaction. High-low prices reflect the altitude of trades in the market and the degree of volatility in times of burst and booms. In our approach, we try to adjust the spread by dividing them on the high low value of currencies.

Order flow has a strong correlation with macroeconomic fundamentals and a powerful predictor of the exchange rate fluctuations (Rime et al., 2010). The order flow could be driven by the ‘push-pull’ mechanism. The well-informed investors –so-called ‘push’- are the active customers in the market, and their actions initiate the price movements to push the exchange rate up or down. The less-informed investors, generally the individual traders motivated by the price movements, intervene in the market to take opposite positions. They are the “pull” investors.

3. METHODOLOGY AND DATA COLLECTION

3.1. The Data Collection

The used data are monthly from February 1990 to September 2018 for the monetary model of exchange rate, and from December 2008 to September 2018 to test the microstructure effect on the exchange rate. Generally, micro-based models rely on order flows or spreads to highlight the effect of FOREX market structure on future exchange rate. Order flows data were extracted commonly from Electronic Brokerage System (EBS) or from the Eikon Reuters in the earliest research papers (tract the Deutsche Mark) of Evans and Lyons. In our days, order flow data are so difficult to access because of their exclusivity on the EBS database or other banks datasets. In our empirical analyses, we try to construct an approximate variable to order flow informative aspect with a combination of spread and high and low difference. To close this gap in data, we collect monthly information about high and low exchange rate difference and ask-bid prices of exchange rate from the Eikon Thomson Reuters. Data are in link with one of the biggest interdealer foreign exchange market (EBS).

Dealers use Ask and Bid to protect themselves from undesirable investors’ interventions and to identify the more informative investors. Accordingly, spread varies in order to correct the dealers’ market positions if there are shifts in investors’ behavioral or market conditions. Most of the microstructure literature does not use the spread in their empirics; they believe that spreads are positive and poor. In the opposite way, a connecting part of informative panel between investors, dealers and currency’s price lays in the spreads’ percentage of change weighted. in our empirical work, we build a new microstructure factor called “spread,” Figures 1 and 2 show that spread factor fluctuates in the same way of exchange rate, and holds the same amplitude in high movement and low variation.

Figure 1: USD/JPY fluctuation in term of the log spreads: amplitude of change

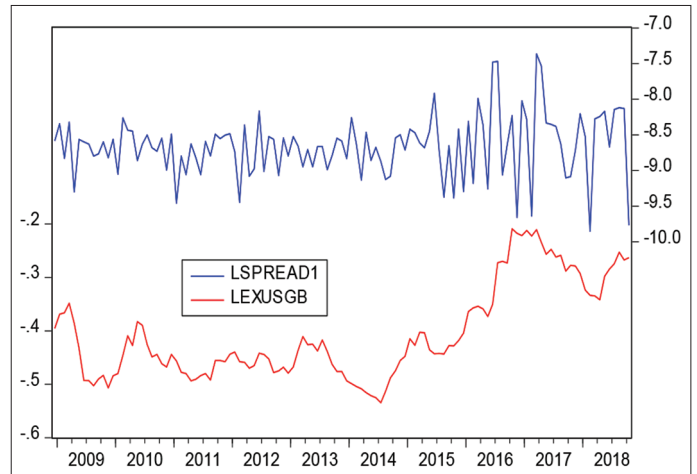
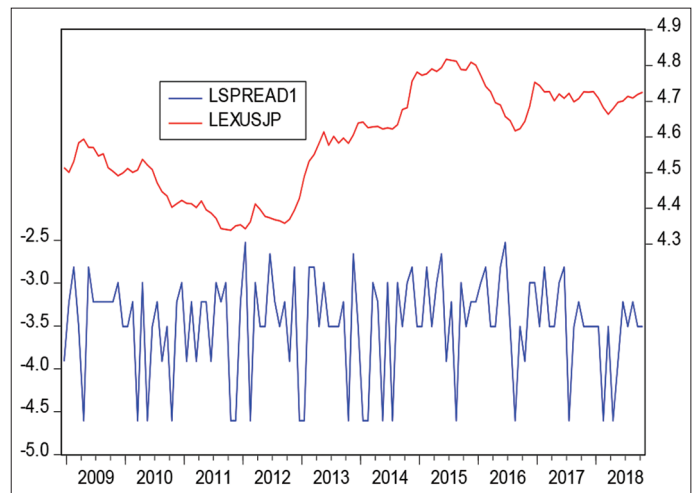


Figure 2: USD/JPY fluctuation in term of the log spreads: amplitude of change



To choose the counties’ available for our sample, we take into account the tri-lemma issue.

Most of the microstructure approach depends only on the order flow to show the strong evidence of investors’ decisions in the short-run variability of exchange rate. Order flows stress investors-dealers interactions so that currency value incorporates investors behavior and dealers reaction. To hold the same informational aspect, we use two new variables in order to incorporate maximum information in our explanatory model. The first factor is the log spread to obtain negative numbers, which are more appropriate to cointegrated models. Spreads are important indicator of the market volatility and risk holding by dealers. The second factor is combination between high-low difference and spread variation to the spread average (the average is calculated on a full sample period). Spread variation weighted by high-low difference may hold strong information about dealers influence on price variability and its target in long run and short-run. High-low price difference is usually used in microstructure as a volatility indicator and a measurement of the transaction volume in the market. Spread variations propose a solution to overcome the positivity problem as

we can see in Figures 3 and 4. Dealers change their remuneration following a shift in risk or in investors' behavior. Investors' private information can be transferred to the market into price variation or transaction volume so that high and low difference varies. To test the explanatory power of spreads and high-low spreads, we use cointegration test model to verify their long-term effects, and we construct an error correction model to verify their short-run effects on exchange rate.

Interest rate data are monthly and short-term aspect that contribute to a more significant information about the exchange dynamic on long and short horizons. To measure the United States interest rate, we use the 3-month treasury bill yield extracted from the Federal Reserve Economic Data. Government bonds are the first determinant of confidence of foreign and domestic households in the U.S government policies... A short-term interest on 3-month treasury bills in Japan is extracted from international financial statistics by which we highlight the Japanese short-run interest rate. 3-month or 90-days interest rate (yields) on government bonds represents the measure of interest rate in the United Kingdom, and its performance is important to determine the interbank sector. Data was collected from the international financial statistics on a monthly frequency.

We use the short-run money supply M1 as another monetary factor. M1 is initiated from the currency in circulation and other checks excluding bank deposits and mutual funds' deposits. M1 can highlight the closet money circle to exchange rate. Money

Figure 3: Log spread and high-low spread information distribution of the USD/JPY

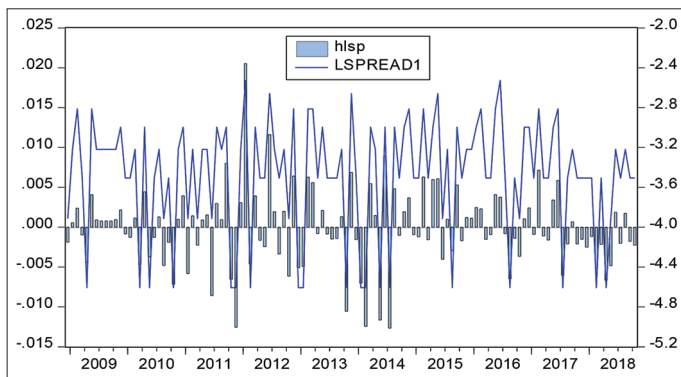
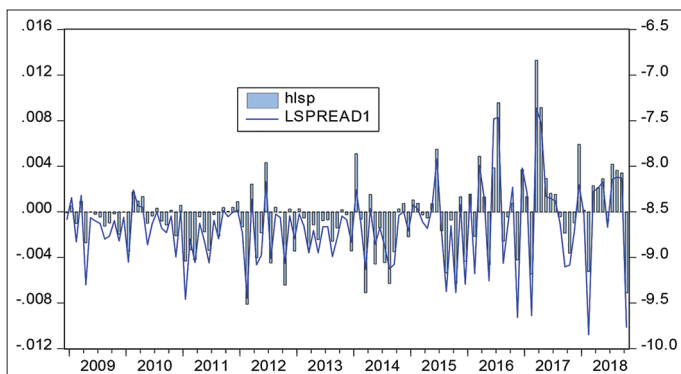


Figure 4: Log spread and high-low spread information distribution of the USD/GBP



supply data are from international monetary fund database, the international financial statistics.

