Revisiting Uncovered Interest Rate Parity: Switching Between UIP and the Random Walk

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REVISITING UNCOVERED INTEREST RATE PARITY: SWITCHING BETWEEN UIP AND THE RANDOM WALK

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Abstract

In this paper, we examine in which periods uncovered interest rate parity was likely to hold. Empirical research has shown mixed evidence on UIP. The main finding is that it doesn't hold, although some researchers were not able to reject UIP in periods with large interest differentials or high volatility. In this paper, we introduce a switching regime framework in which we assume that the exchange rate can switch between a UIP regime and a random walk regime. Our empirical results provide evidence that exchange rate movements were consistent with UIP over some periods, but not all. Consistent with the existing literature we also show that in periods with large interest differentials or increased exchange rate volatility, the exchange rate is more likely to follow UIP.

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1. Introduction

The theory on UIP predicts that the interest rate differential between two countries is equal to the expected change in the level of the exchange rate. Mixed empirical evidence is found for UIP to hold. Many researchers have found no or only a weak relationship, see for example Engel (1996) for an overview. However, others have shown that UIP cannot be rejected in particular time periods. For example, Huisman et al. (1998) pointed out that in cases of high interest rate differences and high volatility UIP holds. Notwithstanding these results, the puzzle remains that UIP is not as uniformly powerful as the theory predicts.

In this paper, we apply a regime switching methodology in which we assume that the exchange rate switches between two regimes over time. The first regime is a UIP regime in which changes in exchange rates are described by the observed interest rate differential between the two currencies involved. The second regime is a random walk with drift. The latent regime indicator follows a Markov process. Transition probabilities allow for switching between the regimes.

The motivation for this framework is that we would like to measure in which periods UIP is likely to hold and in which periods not. The strength of the regime switching methodology is that we let the model determine in which sample periods exchange rate changes are consistent with UIP, and when they are not. Furthermore, based on the estimated regime probabilities, we investigate whether specific interest rate market conditions can be related to the periods with a high probability of being in the UIP regime.

The paper is structured as follows. In the next section we introduce our switching regime model. In Section 3 we describe the data used in this study. The results are presented in Section 4. Conclusions are in Section 5.

2 The switching regime framework

We assume that the exchange rate can be in one out of two regimes at each moment in time. The first regime is described by UIP; the second is a random walk. Let $s(t)$ be the exchange rate at time t. We define the exchange rate as the foreign price for 1 unit of the home currency. For instance, if the dollar - euro (USD/EUR) exchange rate equals 0.80, we say that 1 dollar costs 0.80 euro. Furthermore, let $i^h(t)$ the interest rate at time t for the home currency (measured as a weekly number) and let $i^f(t)$ the interest rate at time t for the foreign currency. In the case of the USD/EUR exchange rate, USD is the home and EUR is the foreign currency.

In the first regime, we assume that the exchange rate follows UIP. The expected change in the value of the natural logarithm of the exchange rate equals the different in interest rates levels between the foreign and home country. Let $\varepsilon_1(t)$ be an IID noise process with zero mean and constant variance σ_1^2.

(1) $$\ln s(t+1) - \ln s(t) = i^f(t) - i^h(t) + \varepsilon_1(t). \qquad \text{(UIP regime)}$$

In the second regime, we assume that the exchange rate follows a random walk with drift. The change in the value of the natural logarithm of the exchange rate equals the drift term plus a noise process. Let $\varepsilon_2(t)$ be an IID noise process with zero mean and constant variance σ_2^2 and we assume that both errors $\varepsilon_1(t)$ and $\varepsilon_2(t)$ are independent. The random walk regime is specified in as follows.

(2) $\ln s(t+1) - \ln s(t) = \mu + \varepsilon_2(t).$ (Random walk regime)

At each time we assume that the exchange rate can be in the UIP regime or in the random walk regime. To this end we define a latent variable z_t that can have the values z_t=1 for the UIP regime, and z_t=0 for the random walk regime. The evolution of the regime indicator z_t is assumed to be Markov. Transition probabilities allow the exchange rate to switch between both regimes. Let $p(i,j)$ be the (fixed) transition probability that the exchange rate is in regime i next week being in regime j this week. By definition it holds that $p(i,j) = 1 - p(j,j)$; that is, the exchange rate either stays in the same regime or switches to the other regime from one week to the other.

