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"Can Taylor rule fundamentals provide evidence of out-of-sample predictability for the NOK/USD exchange rate?"

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Preliminary
Master Thesis Report

"Can Taylor rule fundamentals provide evidence of out-of-sample predictability for the NOK/USD exchange rate?"

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Programme:
Master of Science in Business, Major in Economics

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1. Introduction

The topic of exchange rate fluctuations is one of the most debated issues in the economics and finance literature. There has been extensive research on exchange rate predictability using economic fundamentals. However, it has been challenging to develop a model that performs better than a random walk (Meese and Rogoff, 1983). In the recent years there has been several attempts of developing alternative models. A line of research has investigated the use of Taylor rule fundamentals in order to find evidence on predictability. However, little research has studied the predictability of the NOK/USD exchange rate, and this has captured our interest. Our research paper aims to answer if Taylor rule fundamentals can tell us something about the exchange rate predictability in Norway. Hence, our working research question is:

"Can Taylor rule fundamentals provide evidence of out-of-sample predictability for the NOK/USD exchange rate? "

This paper is motivated by the research of Molodtsova and Papell (2008). In their paper they focus on out-of-sample exchange rate predictability using Taylor rule fundamentals, with United States as the base country. In Cheung, Chinn and Pascuals (2005) research on out-of-sample performance of interest rate parity, monetary, productive-based and behavioural exchange rate models, they find that none of these models outperform the random walk at any horizon.

In order to answer the research question we construct models that may explain exchange rate movements. First, a model that incorporates Taylor rule fundamentals is developed. Secondly, we intend to investigate interest rate-, monetary- and purchasing power parity fundamentals models. Subsequently, we wish to compare these models to our benchmark, the random walk model. As we would like to be as close to reality as possible, we choose to develop an out-of-sample forecast instead of an in-sample forecast.

When it comes to exchange rate predictability, the concept of Uncovered Interest Rate Parity (UIRP) is essential. Related to the collapse of UIRP, is the forward premium puzzle. The puzzle refers to the finding that future exchange rates and current interest rate differentials are negatively correlated (Obstfeld and Rogoff, 1996). Therefore, this puzzle suggest that the interest rate differential bear little predictability for the future rate of change in exchange rates. Subsequently, we need to take this puzzle into consideration when conducting our research.

The structure of the Preliminary Master Thesis Report is as follows: Section one will introduce the theoretical framework providing the basis for our research. Secondly, section two contains a literature review, introducing and discussing former research on our topic. Furthermore, section three will consider which type of data and sample period we will be using in our study. Lastly, in section four a preliminary schedule is postulated, with the main aim of specifying deadlines and our planned progress.

2. Theoretical framework

2.1 Uncovered Interest Rate Parity

The concept of Uncovered Interest Rate Parity (UIRP) is important for exchange rate determination theory. UIRP argues that the interest rate differential between two countries is equal to the expected change in the spot exchange rate. The point behind the UIRP is that it should function as a market clearing mechanism, but the evidence has not been convincing (Juselius, 1995). The UIRP formula is presented as:

$$1 + i_t = (1 + i_t^*)E_t\left\{\frac{S_{t+1}}{S_t}\right\} \tag{1}$$

Where i_t refers to the domestic interest rate, i_t^* is the foreign interest rate, while S_t and S_{t+1} refer to the nominal exchange rate in period t and t+1.

2.2 The Forward Premium Puzzle

The forward premium puzzle is connected to the collapse of UIRP. According to economic models, domestic currency is expected to depreciate when domestic nominal interest rates exceed foreign interest rates (Bansal and Dahlquist, 2000). Consequently, the puzzle suggests that the nominal interest differentials bear little predictive power for the future rate of change in the nominal exchange rate

(Gourinchas and Tornell, 2004). When discussing the forward premium puzzle, a suitable starting point is to investigate whether the forward rate, $\mathcal{F}_t$, is equal to the expected value of the future spot rate, ε_{t+1}:

$$\mathcal{F}_t = E_t\{\varepsilon_{t+1}\} \tag{2}$$

An extensive amount of research finds that the forward rate is an unbiased estimate of the future spot rate. Therefore, agents can earn arbitrage profits by speculating in forward foreign exchange rate. The condition implies that the expected domestic currency profit is zero, while expected foreign currency profit is not, causing a problem. In general:

$$E\left\{\frac{1}{\varepsilon_{t+1}}\right\} > \frac{1}{E_t\{\varepsilon_{t+1}\}} \tag{3}$$

Therefore, if equation (2) holds we cannot have that:

$$\frac{1}{\mathcal{F}} = E_t\left\{\frac{1}{\varepsilon_{t+1}}\right\} \tag{4}$$

This is referred to as Siegel's paradox, and it states that the foreign currency forward rate should be equal to the expected foreign-domestic exchange rate. The paradox is that foreign investors only care about own currency return, and at the same time risk-neutral domestic investors only care about their currency returns (Obstfeld and Rogoff, 1996). For this equilibrium to hold there must exist a risk premium. In the following equation for the exchange rate changes, the risk premium is referred to as $(f_t - e_t)$:

$$e_{t+1} - e_t = a_0 + a_1(f_t - e_t) + \varepsilon_t \tag{5}$$

As a preliminary step we want to test if one can reject the null hypothesis that a_0=0 and a_1=1. If it is found that the forward rate estimate the expected future spot rate perfectly, then the error term is serially uncorrelated. However, empirical evidence put forward by Hodrick (1987) and more recent studies, points out that the log forward rate is not equal to the expected value of the future log spot rate. Notably, realized exchange rate changes goes in the opposite direction of what is predicted by the forward premium. This suggests that it is possible to make profits from betting against the forward rate (Obstfeld and Rogoff, 1996).