In order to capture the influence of capital flows on the exchange rate, we use the net international investment position as an indicator of a country's net position. Net international investment position is the result of a nation's foreign assets minus its foreign liabilities, which is very closely to the net foreign assets. Classical theories of exchange rate use the balance of payments as a measure of the capital inflow and outflow. The most common measurement of net foreign asset is the Lane and Milesi-Ferretti (2001) method whose calculation is based on determining net position of nations adjusted for current account. In our approach, Net International Investment Position (NIIP) are the total assets owned by a country. NIIP are extracted from the International Financial Statistics (IFS) database from 1990 to 2018 in an annual frequency. 2018 data are the average of the first two quarters of the year. To convert data from annual to a more high frequency distribution, we have used the Chow and Lin (1971) regression-based method that finds values of a lower-frequency $y(t)$ by relating it to a higher-frequency series $x(t)$ using the following equation:

$$y_i = X_i \beta + \mu \tag{1}$$

Where β is a vector of coefficients, and μ is a random vector with mean zero and covariance vector v . y_i and X_i are $3n \times 1$ and $3n \times p$ matrix. The originated method establishes a generalized least squares to estimate the covariance matrix by assuming an AR (1) errors. In Eviews, there is another model to estimate time series for the model:

$$\mu_t = \rho \mu_{t-1} + \epsilon_t \tag{2}$$

Where ϵ_t follows a normal distribution $N(0, \sigma^2)$. The absolute value of ρ is inferior to one. ρ and β are estimated with the maximum likelihood and the Kalman filter on Eviews.

3.2. Cointegration Model

The cointegration notion means a linear combination of two or more time series, when each one of them is integrated in order one $I(1)$, is automatically integrated in order zero $I(0)$. Instead of showing a spurious regression of one variable on another, Cointegration means a long-run relationship among them. Integrated series imply an error correction model to scan the short-run dynamics.

The first apparition of the Cointegration model was in the (Engle and Granger, 1987) papers to make a meaningful regression of the $I(1)$ variables. They try to describe the main issues and methods involved, mathematically, in many applications, and they show the strong relationship of Cointegration and error correction model. Cointegration phenomenon is extensively discussed over the two past decades. Authors describe it as a solution of non-stationary component in a time series linear that propose some combinations of a stationary time series. A wide literature attempts to build some economic models based on Cointegration such as consumption function, purchasing power parity and spot exchange rate.

The first step is to use unit root tests in order to find the number of integrations into a raw of data series. Secondly, economic theory suggests verifying the cointegration by a direct run of the test. The third step is based on the precedent regression with test for cointegration that runs an appropriate unit root test for residuals. After verifying the cointegration test and its order, we pass through the lagged residuals to estimate error correction term in the error correction model. However, other studies confirm the existence of biases in small samples, in spite of considerable excellent proprieties in large samples. Therefore, results consistency has a relation with sample size in estimating a cointegrated regression and its step's order. Numerous research papers replace the fourth step by a full estimation of the error correction model in order to get more accuracy in estimating the long-run model jointly with short run dynamics, better than to estimate it separately.

4. MODEL CONSTRUCTION

4.1. Structural Model: Effectiveness of the Long-term Variables

Structural models can hold many macroeconomic variables depending on the objective of the research of which effect to stress. In our paper, the objective is to find determinants that are more effective to show the role of investors, government and monetary authorities in the short and long-run variation of exchange rate. Monetary policy and government policy effectiveness are usually measured with macroeconomic variables, instead investors' intervention lay in the microstructure variables. In the first step, we test a structural model using a classical ordinary least squared (OLS) method on large dataset to show the contribution of each factor in long horizons of exchange rate. The interest rate and money supply are the two instruments merely influenced or taken by the central banks, and Uncovered Interest Parity and (Dornbusch, 1976) overshooting monetary model are the most important representation of these variables.

$$s_t = \Delta(i_t - i_t^*) + \varepsilon_t \tag{3}$$

To test fundamentals, we construct a model based on three fundamental components inspired by the uncovered interest rate parity. In a stick price environment, exchange rate depends on

interest rate, money supply and net foreign asset differential. Currency determination follows relative factors that drive the exposition of countries on the international market such as foreign assets held by domestic households. This first step gives more significance to the results of cointegration test with a large sample to test of long run variables whereby a test of every factor weight on the exchange rate.

$$-s_t = \beta_0 (i_t - i_t^*) + \beta_1 \Delta(i_t - i_t^*) + \beta_2 \Delta(m_1 - m_2^*) + \beta_3 \Delta(NFA_t - NFA_t^*) + \mu_t \tag{4}$$

Where NFA is the net foreign assets, m is the money supply. Fundamentals show a strong stationary significance on a large data set. Table 1 indicates that major variables are stationary in the first difference for both dollar/yen and dollar/pound exchange rate for both tests. The null hypothesis of the unit roots test is the stationarity of a variable that we accept if the p-value is below 5% in our model. We implement two types' tests to confirm the stationarity of the variables in first differences, the (Elliott et al., 1996) test and the classical augmented Dicky-Fuller ADF. Almost variables are stationer in both tests except for USD/GBP interest rate differential, which is significant only on the ADF test. We use a trend and intercept in the tests and a Schwarz Info Criterion to verify the variables length over a maximum of 11 lags.

Foreign assets and money supply can improve the model explication in the long-run. Investors and government can borrow more in case of more money circulation in the country giving possibilities of more investments. Investments in foreign countries make investors in need to foreign currencies and to hedge the risk of exchange rate fluctuation. Accordingly, investors intervene in the FX market or change their altitude of investments in regard of the currency value. Table 2 shed the light on the importance of NFA in improving the model explanation of fluctuation. Adj.R² increases from 9.8% in the old overshooting model in [3] to more than 12% when we add the foreign position to the model for the USD/JPY. For the USD/GBP, country's foreign exposure improves the explanatory power from 6% to 9% with the same amplitude of 3% as the USD/JPY. In contrast, NFA does not hold a significant coefficient for both exchange rates. Long-run coefficients chosen in our model are significant in the analysis of exchange rate at short term and long term.

Table 1: Unit root test: large sample

Unit root test of the structural model variables: from 1990m02 to 2018m10								
	USD/JPY				USD/GBP			
	Levels							
	Lexusjp	M1diff_usjp	Intdiff_usjp	Nfa-usjp	Lexusgb	M1diff_usgb	Intdiff_usgb	Nfa-usgb
ERS	-1.04230	0.583942	-2.403350	1.90268	-2.67515	-1.710973	-1.986293	-1.722966
ADF	-2.96684	-1.015283	-2.707710	0.24030	-2.63658	-1.706392	-1.883606	-2.234579
P-value	(0.0391)	0.7488	0.0737	0.9748	0.2642	0.7466	0.6608	0.4683
First differences								
ERS	-1.01281	-7.868912	-2.848484	-7.10851	-5.25084	-2.769609	-1.915121	-8.098826
ADF	-13.6466	-14.66770	-3.964302	-7.87050	-13.8354	-9.777412	-8.534864	-8.113046
P-value	0.0000	0.0000	0.0018	0.0000	0.0000	0.0000	0.0000	0.0000

Unit root test using the (Elliott et al., 1996) Dicky-Fuller (ERS) and the classical ADF tests statistics with a constant and trend. Lag length are used a Schwarz Info criterion allowing to 11 lag in maximum. Numbers in Boldfaces are significant at 10% msl. Critical values: ERS (*, **, *** for usd/jpy [-1.616079 [-1.941753] [-2.571741]], usd/gbp [-3.474100] [-2.901800] [-2.590650], **, *** for usd/jpy [-2.571239 (-2.869800) (-3.449332) usd/gbp (-3.985199) (-3.423058) (-3.134451). P-values in parentheses are significant at 5%. ADF: Augmented Dicky-Fuller

Table 2: Regression model for macroeconomic and monetary variables: from 1990m02 to 2018m10

Coefficient	USD/JPY				USD/GBP			
	[1]	[2]	[3]	[4]	[1]	[2]	[3]	[4]
Constant	4.655437 (0.030334)	4.653771 (0.030120)	4.654247 (0.030269)	4.661600 (0.030696)	-0.441034 (0.029142)	-0.442959 (0.029654)	-0.440276 (0.029138)	-0.434787 (0.031428)
Int. differ	0.020465 (0.009290)	0.020713 (0.009132)	0.020786 (0.009141)	0.021301 (0.008917)	0.014685 (0.0087420)	0.014034 (0.008854)	0.015192 (0.008710)	0.015829 (0.009125)
Δ(int. diff)		-0.123029 (0.0064)	-0.126559 (0.044930)	-0.149139 (0.045236)		0.033279 (0.036803)	0.034289 (0.036968)	0.021681 (0.033544)
Δ(M1diff)			5.62E-05 (8.60E-05)	4.47E-05 (8.34E-05)			0.000213 (0.000247)	0.000192 (0.000239)
Δ(NFA)				2.67E-07 (1.56E-07)				1.69E-07 (1.48E-07)
R ²	0.075654	0.104565	0.106282	0.134600	0.052021	0.057346	0.066632	0.093527
Adj.R ²	0.072951	0.099297	0.098373	0.124358	0.049257	0.051818	0.058396	0.082831
N	343	343	343	343	343	343	343	343

Δ is the first difference. Dependent variable is the log of exchange rate, dollars per foreign currency unit. OLS regression coefficients (Newey–West robust standard errors in parentheses with 6 Bandwidth length). Boldface denotes coefficients significant at the 10% marginal significance level. “Int. diff.” is the bond interest differential, in percentage, NFA is the net foreign assets in billions of USD and M1diff is money supply differential of M1 money supply

4.2. The Hybrid Models

After the replication of the Evans and Lyons (2002) to verify the idiosyncratic aspect, Chinn and Moore develop a model with more explicative variables and a recent dataset. The model is based on some macroeconomic variables (money supply M2, industrial production and interest differential) augmented with the order flow accumulation. Using a (Johansen, Statistical analysis of cointegration vectors, 1988) cointegration test, they find a strong evidence about the order flow effect on the exchange rate in long and short run. Results are less remarkable in comparison with Evans and Lyons. The first model to combine micro and macro fundamentals is the ‘hybrid’ model of Evans and Lyons in 2002;

$$\Delta s_t = \beta_0 + \beta_1 (i_t - i_t^*) + \beta_2 (of_t) + \beta_3 \Delta(i_t - i_t^*) + \mu_t \quad (5)$$

Where: of_t is the order flow.