Note that the specification of our regime switch model, given by quations (1) and (2), differs from the regime switch model in Engel and Hamilton (1990). These authors postulate that the logarithmic exchange rate *levels* switch between two regimes. In our model the exchange rate *returns* may switch between regimes. Our regime switch specification corresponds with the classic way of testing the UIP condition, which is to regress the realized exchange rate changes on the interest rate differential. See for example Hansen and Hodrick (1980) and Fama (1984).

The parameters in regime switching models can be estimated by maximum likelihood. To specify the likelihood functions, we assume that both error processes $\varepsilon_1(t)$ and $\varepsilon_2(t)$ are independently and normally distributed. For further details on estimating regime switching models, we refer to Hamilton (1989, 1994), Engel and Hamilton (1990), and Cheung and Erlandsson (2005).

What does our model imply for the UIP relationship in exchange rates? Note that uncovered interest parity is defined by the equality between the expected exchange rate change and the interest rate differential: $E_t[\ln s(t+1) - \ln s(t)] = i^f(t) - i^h(t)$. The empirical failure of UIP can be explained by two sources: forecast errors and/or time-varying risk premia. Following Fama (1984) and Evans and Lewis (1995) we can write the speculative excess returns on having a forward contract as

(3) $\ln s(t+1) - \ln s(t) - [\, i^f(t) - i^h(t) \,] = \theta(t) + u(t+1),$

where $\theta(t)$ is the risk premium and $u(t+1)$ is the forecast error. In order to identify the risk premium a common assumption is that rational expectations hold, see Evans and Lewis (1995). In our regime switch model we get

(4) $E_t[\ln s(t+1) - \ln s(t)] = [\, z_t\ p(1,1) + (1 - z_t)\,(1 - p(2,2))\,]\,(i^f(t) - i^h(t)\,) +$

$[\, z_t\ (1 - p(1,1)) + (1 - z_t)\, p(2,2)\,]\,\mu\,.$

Note that the terms between square brackets are time-varying. As a consequence the regime switch model provides a time-varying parameter equivalent of the unconditional regression models of Hansen and Hodrick (1980) and Fama (1984).

3 Data

We use weekly data from 8 January 1992 through 16 May 2006 (749 observations, Wednesday London closings). We examine the results for the following currencies against the US dollar (USD): Canadian Dollar (CAD), Swiss Franc (CHF), Euro (EUR), UK Sterling (GBP), Japanese Yen (JPY), Norwegian Kroner (NOK) and the Swedish Kroner (SEK), all defined as the price in terms of the specific currency for one US Dollar. In Table 1 we provide summary statistics of the data.

– Table 1 –

4 Results

The parameter estimates for the different exchange rates are presented in Table 2.

– Table 2 –

The model shows evidence that the regime switching model is capable of identifying both regimes for the exchange rates under consideration. Let us focus on the estimates for the USD/EUR exchange rate. The (weekly) volatility (σ_1) equals 0.0229 and is significantly different from zero for the first UIP regime. The drift in the random walk regime (μ) is not significantly different from zero and the volatility parameter of this regime (σ_2) equals 0.0125 and is significantly different from zero. Note that the volatility of the random walk regime is lower than the volatility estimate of the UIP regime. The transition probability $p(1,1)$ equals 0.9317 and is significant. This reflects the persistence of the UIP regime. Being in the UIP regime in one week, the probability is approximately 93% that the USD/EUR exchange rate will remain in the UIP regime next week. Consequently, a switch to the random walk occurs with a probability of approximately 7%. The random walk regime is more persistent as the transition probability $p(2,2)$ equals 0.9920 implicating that there is a 99% probability that the USD/EUR remains in the random walk regime next week being in the random walk regime this week. The probability of switching to the UIP regime is roughly 1%. This result implies that the USD/EUR exchange rate seems to follow a random walk more often than it frequently UIP.

Similar results are obtained for the USD/GBP and USD/JPY exchange rates. The exchange rates seem to switch between UIP and a random walk, both in a persistent way with high probabilities of staying in the same regime over the weeks, but the frequency with which the exchange rates are in the random walk regime is higher than the frequency with which they are in the UIP regimes.

In Figure 1, we plot the time series of the USD/EUR and the weekly probability estimates that the exchange rate is in the UIP regime. These probabilities are calculated using information from all observations up to and including the time period for which the probability is reported.