An interpretation of the problem above is proposed by Fama (1984). He suggests that a small positive or negative slope coefficient (a_1 in the equation above) imply that the rational expectations risk premium on foreign exchange must be extremely variable (Fama, 1984):

$$Var(rp_t) > Var(E_t\{e_{t+1}\} - e_t \tag{6}$$

Where rp_t represents the bias in the log forward premium.

Famas implications are considered a significant challenge when it comes to model exchange risk, however it should not be over-elaborated (Obstfeld and Rogoff, 1996). For the major currencies, expected changes in the exchange rates are small, and it is hard to reject the hypothesis that exchange rates follow a random walk. As prominent in equation (6), the interesting finding might be that the exchange rate changes are small, not that the variance of the risk premium is large.

2.3 Taylor Rule Fundamentals Model

In our research we intend to use the Taylor rule model of exchange rate determination as a starting point. Furthermore, we take different specifications into account so that an equation for exchange rate predictability can be developed. The Taylor rule for the foreign currency is subtracted from the domestic currency, providing the interest rate differential. There are several possibilities for the right-hand-side of the equations, while the left-hand-side comprising the interest rate differential is unaltered. This model provides the base of our analysis. First, we want to examine the link between the fundamentals that arise when the central banks set the interest rate according to the Taylor rule, and the exchange rates. The Taylor rule provides a guideline for the central bank, so that the interest rate can be set in response to changes in the economic variables. The monetary policy rule can according to Taylor (1993) be specified as:

$$i_t^* = \pi_t + \phi(\pi_t - \pi^*) - \gamma y_t + r^* \tag{7}$$

Where i_t^* is the target for the short-term interest rate, π_t is the inflation rate, π^* is the target level of inflation, y_t is the output gap or percent deviation of actual GDP from an estimate of potential level, and r^* is the equilibrium level of the real interest rate. If inflation rises above the target level, and/or output is above potential output, the central bank will according to Taylor rule raise the target for the short-term nominal interest rate. According to the natural rate hypothesis, output cannot permanently exceed potential output; therefore the target level of the output deviation from natural rate y_t is 0 (Molodtsova and Papell, 2009). It is generally believed that deflation is much worse for an economy than low inflation, therefore the target level of inflation is positive. According to Taylor, the equilibrium level of the real interest rate and the inflation target were both equal to 2 percent, while output and inflation gaps enter the reaction function with equal weights of 0.5.

Following Clarida, Gali, and Gertler (1998) it is common practice when it comes to other countries than the US, to include the real exchange rate in the monetary policy rule. Furthermore, one can specify a variant of the Taylor rule that allows for the possibility that the interest rate adjusts gradually to achieve the target level. The interest rate differential can be constructed by subtracting the interest rate reaction function for the foreign country from the one for the domestic country. If one or both central banks target the PPP level of the exchange rate, the real exchange rate will appear on the right-hand-side of the equation. The Taylor rule based forecasting equation is derived by expressing the expected rate of depreciation as UIRP equal to the interest rate differential, and then solving expectations forward (Molodtsova and Papell, 2009):

$$\Delta s_{t+1} = \omega - \omega_{u\pi}\pi_t + \omega_{f\pi}\tilde{\pi}_t - \omega_{uy}y_t + \omega_{fy}\tilde{y}_t + \omega_q\tilde{q}_t - \omega_{ui}i_{t-1} + \omega_{fi}\tilde{i}_{t-1} + \eta_t \quad (8)$$

Where the variable s_t is the log of the domestic currency's nominal exchange rate determined as the domestic price of foreign currency. q_t is the real exchange rate, while u and f are coefficients for the domestic and foreign country, and ~ denotes foreign variables.

2.4 Interest Rate Fundamentals Model

If one assumes that UIRP holds, it can be used as a forecasting equation. Further, a more flexible specification is required, since exchange rate movements may consist with UIRP in the long run, but not in the short run. This result in a forecasting equation, depending on the interest rate differential (Clark and West, 2006):

$$\Delta S_{t+1} = \alpha + \omega(i_t - \tilde{\imath}_t) \tag{9}$$

Where the change in domestic currency's nominal exchange rate is a function of the interest rate differential. From this equation we observe possible consistency with UIRP, since we do not restrict ω.