This model was a subject to many empirical subjects to testify the effect of order flow in combination with other monetary variables in explaining exchange rate. Chinn and Moore (2011) find that the explanatory power of the model increases when levels order flow is added to monetary fundamentals. Interest rate differential lose its effectiveness after adding the order flow to the model in the dollar/euro exchange rate. In general, the addition of order flow reduces the significance of interest rate because order flow can hold information about the interest rate. they conclude that the order flow date are not the artifact of high-frequency date in accordance with (Berger et al., 2008) whose research paper find a weaker significance of the following model at lower frequency. These results are may be attributable to the transitory effect of order flow on prices including the exchange rate.

Key variables in our research are displayed in Figures 5 and 6 to show the causality effect between the two variables for both dollar/pound and dollar/yen. Note that the exchange rate in term of USD/GBP and USD/JPY is impacted positively by the modified spread (adjusted with high and low prices). Even the non-modified spread holds a positive effect on the exchange rate variability; statistically and econometrically when we run a regression between the two

variables. Currency’s future values depend on both the spread and the high low spread.

As a result of this unique microstructure approach of assets history and specificity in financial modeling, it will be necessary to adopt some variables of FOREX microstructural market to explain financial aspect in exchange rate variation. What is certain to happen though, is that the microstructure variables will evolve to a better overview of the currency value.

$$hlspt = \frac{sp_t - (\frac{1}{n} \sum_{i=1}^n sp_i)}{h_t - l_t} \quad (6)$$

Where sp : the spread of both exchange rates, h : is the high value of the currency value in the month and l : is the lowest. The spread adjusted by high low values ($hlspt$) depends on the dealer’s adjustments of spread regarding spreads’ average overall the period (10 years in our sample). To study the various components of microstructure discussed above on the contemporaneous exchange rates on different frames of temporal length, we run a cointegration test on the following general model to highlight its effects on the long run, and we study the error correction model to find the equilibrium component held in our mode:

$$\Delta s_t = \beta_0 \Delta(i_t - i_t^*) + \beta_1 \Delta(m_t - m_t^*) + \beta_2 \Delta(NFA_t - NFA_t^*) + \beta_3 MC_t + \mu_t \quad (7)$$

This model represents the pursuit of (Lyons, 2001) theory to exploit the microstructure effects in pricing assets where spread and order flow realize the best indicator in microstructure to include in an exchange rate model. Our approach highlights two variables, the so-called MC in our model, by including the direct effect of spread (log spread) and the indirect effect (transformed spread).

4.3. Error Correction Model

Error correction model and co-integration are historically and strongly related in the literature. Many economic models discuss the importance of doing such tests. The purpose of ECM is to correct the disequilibrium of a period in the next one. For instance, prices are dependent on demand whereby prices in the current

Figure 5: Regression function of USD/JPY exchange rate first log difference and high-low spread

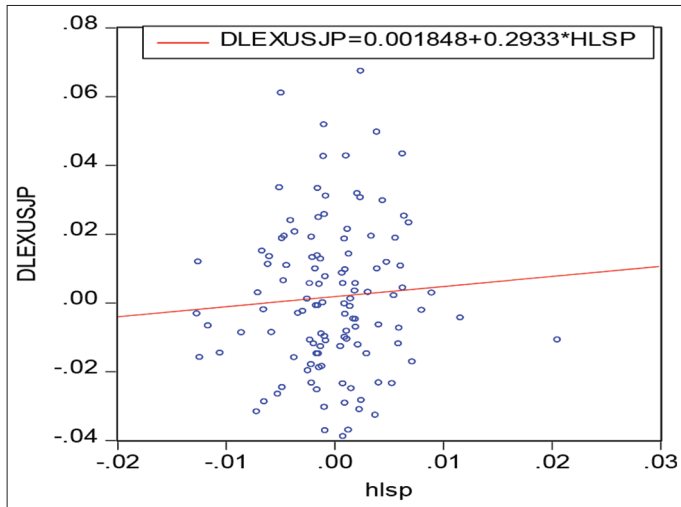
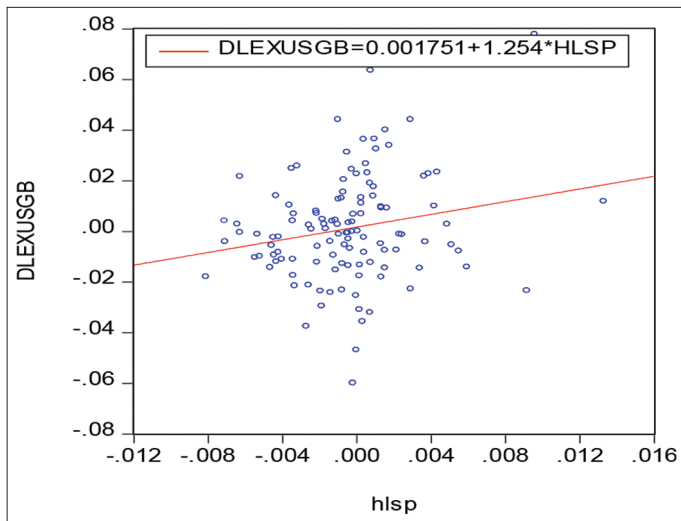


Figure 6: Regression function of USD/GBP exchange rate first log difference and high-low spread



period are subject in the demand’s behavior shift in previous period. Error correction model is a time series data analyses model that shows the first differences of the variables. It contains an error correction term in order to bring two or more I (1) series into long-run equilibrium. The adjustment process in some error correction models may involve an optimal behavior in term of costs and incomplete information.

$$\Delta y_t = \beta_0 + \sum_{i=1}^n \beta_i \Delta y_{t-i} + \sum_{i=0}^n \delta_i \Delta x_{t-i} + \varphi z_{t-1} + u_t \quad (8)$$

Z is the error correction term of the model and OLS residuals following a long-run cointegration regression:

$$y_t = \beta_0 + \beta_1 x_t + \varepsilon_t \quad (9)$$

Error correction models are necessary after doing the cointegration test for allowing us to study the short-run dynamics in the relationship among variables (exogenous and endogenous).

Estimating with ECM follows a common procedure. First step is to specify an econometric model with an exact number of lag structures using some relative tests on all the explanatory variables including differenced and lagged values of dependent variables. Secondly, the precedent equation must be reformulated in a simpler way, serving to a more easily interpretation by building a term by which we can determine the long-run equilibrium timing. This term is a major feature of the ECM model, this so-called error correction term represents the long-run achievement (negative error correction terms are the most significant). Another feature of the model is to have an explicit form of this long-run equilibrium rather than being in an implicit form. The explicitly is produced by the famous error correction term. Every time we have more than one equation, VAR models do not satisfy to estimate economic models, and we must employ the vector error correction model VECM.

4.4. Out-of Sample Forecast

Forecasting in financial economics stills not an accurate tool to find robustness and validity of econometric models. Its task must be taken under proportions and alternatives when finding the best forecast model. Forecasting financial prices represents a numerous probability of future prices depending on contingent relation between outcomes of a current decision and the events that will happen in the future. Theses future propositions are valid for exchange rate in relation with many variables such foreign investment, currency strategies and macroeconomic variables. This inaccuracy in forecasting asset prices can be evaluated to build comparisons with forecasting scenarios or models. In order to verify the robustness of the microstructure variables in explaining exchange rate, we compare the ‘twofold’ model, monetary model and random walk.