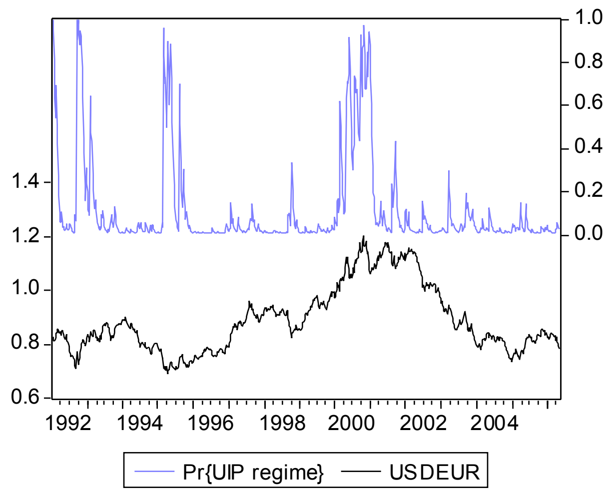

Figure 1: weekly USD/EUR spot exchange rates and the estimated probabilities that the exchange rate is in the UIP regime.

Figure 1 reveals that the USD/EUR was likely to follow UIP in four periods. The first period is the month January 1992, the second period is from September through October 1992, the third period is from March through May 1995, and the fourth period is from May 2000 through January 2001. Note the persistence of the probabilities of staying in either regime. This is consistent with the parameter values for the transition probabilities $p(i,i)$. Once the exchange rate is likely to follow the UIP regime or, equivalently, once it is likely to follow the random walk regime, the exchange rate stays in that regime for a couple of weeks.

Figures 5 through 9 show the probabilities of the UIP regime for the other exchange rates in the sample. The different exchange rates switch differently between UIP and the random walk. For the British Pound and the Swedish Kroner it is hard to identify a UIP regime, except for the turmoil period in 1992. Other exchange rates, such as the Yen and the Norwegian Kroner, seem to switch more often to UIP periods.

The fact that the exchange rates switch between the two regimes assumed in our framework raises the question if it is possible to characterize the differences between the estimated regimes. Table 2 reveals one potential difference. For all currencies, the volatility in the UIP regime is higher than the volatity of the random walk regime. For the USD/EUR and EUR/JPY the volatility of the UIP regime is roughly twice as high. For the EUR/GBP, the volatility of the UIP regime is about four times the volatility of the random walk regime. This might be due to a difference in the frequencies with which these regimes occur. Recall that we observed that the frequency with which the random walk regime occurs is the highest. However, this difference in frequency is unlikely to account for the volatilities to double or to quadruple. Furthermore, the observed difference in volatility estimates is consistent with findings in previous research. For instance, Huisman et al. (1998) show that UIP seems to hold in periods where forward premiums are high indicating that UIP tends to hold in high volatility periods.

In order to obtain more insight in the differences between the periods in which exchange rates follow UIP and periods in which the exchange rates follow a random walk, we examine the probability levels of being in one of both regimes over time. To do so, we calculate the weekly estimates for the smoothed probabilities, i.e. $\Pr(z_t = 1| I_T)$ and $\Pr(z_t = 2| I_T)$, where I_T is the information set that contains the sample histories of both the exchange rates and the interest rates. In Figure 2, we show the estimated probabilities for the exchange rate being in the UIP regime related to the interest differential between the dollar and the euro. From Figure 2, it seems that periods in which the USD/EUR was likely to follow UIP, coincide with periods in which interest rates were starting to change dynamics. The second period of high probabilities of being in the UIP regime coincides with the start of an increasing trend in the interest differential. The third period is where the previous trend starts to slow down. The last period coincides with a period in which the interest differential starts an increasing trend. However, the change in the trend in the interest differential starting in 2004 does not coincide with high probability of the UIP regime.

