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The importance of interest rates for forecasting the exchange rate

Abstract:
This study compares the forecasting performance of a structural exchange rate model that combines the purchasing power parity condition with the interest rate differential in the long run, with some alternative models. The analysis is applied to the Norwegian exchange rate. The long run equilibrium relationship is embedded in a parsimonious representation for the exchange rate. The structural exchange rate representation is stable over the sample and outperforms a random walk in an out-of-sample forecasting exercise at one to four horizons. Ignoring the interest rate differential in the long run, however, the structural model no longer outperforms a random walk.

Keywords: Equilibrium real exchange rate, cointegration VAR, out-of-sample forecasting

JEL classification: C22, C32, C53, F31

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1. Introduction

The well cited finding by Meese and Rogoff (1983), that a comprehensive range of exchange rate models were unable to outperform a random walk, has motivated numerous studies to examine the role of economic fundamentals in explaining exchange rate behaviour. Later on, however, MacDonald and Taylor (1994), Chrystal and MacDonald (1995), Kim and Mo (1995) and Reinton and Ongena (1999) among others, have found that a series of monetary models can beat a random walk in forecasting performance, at least at the long horizons, using a metric like the root mean square errors (RMSE) for evaluation. However, although the monetary models have proved somewhat successful in explaining exchange rate behaviour, they have also encountered many problems. In particular, many of the cointegrating relationships have taken on incorrect signs when compared to theoretical models (McNown and Wallace (1994)).

One of the basic building blocks of the monetary models is the purchasing power parity (PPP). However, empirical evidence from the post Bretton Woods fixed exchange rate system, have found little to support the PPP condition (see e.g. Rogoff (1996) for a survey)[1] and forecasts based on the PPP condition alone, have provided mixed results (see for instance Fritsche and Wallace (1997) among others).

The PPP condition has its roots in the goods market. Another central parity condition for the exchange rate that plays a crucial role in capital market models is uncovered interest parity (UIP). However, empirical evidence has also generally led to a strong rejection of the UIP condition in the Post Bretton Woods period (see e.g. Engel (1996) for a survey). On the other hand, Johansen and Juselius (1992) have suggested that one possible reason why so many researches have failed to find evidence in support of these parity conditions is the fact that researchers have ignored the links between goods and capital markets when modelling the exchange rate. By modelling the whole system jointly, one is better able to capture the interactions between the nominal exchange rate, the price differential and the interest rate differentials, as well as allowing for different short and long run dynamics.

This paper examines whether a dynamic exchange rate model that combines the purchasing power parity condition with the uncovered interest parity condition in the long run, can outperform a random walk model in an out-of-sample forecasting exercise. The model is applied to Norway. Previous

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[1] The rejections have been less clear-cut using panel data, see e.g. Frankel and Rose (1996) among many others. However, see O'Connell (1998) and Chortareas and Driver (2001) for critical assessments of these panel data studies. See also the recent study by Holmes (2001), who using a new panel data unit root test, finds clear evidence against PPP.

studies of the determination of the real exchange rate in Norway have generally rejected the notion of simple PPP using conventional (time series or panel data) unit root tests (see e.g. Serletis and Zimonopoulus (1997) and Chortareas and Driver (2001)), or by testing for PPP in multivariate studies (see e.g. Jore et al. (1998), Alexius (2001), with the exception of Akram (2000a)). In a recent study, however, Bjørnland and Hungnes (2002), using a multivariate cointegrating framework, showed that PPP holds against a basket of Norway's trading partners *only* when they incorporate the interest rate differential in the long run. However, pure PPP was rejected.

The long run analysis presented here builds on Bjørnland and Hungnes (2002), but the estimation period, sample frequency and some of the variables vary. Having determined the long run equilibrium relationship, a parsimonious short-run representation for the exchange rate that includes the long-run equilibrium is established. Finally, its forecasting performance is analysed and compared to alternative exchange rate specifications.

The rest of this paper is organised as follows. In Section 2 we discuss the hypothesis of PPP and how possible sources of deviations from PPP can be linked to the UIP condition. Section 3 identifies the econometric model used to estimate the long run exchange rate, and thereafter presents the empirical results. In Section 4 we implement the long run relationships in a short run dynamic model, and investigate whether this model is stable over the sample. Section 5 examines whether the structural model outperforms a random walk model in an out-of-sample forecasting exercise. The forecasting performance of an alternative structural model that identifies a long run relationship based on pure PPP, thereby ignoring any long run link with the interest rate differential, is also examined. Section 6 summarises and concludes.