Out-of-sample forecasting is an evaluation method of models’ robustness. The first study of (MEESE and ROGOFF, 1983) has compared an out-of-sample prediction of classical monetary models and the random walk model of exchange rate in a horizon of 1 year; their results give advantage to the random walk in predicting. Chinn and Meese (1995) conducted a similar study of exchange rate based an out-of-sample prediction of error correction term and the predicted change on a horizon up to 4 years. Lately, Cheung et al. (2005) and Cheung et al. (2019) used the same method of out-of-ample rate prediction on structural models and random walk on a horizon up to 20 quarters using a root of mean squared errors and a change factor to compare the random walk predictions with the other models. As this has become a tendency in exchange rate literature, our model shall pass through the prediction test to prove its robustness and its prediction power. Therefore, we test the out-of-sample rate forecasts in levels for United States, United Kingdom and Japan error correction model with those of a random walk. The evaluation criterion in our approach is the Root Mean Squared Error (RMSE) for the log exchange rate level with the other models:

$$RMSE = \sqrt{\frac{1}{T-t_0-w} \sum_{t=t_0}^{T-w} e_{s,t+h}^2} \quad (10)$$

Where t_0 is the first observation in our period to forecast, w is the forecasting horizons and $e_{s,t+h}$ generates the forecast

error of the model in prediction affected on the log exchange rate levels in comparison with actual log exchange rate level.

5. RESULTS ANALYSIS

5.1. Descriptive Statistics

In the first structural model tested in the previous chapter, descriptive statistics in Tables 3 and 4 for dollar/pound and dollar/yen show that most of the variables keep a normal through the 1990m02 to 2018m10 period. Kurtosis in most of cases is negative except for the interest differential, which indicates that the distribution is inclined more on the left side. D denotes in the Table 3 the first difference of the variables. NFA and money supply are in billions of dollars. Kurtosis tells us that not all the distributions follow a normal distribution. For the USD/GBP in Table 4, interest rate and log exchange rate are below the critical value (3) whereby those variables are normally distributed, instead the rest of the variables hold some a non-normal distribution. For the USD/JPY in Table 4, we add the money supply to the log exchange rate and interest differential in the list of seemingly normal distribution according the kurtosis.

- Microstructural model

In a small sample, from 2008m12 to 2018m10, distribution of variables changes their altitude in term of normality and distribution tails. For the USD/JPY descriptive statistics in Table 5, first difference of net foreign assets and money supply change their Skewness value to positive by which tails are adjusted to the right side. Kurtosis shows that only the log spread is below the critical value, other variables do not show a large difference from normality value. For the USD/GBP descriptive statics in Table 6,

most of the variables hold a Skewness positive value except for the money difference, money supply is largely under the normality critical value with about 27 of kurtosis. Distribution is sharp in the middle oppositely to a normal distribution.

5.2. Test of First Difference Stationarity: Unit Root Test

We approve the stationarity of different endogenous variables by rejecting the unit root tests' in two test specifications, the (Elliott et al., 1996) (ERS) and the classical Augmented Dicky-Fuller (ADF) with intercept for the USD/JPY variables, and intercept and trend for USD/GBP variables. In Table 7, all variables for USD/JPY model are significant for ADF test. The Number of lags for every explanatory variable is based on the Schwarz Info Criterion where first difference of microstructure variables holds an important number up to six lengths giving more dispersed information than the macroeconomics variables.

In Table 8, we test the unit root test of USD/GBP variables for the two-test specification. As for the USD/JPY, ADF test indicates that all the variables are first difference stationary in term of the critical values and the p-values. To determine the lag length of every variable, we use the Schwarz Info criterion with a maximum of 11 lags. Microstructural variables show a more important number of lags like the USD/JPY variables. This important lag length is probably due to the important information held by the spread and their dispersion along the variation in the value of currency.

5.3. Optimal Length and Johansen Cointegration Test

In the previous section, we have demonstrated that most of the macroeconomic fundamentals –interest rate differential,

Table 3: Descriptive statistics of USD/GBP: 1990m02 to 2018m10

	Lexusgp	Dintdiff_usgp	DNFA_usgp	Dm1diff_usjp	intdiff_usjp
Mean	-0.475261	0.015145	-22556.70	0.043793	-2.337573
Median	-0.469003	0.030800	-11650.33	-0.682562	-2.509600
Maximum	-0.209450	0.820574	393457.0	166.9235	1.619784
Minimum	-0.727597	-0.930000	-546721.0	-462.9466	-6.280000
Std. Dev.	0.107805	0.246287	106536.7	49.76736	1.673607
Skewness	-0.064555	-0.274646	-0.638195	-4.268457	0.066623
Kurtosis	2.967042	4.176173	8.356995	45.58022	2.262297
Jarque-Berra	0.254495	24.15315	434.6808	27032.01	8.054756
Observations	344	344	344	344	344

D is the first difference, dependent variable is the log of exchange rate, intdiff is the interest difference, m1diff is the money supply difference, NFA is the net foreign assets

Table 4: Descriptive statistics of USD/JPY: 1990 m02 to 2018m10

	DNfa_usjp	Dm1diff_usjp	Dintdiff_usjp	Lexusjp	intdiff_usjp
Mean	-32140.45	-2100.004	-0.003590	4.694936	1.966035
Median	-22366.69	-2336.339	0.002000	4.703594	1.351000
Maximum	233754.4	-85.15116	0.687000	5.065493	5.788000
Minimum	-472373.7	-4682.099	-1.145000	4.339158	-0.844000
Std. Dev.	92773.62	1301.660	0.204825	0.144070	1.945475
Skewness	-1.101209	-0.038352	-1.154548	-0.475671	0.436143
Kurtosis	6.796444	1.856038	8.941941	3.194369	1.645702
Jarque-Bera	275.3094	18.78687	580.7931	13.47461	37.08696
Probability	0.000000	0.000083	0.000000	0.001186	0.000000
Observations	343	343	343	343	343

D is the first difference, dependent variable is the log of exchange rate, intdiff is the interest difference, m1diff is the money supply difference, NFA is the net foreign assets

money supply, and net foreign assets- are stationary at their first difference. Simultaneously, they appear to be integrated in the first order as the first step of cointegration test. The second step to evaluate the cointegrated vectors is to affect lag length criteria of the structural model, and the structural model augmented with two-microstructural variables in their first differences then in their levels denominated the ‘twofold’ model.

The most common measures of optimal length are the Akaike Information Criterion (AIC) and the Schwarz Info Criterion (SIC). The two-criterion show that the short length in the VAR specification are 2 or 3. In contrast, when we apply the autocorrelograms up to 8 length, we can see more correlation between variables in lags greater than 3. Meanwhile, applying the VAR model to variables makes residuals apparently uncorrelated. We

Table 5: Descriptive statistics of USD/JPY Sample: 2008M12 to 2018M10

	Dlexusjp	Dintdiff_usjp	Dm1diff_usjp	DNfa_usjp	ISpread_usjp	hlsp_usjp
Mean	0.001756	0.018376	-3.078487	-39753.07	-3.475795	-0.000184
Median	-0.000849	0.004000	-20.32154	-35990.71	-3.506558	-0.000790
Maximum	0.073792	0.200000	369.2456	233754.4	-2.525729	0.020536
Minimum	-0.038918	-0.052000	-844.9863	-293718.7	-4.605170	-0.012670
Std. Dev.	0.022565	0.046110	153.4186	101293.6	0.586644	0.004921
Skewness	0.697848	1.811444	-0.953068	0.054231	-0.823415	0.263516
Kurtosis	3.533977	5.862651	9.765778	3.218972	2.737429	5.312816
Observations	117	117	117	117	117	117

D denotes the first difference; lexusjp is the log of usd/jpy exchange rate. Lspread is log of usd/jpy exchange rate spread. M1diff_usjp is the U.S-Japan M1 difference in billions of dollar. Intdiff_usjp is U.S-Japan interest differential in percentage. Hlsp_usjp is usd/jpy spread change weighted by high-low difference. Nfa_usjp is U.S-Japan net foreign position difference in millions of dollar

Table 6: Descriptive statistics of USD/GBP sample: 2008M12 2018M10

	Dlexusgp	Dintdiff_usgp	Dm1diff_usgp	dNfa_usgp	hlsp_usgp	ISpread_usgp
Mean	0.001122	0.018305	3.822921	-38901.32	-0.000502	-8.656576
Median	-0.000609	0.005000	7.006924	-49143.68	-0.000438	-8.628584
Maximum	0.077826	0.200000	157.4663	244377.5	0.013296	-7.362026
Minimum	-0.059854	-0.052000	-462.9466	-266775.1	-0.008108	-9.848775
Std. Dev.	0.020768	0.045919	74.74873	107888.6	0.003339	0.437633
Skewness	0.495694	1.823005	-3.994363	0.390978	0.776773	0.059241
Kurtosis	4.574552	5.920741	26.62183	2.622252	5.401642	4.101213
Observations	118	118	118	118	118	118

D denotes the first difference; lexusgp is the log of usd/gbp exchange rate. Lspread is log of usd/gbp exchange rate spread. M1diff_usgp is the U.S-U.K M1 difference in billions of dollar. Intdiff_usgp is U.S-U.K interest differential in percentage. Hlsp_usgp is usd/gbp spread change weighted by high-low difference. Nfa_usgp is U.S-U.K net foreign position difference in millions of dollar