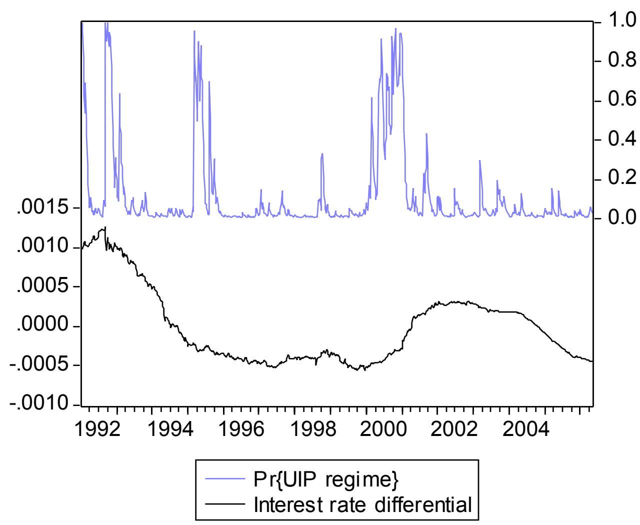

Figure 2: weekly interest differential between the dollar and the euro expressed as annualized percentages and the estimated probabilities that the exchange rate is in the UIP regime.

Figure 3 provides insight in the relation between the interest rate differential and the probability of being in the UIP regime.

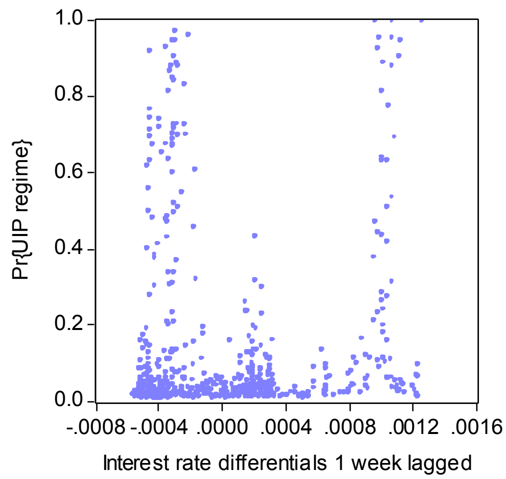

Figure 3: scatter diagram of the weekly interest rate differential between the dollar and the euro at week t-1 and the probability of being in the UIP regime in week t.

Figures 3 shows that the high probabilities on being in the UIP regime only occur in periods when the previous week interest rate differential between the dollar and the euro was large in absolute terms. This observation is in line with Flood and Rose (1994) and Flood and Taylor (1996). However, the relationship is not unique. Periods with high interest rate differentials do per definition lead to a high probability on UIP as also low probability values are apparent in Figure 3 for those periods. Bilson (1981) and Huisman, Koedijk, Kool, and Nissen (1998) test for UIP in periods with high and low forward premiums separately. High forward premiums can partly be explained by both large absolute interest rate differentials and high volatility. Therefore, we examine the relation between the weekly returns and the probabilities on UIP. Figure 4 provides insight. The pattern is less obvious than in figure 3. However, the biggest absolute returns do coincide with high probabilities on being in the UIP regime. This suggests that in periods with high volatility, UIP is more likely to hold.

UIP seems to be likely to hold in periods with large changes in the USD/EUR and big interest rate differential. Both factors are hardly correlated as the correlation between the lagged weekly interest rate differentials and the log returns on the spot exchange rate is equal to -0.0269 for the USD/EUR, measured over the whole sample. In order to examine the relation between these factors and the probability of being in the UIP regime, we regress the probability that the exchange rate is in the UIP regime in week t, $p(t)$, on the squared change in the exchange rate in week t, $s^2(t)$, and on the squared interest differential observed in the previous week, $id^2(t\text{-}1)$. The following equation specifies the regression model.

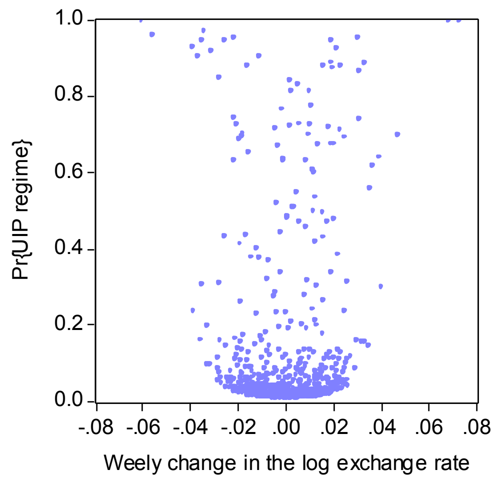

Figure 4: scatter diagram of the weekly log return on the USD/EUR and the probability of being in the UIP regime.