2. Long run real exchange rates

A natural starting point for discussing the relationship between exchange rates and fundamentals is the concept of PPP. Assuming no costs in international trade, then domestic prices would equal foreign prices multiplied by the exchange rate. The expression for PPP can then be written (in log-form) as

$$v_t = p_t - p_t^*, \tag{1}$$

where p_t is the log of the domestic price, p_t* is the log of the foreign price, and v_t is the log of the nominal exchange rate.[2] However, since trade is costly, PPP will not hold continuously. It is therefore informative to define the log of the real exchange rate as

[2] Since we use price indices in the estimation, we can only test relative PPP.

$$r_t = v_t - p_t + p_t^* , \qquad (2)$$

where r_t is the real exchange rate. If PPP is valid, the real exchange rate is stationary and fluctuates around a fixed value in the short run. In a univariate framework, PPP can be tested by simply testing for whether the real exchange rate is stationary or not. Alternatively, PPP can be cast in a multivariate framework by applying cointegration methods.

The massive empirical testing of PPP has generally cast doubt on long run PPP, either by rejecting the hypothesis that PPP follows a stationary process, or by suggesting that the real exchange rate adjusts too slowly back to a long run equilibrium rate to be consistent with traditional PPP (the half time is normally found to be 3-4 years, see e.g. Rogoff (1996)).[3] Instead, long run deviations from PPP, suggest the influence of real factors with large permanent effects, like productivity differentials, fiscal policy and other relevant variables, again see Rogoff (1996) for a survey. These factors will work through the current account, and thereby push the real exchange rate away from PPP.

However, as several authors has emphasised, (see e.g. MacDonald and Marsh (1997) and Juselius and MacDonald (2000)), the balance of payment constraint implies that any imbalances in the current account has to be financed through the capital account. Shocks that force the real exchange rate away from PPP has to be captured through the movements in interest rates, since they reflect expectations of future purchasing power. Hence, massive movements in capital flows in response to interest rate differentials can keep the exchange rate away form purchasing power parity for long periods. The PPP condition in the goods market will therefore be strongly related to the central parity condition in the capital market, namely that of UIP.

According to the UIP condition, the interest rate differential will be an optimal predictor of the rate of depreciation, providing the conditions of rational expectations and risk neutrality are satisfied, hence

$$\Delta v_{t+1}^e = i_t - i_t^* , \qquad (3)$$

where Δv_{t+1}^e is the expected depreciation rate from period t to t+1, i_t is the domestic interest rate and i_t^* is the foreign interest rate. Hence, an interest rate differential at time t, will then lead to an expected depreciation rate at time $t+1$.

[3] In a recent study, Murray and Papell (2002) also find the half life of deviations from PPP for each of 20 countries (including Norway) to lie between 3-5 years. However, their confidence intervals are much larger than previously reported, implying in fact that univariate methods provide virtually no information regarding the size of the half life.

Assume that in the long run, the current account (ca) depends upon the deviation from PPP whereas the capital account (ka) depends on the nominal interest differentials adjusted for expected exchange rate changes. The balance of payment then implies that

$$ca_t + ka_t = \gamma\left(v_t + p_t^* - p_t\right) - \lambda\left(i_t - i_t^* - \Delta v_{t+1}^e\right) = 0\,, \tag{4}$$

where γ captures the elasticity of net exports with respect to competitiveness and λ represents the mobility of international capital. Assuming that capital is less than perfect mobile ($\lambda<\infty$) and that in equilibrium, Δv_{t+1}^e=0, (4) can be solved for the exchange rate to yield a long run equilibrium relationship (see also Bjørnland and Hungnes (2002))

$$v_t = p_t - p_t^* - \upsilon\left(i_t - i_t^*\right), \tag{5}$$

where $\upsilon=\gamma/\lambda$. Equation (5) states that the nominal exchange rate is a function of both the price level differential and the interest rate differential, where the speed of adjustment to the interest rate differential is given by υ. Another way to interpret (5) is that the non-stationarity of the real exchange rate (v_t-p_t+p_t*) can be removed by the non-stationarity of the interest rate differential (i_t-i_t*).