Table 7: Unit root test for dollar/yen time series’ variables: 2008M12 to 2018M12

	Lexusjp	M1diff_usjp	Intdiff_usjp	hlsp_usjp	Nfa_usjp	ISpread_usjp
Levels						
ERS	-1.853789	-1.233188	7.676901	-12.42792	0.301552	-9.790873
Lag	2	1	2	0	2	0
ADF	-2.188809 (0.4909)	-1.252427 (0.6497)	6.905283 (1.0000)	-13.28997 (0.0171)	-1.278552 (0.6378)	-12.27114 (0.0000)
First differences						
ERS	-6.974553	-4.800137	-0.901692	-1.718846	-2.864528	-0.961407
Lag	0	1	3	6	1	6
ADF	-7.888803 (0.0000)	-8.649745 (0.0000)	-2.552335 (0.1001)	-9.816787 (0.0000)	-4.427284 (0.0005)	-10.08038 (0.0000)

Unit root test using the (Elliott et al., 1996) Dicky-Fuller (ERS) and the classical augmented Dicky-Fuller (ADF) tests statistics with only a constant. Lag length are used a Schwarz Info Criterion allowing to 11 lag in maximum. Numbers in Boldfaces are significant at 10% msl. Critical values: ERS (*, **, ***) for -1.614927 (-1.943563) (-2.584707), (*, **, ***) for -3.152153 (-3.453179) (-4.047795). P-values in parentheses are significant at 10%

Table 8: Unit root test for dollar/pound time series’ variables

	Lexusgb	M1diff_usgb	Intdiff_usgb	hlsp_usgb	Nfa_usgb	ISpread_usgb
Levels						
ERS	-1.409655	-1.637500	-1.833834	-9.878872	-1.944291	-10.64963
Lag	0	1	1	0	2	0
ADF	-2.100494 (0.5399)	-0.675236 (0.9721)	-1.742720 (0.7259)	-10.71428 (0.0000)	-2.320825 (0.4191)	-11.85805 (0.0000)
First differences						
ERS	-3.793103	-2.537909	-7.431526	-0.685320	-2.931032	-1.945488
Lag	0	1	0	11	1	5
ADF	-9.384304 (0.0002)	-5.469544 (0.0001)	-7.457444 (0.0000)	-6.618941 (0.0000)	-4.325378 (0.0041)	-7.605958 (0.0000)

Unit root test using the (Elliott et al., 1996) Dicky-Fuller (ERS) and the classical ADF tests statistics with a constant and trend. Lag length are used a Schwarz Info criterion allowing to 11 lag in maximum. Numbers in Boldfaces are significant at 10% msl. Critical values: ERS (*, **, ***) for -2.725000 (-3.015000) [-3.562000]), (*, **, ***) for -3.149922 (-3.449365) [-4.039797]). P-values in parentheses are significant at 10%. ADF: Augmented Dicky-Fuller

fix the optimal lag length criteria for testing the (Johansen, 1988) cointegration test by 3.

After fixing the optimal length, we use it in the (Johansen, 1988) maximum likelihood procedure to verify the presence of cointegration and the number of the possible cointegrated vector in every model. We report the results of cointegration test in Table 9. The structural model test represents the first three columns in order to involve the macroeconomic specifications.

Columns 4 to 6 highlight the cointegration test of the structural model to which we add high-low spread and log spread variables. Columns 2 and 5 allow for a constant in both exchange rate USD/GBP and USD/JPY for the cointegration equation, columns 1 and 4 test for cointegration equation with a no constant and no trend, columns 3 and 6 involve a constant and trend in the cointegration equation. Columns 2, 3, 5 and 6 allow for a linear deterministic trend in the data, instead columns 1 and 4 assume no deterministic trend in the data.

Results in parentheses indicate the number of cointegrating vectors using the two-common test of cointegration, trace and maximal eigenvalue. Respectively, the left number indicates number of cointegrating vectors with Trace criteria, and right number is for the maximum eigenvalue criteria.

Analyzing the Table 9 indicates some difficulty in finding evidence of cointegration in structural model-money, net foreign assets, and interest rate differential-. We use the Akaike Info Criterion to choose the cointegrated vectors with minimum lag length. The selected specification for USD/JPY exchange rate under the structural model is a cointegrating VAR equation with a constant . In contrast, chosen USD/GBP by the AIC does not show a strong evidence of cointegrating relation using a constant and trend in the VAR equation. Ultimately, there is no definitive evidence in concluding that structural model is cointegrated

On the other hand, for the twofold model, cointegrating relation is significant in the case of a constant and a trend embedded in

Table 9: Johansen cointegration test; sample 2008M12 to 2018M10

	Monetary model			'twofold' model		
	[1]	[2]	[3]	[4]	[5]	[6]
Usd/gbp						
Statistic	(0,0)	(0,0)	(0,0)	(1,1)	(1,2)	(2,1)
Prob	(1,1)	(0,0)	(1,0)	(1,1)	(2,2)	(2,2)
Usd/jpy						
Statistic	(1,1)	(1,0)	(2,0)	(3,2)	(2,2)	(4,2)
Prob	(1,1)	(1,1)	(2,2)	(3,3)	(3,3)	(3,2)

The number of cointegrating vector with maximal eigenvalue statistics and trace statistics using 1% of marginal significance level. Statistic denotes the variables with more the 1% critical value. Prob is (Mackinnon et al., 1999) P-values significant at 0.05. Columns [1] and [4] include no trend and intercept in the VAR and in the cointegrating equation. Columns 2 and 5 allow for intercept in cointegration and VAR. columns 3 and 6 indicate a trend and intercept in cointegrating equation and no intercept in the VAR. 'monetary model' is composed from exchange rate, money, net foreign assets and interest rate. 'Twofold' model includes in addition to monetary model spread and high-low spread. Bold numbers are the lowest AIC specification for the single cointegrating vectors. usd/gbp results allow for 3-lags specification in the levels-VAR specification. Usd/jpy allows for 2-lags in levels-VAR specification

the cointegrating relation and VAR equation for both USD/JPY and USD/GBP exchange rate. USD/GBP are significant even with only a constant included in the cointegrating relation and the VAR equation. Results are more significant when we include the microstructural variables to the model, and they show more evidence for the USD/GBP than the USD/JPY in the twofold model.

What we retain from the cointegration test is that the structural model of exchange rate show a less important evidence of cointegrating equation, at least insofar the microstructure variables (high-low spread and log spread) are included. We assume that there is mostly one cointegrating vector for structural model and twofold model in testing USD/JPY model. For the USD/GBP, we suppose that one cointegration is included for the structural model test and two cointegrated equations for the twofold model test.

Our results highlight the effectiveness of microstructural variables (high-low spread and log spread) in determining the long-run exchange rate in combination with the classical macroeconomic factors. The vector error correction model can test the efficiency of exchange rate variables after assuming that a cointegration relation exists among the variables. The spread variables are stationary even in levels. We test their effects in both the first difference and levels model by augmented the error correction model with spreads variables in their levels.

Since Cointegration test is a tool used in econometric to verify if variables hold an explanatory power in long-term for exchange rate variation. it appears so that macroeconomic variables combined with microstructural variables are important for exchange rate process in long run.

5.4. Long-term and Short-term Test of the Model: Vector Error Correction Model

We estimate our model in order to differentiate the long run and short-run coefficients model by implementing the following error correction model, we take the equation that exhibit the exchange rate as the dependent variable

$$\Delta s_t = \sum_{i=1}^3 \tau_i X_{t-i} + \sum_{i=1}^3 \rho_i s_{t-i} + \varphi (s_{t-1} - X_{t-1} B) + \vartheta_t \quad (11)$$

Where X is a vector of structural variables, spreads and high low spreads using a three lag length. is the error correction term whose value must be negative to and largely different from zero to hold a significant information about the long-run respond of exchange rate deviation to its equilibrium. B holds the vector of cointegrating coefficients. ϑ_t is the error coefficient.