(5) $p(t) = c + \beta\, s^2(t) + \phi\, id^2(t\text{-}1) + \varepsilon(t).$

The error term $\varepsilon(t)$ is assumed to be IID$(0,\sigma^2)$. In order to estimate the parameters in the above model, note that the dependent is a truncated variable as probabilities range between zero and one. Therefore, we estimate the parameters using a Tobit model. Table 3 presents the parameter estimates for the different exchange rates.

– Table 3 –

Table 3 provide evidence that the squared log changes and squared one week lagged interest differentials have a significant impact on the probability of being in the UIP regime. For the USD/EUR, the estimate for β, the coefficient for the squared change in the log exchange rate, equals 240.9961 with the robust asymptotic normal standard error equal to 30.2089. The positive and significant parameter estimate implies that the probability of being in the UIP regime in week *t* is high in weeks with big changes in log exchange rate. This result holds for all exchange rates under consideration, providing support for the hypothesis that UIP is more likely to hold in high volatility periods. The second parameter is also positive and significant for all exchange rates. For the USD/EUR, the estimate for ϕ, the coefficient for the squared interest differential observed in the past week, equals 39.9814 with the robust asymptotic standard error equal to 12.3044. The positive and significant parameter estimates for all exchange rates implies that UIP is more likely to hold in periods with large absolute values for the interest rate differentials.

From the results in this section, we conclude that an exchange rate switches between periods in which it is likely to be in a random walk regime and periods in which it is likely to be in an uncovered interest parity regime. The exchange rate is more likely to be in the UIP regime in high volatility periods and periods with large absolute interest rate differentials.

5 Concluding remarks

In this paper, we present a regime switching model for exchange rates that allows the exchange rate to switch between an UIP regime and a random walk. Our model significantly improves upon the random walk as we find that UIP was likely to hold in some periods of times for different exchange rates against the US Dollar. The periods in which UIP was most likely to hold were periods with large interest rate differentials between both currencies in the exchange rates and periods with big movements in the exchange rates.

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7 Appendices: tables and figures

Table 1

Summary statistics of the weekly changes in the log prices in terms of different currencies for one US Dollar. The data consists of Wednesday London closings from 8 January 1992 through 16 May 2006 (749 price observations).

	CAD	CHF	EUR	GBP	JPY	NOK	SEK
Average	-0.0026	-0.0072	0.0007	0.0003	-0.0085	0.0012	0.0192
Stdev	0.0583	0.1096	0.1027	0.0833	0.1051	0.1025	0.1106
Skewness	-0.2025	-0.0386	0.1613	1.0476	-0.7063	0.2341	0.5943
Kurtosis	0.6160	1.3189	1.8837	5.5181	3.9286	1.5754	3.9440
Minimum	-0.0270	-0.0712	-0.0605	-0.0419	-0.0969	-0.0504	-0.0550
Maximum	0.0280	0.0650	0.0731	0.0867	0.0643	0.0723	0.0966

Average is the annualized arithmetic average over the weekly log returns. Stdev is the annualized standard deviation of the weekly returns. Kurtosis is defined as the excess kurtosis over the normal distribution.

Table 2
Parameter estimates for the regime switching model described in equations (1) and (2).

	CAD	CHF	EUR	GBP	JPY	NOK	SEK
σ_1	0.0063	0.0285	0.0229	0.0427	0.0246	0.0187	0.0349
	(0.0002)	(0.0049)	(0.0019)	(0.0170)	(0.0018)	(0.0010)	(0.0052)
μ	-0.0014	-0.0002	-0.0002	-0.0004	0.0004	-0.0001	-0.0002
	(0.0007)	(0.0006)	(0.3810)	(0.0004)	(0.0005)	(0.0006)	(0.0005)
σ_2	0.0106	0.0141	0.0125	0.0108	0.0119	0.0111	0.0137
	(0.0005)	(0.0005)	(0.0004)	(0.0003)	(0.0004)	(0.0006)	(0.0004)
pr1	5.3824	1.6388	2.6133	0.9808	1.9628	2.5440	2.3409
	(0.8133)	(0.6347)	(0.6142)	(0.8251)	(0.4547)	(0.4883)	(0.6399)
pr2	5.3184	4.8960	4.8180	5.5236	3.8573	3.2126	5.9146
	(1.2589)	(0.8717)	(0.7371)	(0.8139)	(0.4670)	(0.5067)	(0.8132)
$p(1,1)$	0.9954	0.8374	0.9317	0.7273	0.8768	0.9272	0.9122
$p(2,2)$	0.9951	0.9926	0.9920	0.9960	0.9793	0.9613	0.9973
LogLik	2585.152	2085.126	2141.319	2292.716	2141.219	2140.345	2105.944