2.5 Monetary and Purchasing Power Parity Fundamentals Model

Mark (1995) argues that the most used approach for out-of-sample exchange rate predictability is to use a model where the nominal exchange rate operates as a function of its deviation from its fundamental value. The change in the log exchange rate can therefore be presented as a function of its current deviation from the fundamental value:

$$S_{t+h} - S_t = \alpha_h + \beta_h z_t + v_{t+h,t} \tag{10}$$

Where $z_t = f_t - s_t$, and f_t is the long-run equilibrium level of the nominal exchange rate determined by macroeconomic fundamentals. Furthermore, by developing two equations for the long run money market equilibrium in the foreign and domestic country, the fundamental value of the exchange rate can be derived as:

$$f_t = (m_t - m_t^*) - k(y_t - y_t^*) \tag{11}$$

Where PPP, UIRP, and no rational speculative bubbles are assumed. m_t and y_t are the logs of money supply and income in period t, and the asterisks refers to variables for the foreign country. k is the fixed value of the income elasticity. By substituting equation (11) into equation (10), we get the equation that we intend to use for forecasting.

For comparison we also like to predict the power of PPP fundamentals. The monetary model is built on the PPP, but it also takes several other restrictions into account. Subsequently, we find it useful to compare the out-of-sample performance of the two models. The linkage between exchange rates and monetary fundamentals are found to be tighter than the one between exchange rates and PPP fundamentals (Mark and Sul, 2001). The equation for PPP fundamentals is:

$$f_t = (p_t - p_t^*) \quad (12)$$

The log of the national price level is p_t, and consume price index is used as a measure of national price levels. This equation is also substituted into equation (10), so that we get the equation to be used for forecasting.

3. Literature Review

In the recent years, there has been a comprehensive amount of literature connecting Taylor rule fundamentals to exchange rate predictability. Several studies have found evidence of predictability when looking at longer horizons, starting with Mark (1995). On the contrary, Kilian (1999) argue that the findings of increasing long-horizon predictability are more likely related to distortions, not power gains. Kilians paper re-examines the data set from Mark (1995), and find only weak evidence that monetary fundamentals differences provide exchange rate predictability. When it comes to examining the performance of the interest rate parity, monetary and productivity based models, Cheung, Chinn and Pascual (2005) find that none of these models outperform a random walk.

Molodtsova, Nikolsko-Rzhevskyy, and Papell (2008) evaluate out of sample-predictability of the U.S dollar/Deutsche Mark nominal exchange rate from 1979 to 1998. They find that predictability increases when using real time data, that is, data that was available at the time the central bank made their decisions. Furthermore, they find higher predictability with models that include differential inflation and output coefficients in the central banks reaction functions, and allowing for the exchange rate in the Bundesbank reaction function.

Molodtsova and Papell (2009) examine out-of-sample predictability with Taylor rule fundamentals, for 12 OECD countries vis-a-vis the United states from 1973 to 2006. They find evidence of short-term predictability for 11 out of 12 countries by using quasi-real time data, and their strongest evidence arriving from incorporating heterogeneous coefficients and interest rate smoothing. Furthermore, Molodtsova, NIkolsko-Rzhevskyy and Papell (2009) find that the variables that are included in central bank´s Taylor rule can have forecasting ability for the USD/EUR exchange rate from 1999-2007.

4. Data and Methodology

The models will be estimated using monthly data from the period January 2001 to December 2015. Norway introduced inflation targeting in 2001, and this is the natural starting point of our analysis. The currencies to be considered in our models are USD and NOK. In order to construct the Taylor rule fundamentals, data on output gap, inflation, interest rates and exchange rates are required. Importantly, our emphasis is on using real time data, which is data that has not been revised. This is important due to the fact that we would like to have information that that was available to the central banks at the time they actually made the decisions. We wish to follow in line with Molodtsova and Papell (2009), therefore for a period time t, we will only use the data point up to t-1 to construct the trend. Subsequently, we wish to add one additional observation to the sample in each period, and re-estimate the OLS regression.

Data on inflation, exchange rates and interests rate are publically available from the Norwegian Central Bank and the The Federal Reserve Bank of St. Louis. However, one challenge is defining the output gap. First of all this is a challenge since GDP is available only on quarterly terms, and we will consider monthly data. Consequently, we will instead use the seasonally adjusted production index for US and Norway. There is no information on which definition of output potential the two central banks use, and since the output gap will depend on the potential, we intend to use percentage deviations from actual output from a linear time, a quadratic time trend and, a Hodrick and Prescott trend. When it comes to inflation, it will be measured by the Consumer Price Index both in Norway and in the US.

5. Time Plan

The final deadline for the Master Thesis is set to September 1st 2017.

January 16th: Due date Preliminary Master Thesis Report.
February: Master Thesis Seminar: Presentation for class and faculty members. Data collection and starting quantitative analysis.
March: Conduct quantitative analysis
April: Finish quantitative analysis, review theory and methodology chapters.
May: Conclude analysis, write final thesis

Planned hand in date 1st of June 2017.

6. Conclusion

This preliminary thesis rapport presents our topic, working research question and provides a brief presentation of the theoretical framework that serves as a basis for our research. Lastly, we present our provisional time plan for finishing the thesis.

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