We run a VECM with three lags and one cointegrating equation to test both exchange rates USD/JPY and USD/GBP, except the twofold model of USD/GBP when we use 3 lags and two cointegrating vectors. We report the results in Tables 10 and 11 of structural model and structural model augmented with spreads variables. We obtain in all cases a negative and significant error correction term. Exchange rates follow a long-run linear

Table 10: USD/JPY monetary and twofold exchange rate regression and ECM results:2008M12 2015M12

Coefficient:	[1]	[2]	[3]	[4]
Error correction term	-0.001597 (0.000719)	-0.039943 (0.014019)	-0.001668 (0.000760)	-0.001742 (0.000664)
Augmented short-runs levels coefficients				
Spread			0.002772 (0.007885)	0.003868 (0.008106)
Lag Spread				-0.006475 (0.008906)
H-L spread			0.008987 (0.741059)	-0.001941 (0.765876)
Lag H-L spread				0.951276 (0.756690)
Long-run coefficients				
Lag interest rate	0.054461** (0.004364)	-0.112064** (0.050115)	0.057712** (0.007117)	0.058243** (0.007057)
Lag money	0.000174** (2.56E-06)	-0.000110* (4.74E-05)	0.000166 (4.72E-06)	0.000166 (4.68E-06)
Lag NFA	2.25E-10 (1.15E-09)	-1.50E-07 (2.87E-08)	-2.34E-09 (2.32E-09)	-2.27E-09 (2.32E-09)
Included short-run coefficients				
Lag spread		-0.844035 (0.093354)		
Lag H-L spread		88.28642*** (15.50459)		
Adj.R ²	0.080871	0.200265	0.066042	0.072429
SER	0.021155	0.019733	0.021325	0.021252
N	115	115	115	115
LM(8)	0.337251 (0.9183)	0.454055 (0.7932)	0.358108 (0.8984)	0.318842 (0.9209)
Q(8)	2.5007 (0.962)	2.4283 (0.965)	2.5089 (0.961)	1.4341 (0.994)
Q(12)	10.546 (0.568)	7.8235 (0.799)	10.175 (0.601)	7.5686 (0.818)

The first log difference of exchange rate is the dependent variable. Estimation of error correction model with nonlinear least squared using Newey–West robust (standard error in parentheses). The long-run coefficients in the first model are estimated using DOLS (2, 2), using Bartlett kernel, and Newey–West bandwidth up to 5. Coefficients for the first differences estimated with ECM are not reported. *Denotes one lag is significant in ECM, **denotes two lags, ***denotes the three lags are significant at 10% msl. Significance of the model is measured by Adj.-R2 and SER. Q (8) and Q (12) are the results of the Q-statistics test of serial correlation for the two orders 8 and 12, respectively. LM (8) test also the serial correlation for order 8 of the Breusch–Godfrey LM test statistics (P-values in brackets). Boldface denotes significance at 10% msl

Table 11: USD/GBP monetary and twofold exchange rate regression and ECM results:2008M12 2018M12

Coefficients	[1]	[2]	[3]	[4]
Error correction term	-0.023752 (0.006818)	-0.019187 (0.012979)	-0.022274 (0.007858)	-0.020923 (0.007344)
Spread			-0.077098 (0.025895)	-0.082458 (0.027489)
Lag spread				-0.047434 (0.024953)
H-L spread			13.95042 (3.766455)	14.46679 (3.574364)
Lag H-L spread				9.645201 (3.686398)
Long-run coefficients				
Lag interest rate	-0.023619 (0.041709)	0.036100 (0.024601)	0.039146* (0.023394)	0.036500 (0.022223)
Lag money	0.000352** (0.000130)	0.000197 (9.09E-05)	0.000179 (8.68E-05)	0.000158 (8.36E-05)
Lag NFA	2.69E-08 (2.64E-08)	-1.18E-08 (1.93E-08)	-1.30E-08 (1.89E-08)	-1.47E-08 (1.77E-08)
New long-run coefficients				
Lag spread		-0.045615*** (0.029215)		
Lag H-L spread		9.343751*** (4.066608)		
Adj.R ²	0.127775	0.234755	0.161950	0.194649
SER	0.019464	0.031245	0.019079	0.018703
N	115	115	115	115
LM(8)	0.662324 (0.6250)	0.549480 (0.6928)	0.598337 (0.6756)	0.185896 (0.9842)
Q(8)	1.4519 (0.993)	2.5106 (0.961)	1.2545 (0.996)	0.9429 (0.999)
Q(12)	4.7344 (0.966)	5.5739 (0.936)	4.7297 (0.966)	6.6829 (0.878)

The first log difference of exchange rate is the dependent variable. Estimation of error correction model with nonlinear least squared using Newey–West robust (standard error in parentheses). The long-run coefficients in the first model are estimated using DOLS (2, 2), using Bartlett kernel, and Newey–West bandwidth up to 5. Coefficients for the first differences estimated with ECM are not reported. *Denotes one lag is significant in ECM, ** denotes two lags, ***denotes the three lags are significant at 10% msl. Significance of the model is measured by Adj.-R2 and SER. Q (8) and Q (12) are the results of the Q-statistics test of serial correlation for the two orders 8 and 12, respectively. LM (8) test also the serial correlation for order 8 of the Breusch–Godfrey LM test statistics (P-values in brackets). Boldface denotes significance at 10% msl

relationship with the implemented coefficients, and have equilibrium or a conditional mean to revert.

We implement the error correction model with three lags to obtain the estimates of long-run and short-run coefficients. We estimate the short run coefficients in two ways. Firstly, we run the error correction model by combining fundamentals and spreads' variables, in this way microstructure variable are taken in their first difference. Secondly, we estimate exchange rate's error correction model in an ordinary least squared equation (OLS) by combining fundamentals in their first difference with level spreads variables.

Error correction models require always-endogenous coefficients to explain the dependent variable, testing weakly exogeneity of spread variables is essential in oldest approaches. We use the (Johansen, 1992) theorem to implement our ECM equation without instrumenting the value of weakly exogenous variable using an OLS.

Our equation is estimated using a nonlinear least square by including three lags of first differences of macroeconomic fundamentals. Then we add the spread and high-low spread to the model with three lags of the first difference, secondly, we add the contemporaneous microstructure variables to structural model,

finally we introduce the lagged spread and lagged high low spread to the precedent variables. In the pursuit of our general-to-specific methodology, the specificity of error correction model requires the minimum lag length to implement. Short lags lead to more accuracy and consistency in performing the model specifications. In our case, we choose to have three lags of first differenced fundamentals and spreads variables.

Correlations between variables pass through the Q-statistics test and the Breusch-Godfrey LM test. Reported results in Tables 10 and 11 reject the hypothesis of serial correlation between variables in all cases.

The estimation of coefficients with ECM is not very consistent in giving results' specification, and then we implement OLS estimation of the coefficients obtained by the model, except for the long-run coefficients estimated with a Dynamic OLS (DOLS). In the DOLS regression, we use fixed two leads and two lags of the right-hand-side variables with an estimation of the standard errors using the Newey-west bandwidth up to 6 incorporating a Bartlett Kernel.

Column 1 of Table 10 indicates that fundamentals affect the exchange rate in a cointegrating relationship confirming the regression relation between fundamentals and exchange rate on the long-run. Money and interest rate coefficients are significant in two lags in the ECM estimates giving a more important influence on two periods. In column 2, we test the significance of a cointegrating relation between short and long run variables and the exchange rate behavior where Spreads' variable enters into explaining the variation. The proportion explained with spreads entrance raises dramatically when we look at the Adj.R² measure, from 8% to more than 20%. High low spreads are significant in the three lags implemented in the ECM. Every 88% percent increase in the variable leads to about 0.19% increase in basis point of exchange rate (appreciation of the dollar in front of the yen). Money and interest rate are wrong signed in the estimation output, money supply loose some of its significance when we add the spreads' variables.

Columns 3 and 4 suggest that the log spread and high-low spread does not enter into cointegrating relationship with exchange rate. Microstructural variables are added as right-hand-variables into the model in their levels. Specifications in column 3 show that the significance of the model fall below even explanatory power of the structural exchange rate model, while it rises slightly from 6% to 7% if we add the first lag of levels log spread and the first lag of high-low spread. In both columns, 3 and 4, money supply loses its significance, instead interest rate holds on. High-low spread and log spread do not show any significance with wrong coefficients taken in their lagged spreads' variables.

We turn now to the USD/GBP regression results reported in Table 11. In column 1, we test the cointegrated equation of the structural model, and we find that the error correction terms are significant, although money supply is the only significant variable among fundamentals. In column 2, we add to the previous cointegrated relationship the spreads' variables, and then the

significance of the model rises from 13% to 23% as shown by the Adj.R². Coefficients of the high-low spread and log spread are significant at the three lag stages. Fundamentals lose their significance when we add the spreads variables into the error correction model estimates, although log spread holds a negative sign. In column 4, spreads variables and the first lag of high-low spread are statistically significant in their levels form. In contrast with USD/JPY results, importing levels microstructure variables to the model improve its significance, but it still below the explanatory power of twofold model. We conclude that results are controversial for both exchange rates where microstructure variables exhibit statistical significance for the USD/GBP in contrast with those findings of the USD/JPY. In both tables, spreads variables show a strong evidence of cointegrating relationship with exchange rate.

To conclude this section, we sum up all the results in the way of finding the best models to estimate the exchange rate. In both cross currencies, fundamentals combined with spreads appear to be significant in the long-run, instead fundamentals augmented with levels spreads show a significant evidence only for the USD/GBP exchange rate. Our new variable high-low spread is significant in both cointegrated relation leading to significant evidence of long-run explanatory power of the exchange rate variation. Obviously, in accordance with cointegrating results in Table 10, spreads hold a long run effects on the exchange rate except for the USD/GBP where spreads hold some short run explanatory power. To test the robustness of results, we pass through a Wald test to verify the coefficients causality and restrictions. Ultimately, we test the validity of the model using an in-sample and out-of-sample test.