Standard errors are in parenthesis. Parameter estimates were obtained from applying maximum likelihood assuming normally distributed errors. The transition probabilities $p(1,1)$ and $p(2,2)$ were obtained from the estimated parameters pr1 and pr2 by applying the following transformation: $p(i,i) = \exp(\text{pr}i) / (1 + \exp(\text{pr}i))$.

Table 3
Parameter estimates for the regression model described in Equation (5). A currency name reflects the exchange rate for that currency against the dollar (price in that currency of one U.S. dollar).

	CAD	**CHF**	**EUR**	**GBP**	**JPY**	**NOK**	**SEK**
c	0.6976	0.0047	0.0451	-0.0189	0.0713	0.2688	0.0006
	(0.0019)	(0.0047)	(0.0092)	(0.0045)	(0.0126)	(0.0156)	(0.0063)
β	-1485.72	191.6683	241.0108	184.6888	234.4421	351.5455	107.5939
	(111.9051)	(15.8576)	(30.2117)	(34.2529)	(62.4418)	(66.7857)	(25.3332)
ϕ	238.7801	5.2695	39.9772	20.9818	16.9282	9.2226	14.0436
	(31.3810)	(3.3950)	(12.3039)	(6.7097)	(4.8396)	(3.9700)	(3.7653)
LogLik	345.1120	589.0198	184.5694	880.8983	205.7823	3.5307	502.3405

Robust asymptotic normal standard errors are in parenthesis. Sample contains data from January 1992 through May 2006 having 748 observations. The interest differential is annualized.

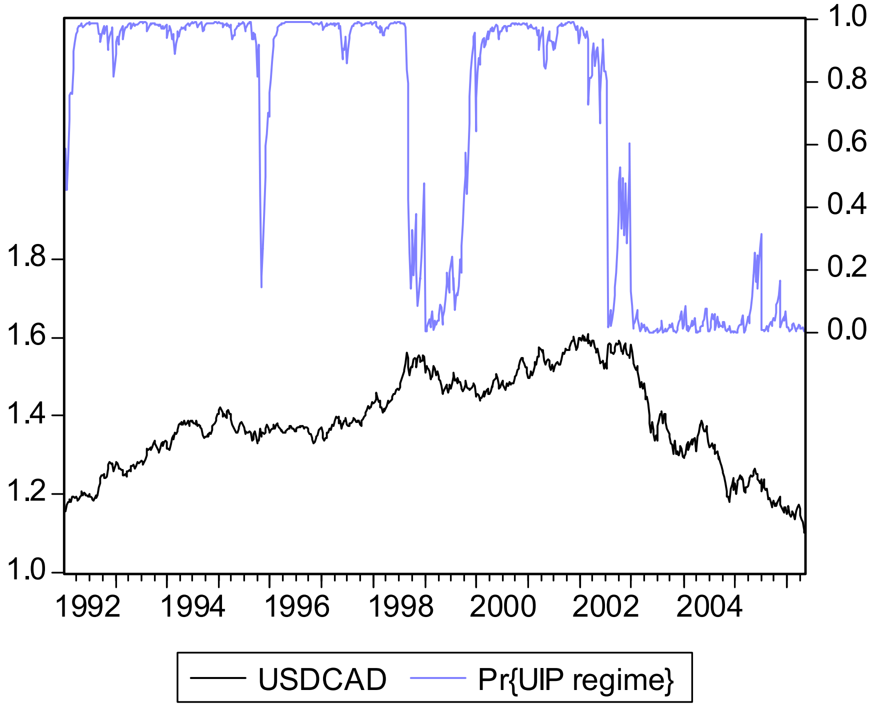

Figure 5: weekly USDCAD spot exchange rates and the estimated probabilities that the exchange rate is in the UIP regime.