5.5. Robustness

In order to test the Granger causality effects, we pass through the Wald test on the exchange rate variables' coefficients by implementing some linear restrictions. As we see in Table 12, most of the results reject the null hypothesis at 5% significance except for the USD/GBP structural model in column 1. Rejection of the no causality effect of coefficients on exchange rate give our models more predictive power in determining exchange rate in short-run. Structural model shows less causality effect on exchange rate in column 1, although adding spreads variables leads to less p-value. As a conclusion, a twofold model of exchange rate holds more predictive power in comparison with the fundamentals model.

6. FURTHER ANALYSIS AND VALIDATION

6.1. Test In-sample Forecast

Model validation is a primordial step in econometric procedure. For our model, we run two different validation tests: an in-sample

Table 12: Coefficients' restriction test: 2008m12 2018m10

	[1]	[2]	[3]	[4]
USD/JPY				
F-statistic	0.0256	0.0001	0.0394	0.0155
Chi-square	0.0173	0.0000	0.0270	0.0079
USD/GBP				
F-statistic	0.1425	0.0000	0.0046	0.0010
Chi-square	0.1258	0.0000	0.0019	0.0002

For understanding the 1, 2, 3 and 4 columns see notes of Tables 11 and 12. Values of f-statistic and chi-square are in P-values. They are significant at the level of 5% msl

stability test to tract the predictive power of the structural model beside the twofold model, and out-of-sample test to compare the forecasting performance of models.

In-sample stability test usually uses recursive residuals for N-steps or one-step-ahead recursive residuals. The predictive procedure in recursive residual test for period t is the difference between the actual observation and the predicted observation with the estimated parameter of $t-1$ observation in the sample.

Prediction's process using the recursive estimation must exhibit all the points in the sample repeatedly for more accurate information. Normality distribution of errors is the basic idea to verify the validity of the recursive test. The results of these sequential predictions are a forecast error that must be subject to normality test for identifying model stability. The recursive residuals test can be used in the validation of structural change, serial correlation, heteroscedasticity, and functional misspecification. In our case, we test the change in regression coefficients with the normality test of errors (Kianifard and Swallow, 1996).

We apply the one-step recursive test for the models of columns 1 and 2 of Tables 10 and 11 with an error correction models. We use ± 2 standard error to compare the structural model and the twofold model for both exchange rates USD/JPY and USD/GBP. More breaks of the recursive residuals in the standard errors line indicate less stability of coefficients in predicting the dependent variables. We report the test's results in Figures 7-10 for the structural and twofold models of both exchange rates. In Figure 7, the dollar/yen structural model indicates the existence of five breaks of the critical line confirming the instability of the structural model at the 10%. By contrast, the twofold model of USD/JPY residuals in Figure 8 show more stability with only three breaks of the critical line.

We turn now to the dollar/pound exchange rate in Figures 9 and 10. The twofold model show more stability then the structural model with only 4 breaks versus 7 breaks confirming the results of the dollar/yen even with different minimum significance level. Furthermore, even with n-step recursive residuals, structural model shows instability ahead of the twofold model. The unconstrained error correction model estimated using the OLS are the basic models to test in the recursive residuals test.

The creation of out-of-sample and forecasting models is a key step to the evolution of econometric exchange rate modelling. The pool of finding parameter specifications need to be expanded and in-sample evidence improved for more results' durability. Exchange rate modeling need to be incentivized by an initial sample, in our case up to December 2008, to implement a 'rolling regression' to the estimated error correction model to meet its out-of-sample forecasts produced, while the sample is moved up to the next observation in a repeated procedure. These actions would continue until the entire out-of-sample observations are "rolled" with this so-called historical simulation or the ex post realizations. This procedure is so close to a forecast evaluation more than a sample forecasting exercise by using a graph comparison among models and the main forecasting evaluation variables.

Figure 7: Recursive one-step-ahead residuals of twofold USD/JPY exchange rate

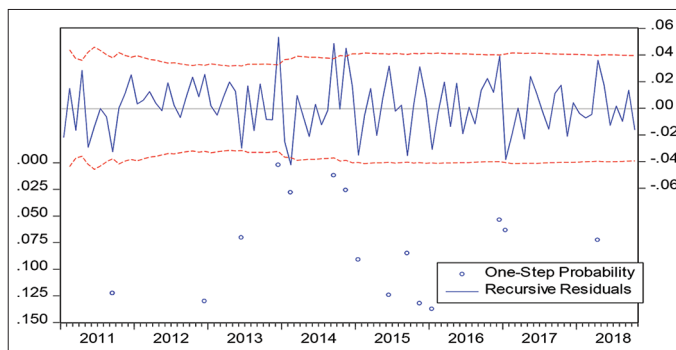


Figure 8: Recursive one-step-ahead residuals of the monetary model USD/JPY exchange rate

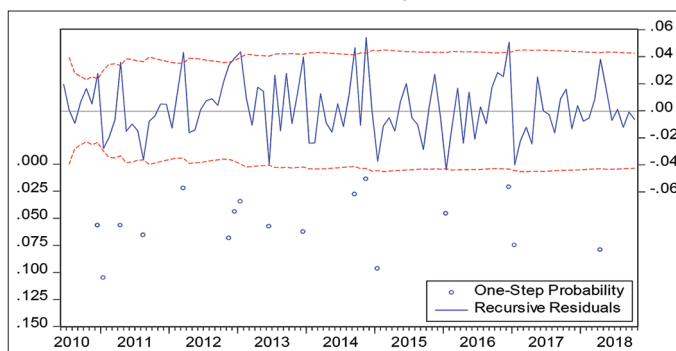


Figure 9: Recursive one-step-ahead residuals of monetary model USD/GBP exchange rate

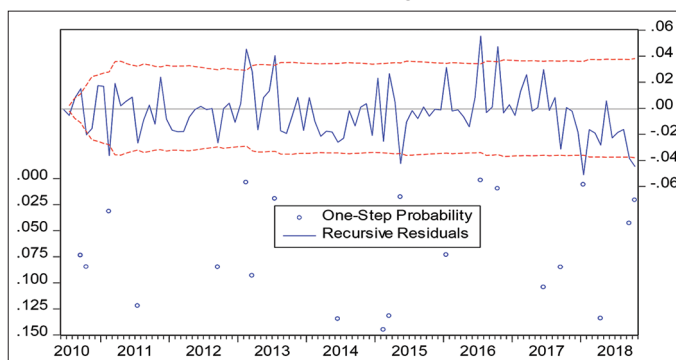
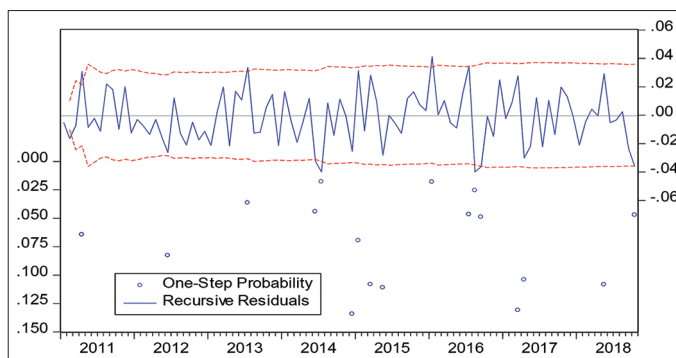


Figure 10: Recursive one-step-ahead residuals of twofold USD/GBP exchange rate



6.2. Out-of Sample Forecast

Standardized results of our results can help capture and leverage forecast data within the monetary model of Tables 10 and 11 (columns 1). To test the forecast performance of the twofold model we take the error correction model in columns 2 for both tables. Forecasts on different horizons give more robust assessment tools, and identify manual operational patterns of out-of-sample distribution. However, much of the results inconsistency comes from unstructured data that often exist in the different horizons of exchange rate variability. As a result, we evaluate the forecast performance of the structural model, random walk model and the twofold model on a horizons of 1, 3 and 6 months ahead. The sample length reserved to the out-of-sample forecast test, 3 years of observations for our test, limits the horizon of forecasting. Random walk model used in our forecast test is represented by the following expression:

$$s_t = s_{t-1} + \varepsilon_t \tag{12}$$

S is the log of exchange rate. We estimate the random walk using an ordinary least squared. The monthly forecasts are reported in Figures 11 and 12 for the structural model, twofold model and random walk model. The error correction specification in our forecast test is implemented in the forecast test with a recursive-cointegrated vector, where we can treat the short-run dynamics and the long-run relationship. For the Dollar/yen out-of-sample forecasts, Figure 11 shows that the twofold model performs better