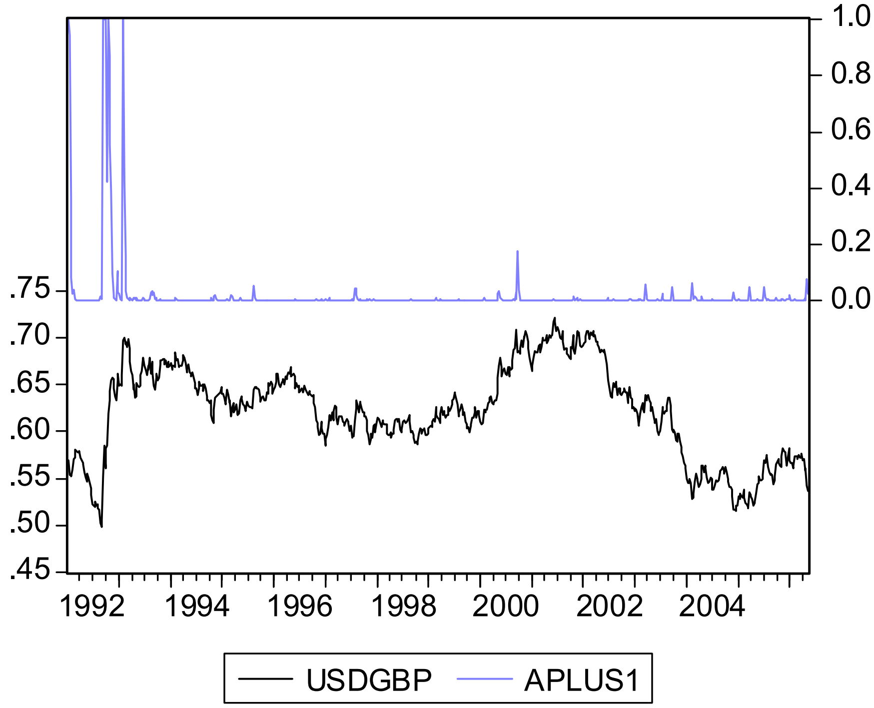

Figure 6: weekly USDGBP spot exchange rates and the estimated probabilities that the exchange rate is in the UIP regime.

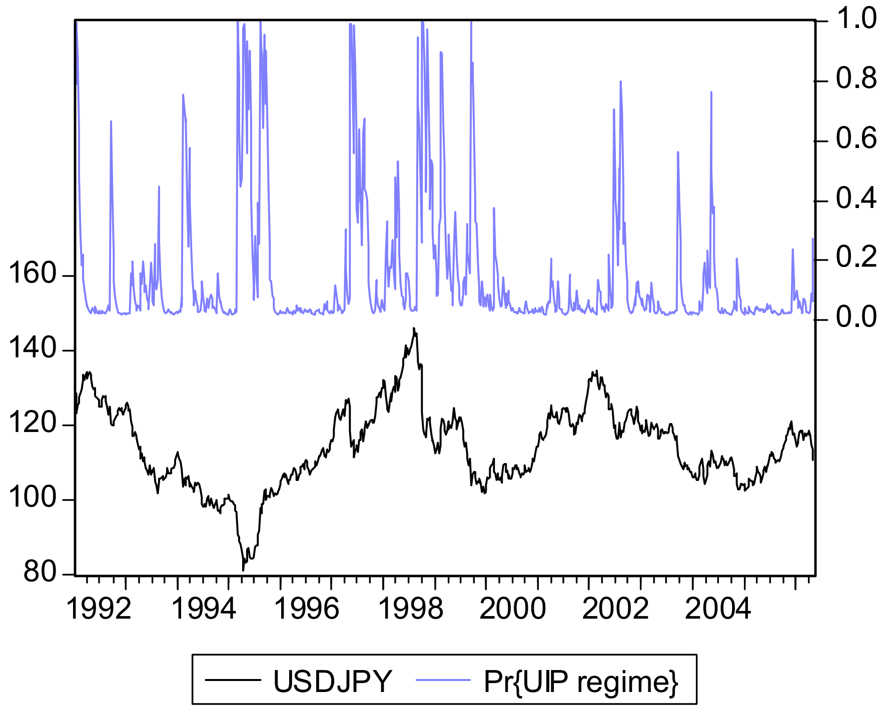

Figure 7: weekly USDJPY spot exchange rates and the estimated probabilities that the exchange rate is in the UIP regime.