Figure 11: Out-of sample forecast of monthly USD/JPY log exchange rate

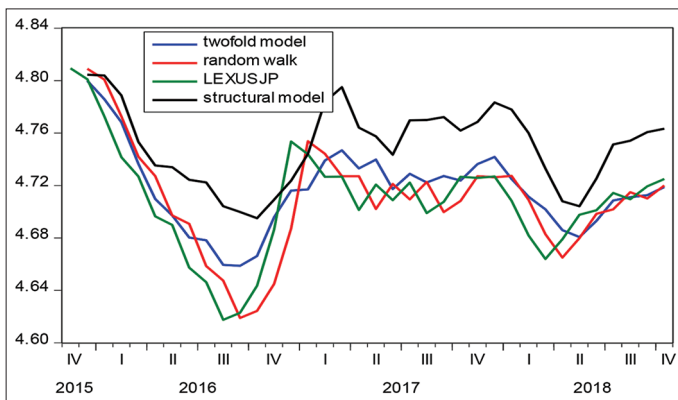
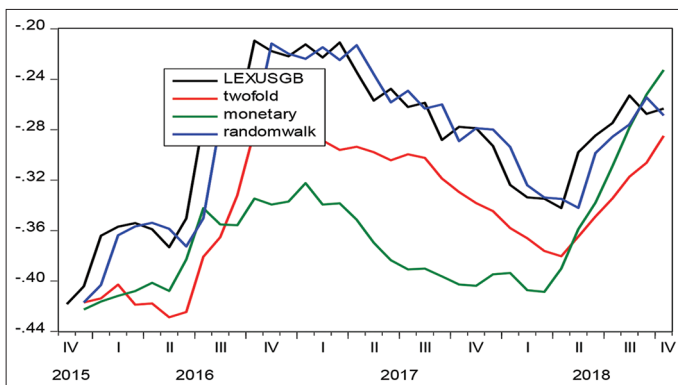


Figure 12: Out-of-sample forecast of monthly USD/GBP log exchange rate



than the structural model and the random walk model in some periods such the first quarter of 2016. Spreads variables hold an important informative component in explaining the USD/JPY exchange rate. However, the twofold model for the GBP/USD exchange rate plotted in Figure 12 holds a poor forecast power versus the random walk model and even the structural model in some periods, the second quarter of 2016 and the third quarter of 2018. For USD/GBP exchange rate, spreads variables do not have a forecasting power in determining currency value. To verify the results in Figures 11 and 12, we evaluate forecasts with different statistics test on multiple horizons.

Every statistical factor provides additional information in order to attend robust results, even with the disadvantages held in its construction. The forecast evaluation can be attributable to the statistics comparison of different forecast horizons. In our out-of-sample forecast, we use the RMSE factor, the Theil inequality coefficient and the Bias proportion when each factor give more information about the forecast procedure. The forecast role of the Theil's inequality statistics is given by a square error calculation based on the difference between the predicted change in the mean square error and the averaged squares of the actual change (Kennedy, 2008). The Theil inequality significance increase when it is close to zero with a perfect forecast power in the zero level. It represents no forecast power in one unity level. The Theil U-statistic is used in our study for the sake of comparability, although it is statistically poor in evaluating the significance of the forecast estimation. In order to compare the forecast statistical power of every model, Results in Tables 13 and 14 exhibit the

Table 13: Forecast evaluation of USD/JPY models: 2008m12 to 2018m10

Model	Statistic	1 month	3 month	6 month
Random walk	RMSE	0.021857	0.021551	0.022134
	Theil	0.002322	0.002287	0.002353
	Bias	0.019442	0.011950	0.017216
Structural model	RMSE	0.050997	0.032592	0.028934
	Theil	0.005393	0.003453	0.003082
	Bias	0.761340	0.334012	0.194403
Twofold model	RMSE	0.020673	0.018716	0.021480
	Theil	0.002194	0.001985	0.002281
	Bias	0.278708	0.181845	0.313121

Root mean squared error for out-of-sample forecasting. Theil is the inequality theil statistics or U-statistics proving more evidence in zero level. Bias is the bias proportion to indicate the constant error information in forecast

Table 14: Forecast evaluation of the USD/GBP models: 2008m12 to 2018m10

Model	Statistic	1 month	3 month	6 month
Random walk	RMSE	0.023574	0.022970	0.023817
	Theil	0.040012	0.037897	0.040997
	Bias	0.049690	0.050187	0.044656
Monetary model	RMSE	0.079492	0.082707	0.075321
	Theil	0.123192	0.124466	0.119008
	Bias	0.636534	0.646200	0.605240
Twofold model	RMSE	0.058499	0.062289	0.051182
	Theil	0.091784	0.094898	0.082198
	Bias	0.892606	0.868962	0.883864

RMSE for out-of-sample forecasting. Theil is the inequality theil statistics or U-statistics proving more evidence in zero level. Bias is the bias proportion to indicate the constant error information in forecast

no-drift random walk statistics in the first three rows and the structural model statistics in the next three rows, and finally the twofold statistics in the last three rows.

Results in Table 13 for the USD/JPY indicates the significance of the twofold model in predicting the exchange rate. Twofold model has less important values than the other two models in predicting the exchange rate on all the horizons leading to the performance of the square errors in forecast procedure. Turning to the USD/GBP results in Table 14, twofold model holds an important U-statistic Theil in front of the random walk model, but the quality of square error forecast is important when we look at the structural model. The results of USD/GBP toward the twofold exchange rate model does not hold a significant evidence against the random walk model, but it still important looking at the structural model.

The most nominated statistical measure in the forecast literature is the root mean square error (RMSE). RMSE uses the average values of the forecast errors in a square root test. the measure of this statistic allows for weighting the important forecast errors more heavily than the less important ones whereby errors importance increase in accordance with the square of the error (Kennedy, 2008). More the RMSE is important, more the square errors are impotent in the prediction procedure. The twofold model represents more large square errors in its forecast process in front of the random walk model for the dollar/pound exchange rate. Nonetheless, RMSE indicates that the exchange rate twofold model outperforms the structural model in all horizons as the results reported in Table 14. We turn now to the USD/JPY RMSE results, square errors are less important for the twofold model than the random walk model leading to more accurate forecast power in all horizons. Twofold model of USD/JPY gives again more information about future currency's values compared to structural and random walk models.

The third variable to analyze is the Bias proportion that corresponds to tendency of the mean square errors in forecasting too high or too low giving by the intercept term in the regression when the actual variability on predicted variability is different of zero (Kennedy, 2008). Table 13 indicates that the USD/JPY twofold exchange rate has a large bias proportion against the random walk model. Accordingly, the constant in the twofold model hold important information about in the process of forecast. We remark that the structural model forecast statistics decrease significantly when we pass through 1 month to 6-month forecast horizon leading to confirm the precedent results of the long-run attribution and significance of fundamentals in explaining exchange rate. For the USD/GBP results, bias proportion is very significant about 88% which may be due to the use of a trend in estimating the error correction model. Structural model improve its forecasts' statistics in long horizons, more evidence on 6 month. Results of forecast out-of-sample favorite the USD/JPY twofold model, instead USD/GBP twofold model does not provide significant results to outperform the random walk.

7. CONCLUSION

We already know that investors, governments and central banks are the main participants in exchange rate determination with different

incentives. We focus so on the facts by which every participant may be responsible for exchange rate variability. After collecting the most important theories and models for determining exchange rate, we remark the importance of macroeconomic factors in the long-run explanatory power. After the raise of the macroeconomic puzzles stressed firstly by (MEESE and ROGOFF, 1983), we have chosen to find other exchange rate vision by studying the (Evans and Lyons, 2002) microstructural approach. In our exchange rate determination procedure, we test combination of macroeconomic and microstructure variables in explaining currency change where fundamentals are the governments and central bank's intervention and microstructural variables are the investor's interpretation on the market. In order to test these hypotheses, we choose interest rate, money supply and net foreign assets as fundamentals, and we implement the spread and an adjusted spread as micro variables. In the first step, we represent the contribution of every variable in explaining exchange rate variation by verifying the structural model explanatory power of the exchange rate. We approve that Net Foreign Asset may hold some significance in the currency determination.

Our main empirical contribution is to test the spread as a long-run variable in the explanatory process of exchange rate by proving the existence of a cointegrating relationship. Spreads in short-run may not provide significant information because it is included as a part of the currency price, but spread variation may hold information about the future exchange rate. We adjust the spread with high and low to provide more information about market liquidity and volatility. Our results show that the twofold model provides more explanatory power of currency variation than the structural model. Combining the micro-based approach with the classical macroeconomic approach in the twofold model provides better forecast performance than the random walk for the USD/JPY. USD/GBP twofold model does not outperform the random walk, but it holds better forecasts then the structural model. However, our results do not generate the importance of every factor in explaining the currency value. Results must be tested for a large dataset using more currencies. In our model, we test two adjusted spread variables, indeed there is other transformed spreads variables, which can hold more important information. Otherwise, micro-based variables are adjusted in reaction to investors and dealers' behaviors and strategies and the future exchange rate return. We can test, in future research, investors' strategies and exchange rate returns using microstructure variables such order flow.

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