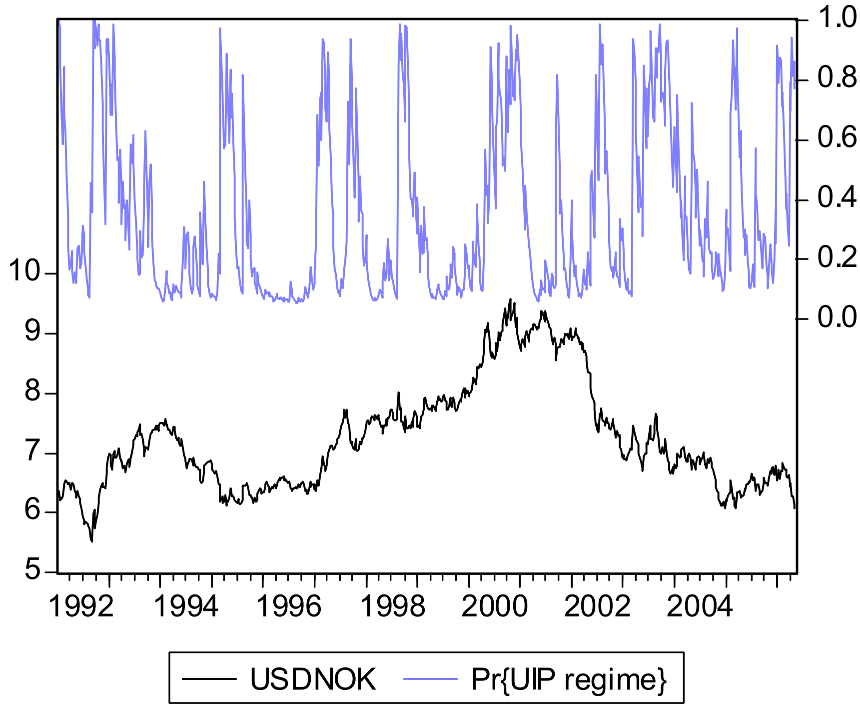

Figure 8: weekly USDNOK spot exchange rates and the estimated probabilities that the exchange rate is in the UIP regime.

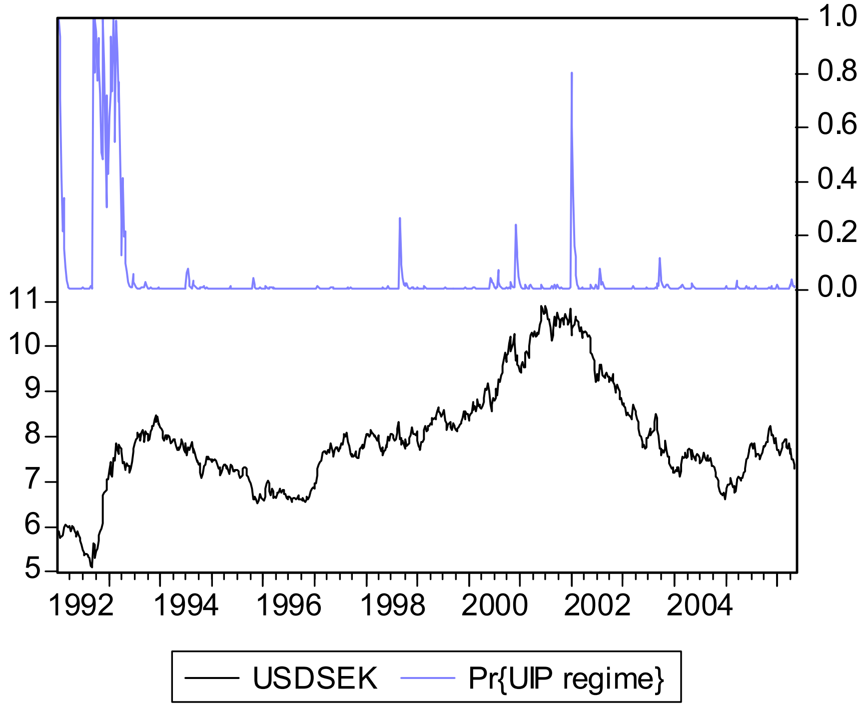

Figure 9: weekly USDSEK spot exchange rates and the estimated probabilities that the exchange rate is in the UIP regime.

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