3. Econometric model

Here we model the whole system jointly within a full information maximum likelihood (FIML) framework, see Johansen (1988). We first define the vector stochastic process as $z_t = \left(v_t, p_t, p_t^*, i_t, i_t^*\right)'$, where *v*, *p, p**, *i* and *i** are defined as above. Assume this process can be reparameterised as a vector equilibrium correction model (VEqCM).[4]

$$\Delta z_t = \mu + \Gamma_1 \Delta z_{t-1} + \Gamma_2 \Delta z_{t-2} + \ldots + \Gamma_{p-1} \Delta z_{t-p+1} + \Pi z_{t-1} + \Psi S_t + u_t\,, \tag{6}$$

where $u_t \sim NIID(0,\Sigma)$. μ is a vector of constants and S_t is a vector of unrestricted centred seasonal dummies. The null hypothesis of *r* cointegrating vectors can then be formulated as

$$H_0 : \Pi = \alpha\beta'\,, \tag{7}$$

[4] Bjørnland and Hungnes (2002) also included the real oil price and a trend (the latter restricted to lie in the cointegration space), but both came out as insignificant, and are therefore excluded here. Consistent with this, Akram (2000b) finds that only when the oil price is below 14 $ per barrel or above 20 $ per barrel, will a change in the oil price have a significant effect on the Norwegian exchange rate. Throughout our sample, the oil price has varied within these limits most of the time.

where α and β are $5\times r$ matrices of rank r, ($r<5$), $\beta' z_t$ comprises r cointegration I(0) relations, and α contains the loading parameters.

3.1. Estimating the long run relationship[5]

The variables used in the econometric analysis are: The log of the nominal exchange rate in Norway relative to its trading partners, log of home and foreign consumer prices and home and foreign interest rates, (see Appendix A for a further description of data and their sources). In addition, a constant and centred seasonal dummies are included in the estimation as unrestricted variables.[6] We use quarterly data, and the estimation period is from 1983Q1 to 2002Q2. The start date for estimation is set to exclude the turbulence in the international capital markets in the early 1980s, which would necessitate a series of intervention dummies which we try to avoid (see the discussion in MacDonald and Marsh (1999)). Unit root tests show that it is reasonable to assume that all variables are integrated of first order, $I(1)$, and we can reject the hypothesis of integration of second order, I(2) (Table A-1).

Estimating a VAR with four lags (four lags were necessary to exclude any problem with autocorrelation, however, using instead three or two lags, the results from the cointegration analysis are virtually unchanged), the cointegration tests indicate one cointegration vector at the 1 percentage significance level (the Trace test for "H_0: No cointegration", yields a test statistic of 91.88 [0.00], where the significane probability of acceptance is in brackets). Testing restrictions on β, we can reject the hypothesis of pure PPP and interest rate differential (based on pure UIP) (LR test $\chi^2(4)$= 35.72 [0.00] and $\chi^2(4)$= 18.58 [0.00] respectively). However, neither of these two hypothesis can be rejected when the rest of the cointegrating vectors are left unrestricted, implying that the hypotheses of PPP and UIP should be combined. In the end, a cointegration vector with PPP augmented with the interest rate differential can not be rejected ($\chi^2(3)$=6.01 [0.11]). This fully restricted vector has the expected signs; if the Norwegian interest rate is high (relatively to the interest rate of Norway's trading partners), the equilibrium real exchange rate must be low, consistent with an appreciation of the Norwegian krone.

The restricted β vector is finally combined with weak exogeneity restrictions on foreign prices and domestic and foreign interest rates. This specification is not rejected ($\chi^2(6)$= 11.0 [0.09]). The

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[5] The empirical estimations are conducted using PcGive 10, see Doornik and Hendry (2001).

[6] The estimated vector autoregressive model does not include any dummies, as none are needed for the misspecification tests. However, Bjørnland and Hungnes (2002) included a set of dummies in the estimation, mainly to take account of extreme oil price fluctuations and changes in the exchange rate regime. Of those only two came out significant here: 1992Q4-1993Q1 and 1997Q1. Both account for an appreciation pressure in excess of what the model can explain. However, the results reported below are virtually unchanged by the inclusion of these dummies, and they are therefore omitted here for simplicity.

additional restrictions do not change the estimated long run coefficients much. The estimated long run exchange rate relation is reported in equation (8), with standard error in parenthesis below.

$$v = p - p^* - \underset{(1.55)}{9.99}(i - i^*) \tag{8}$$

Equation (8) clearly implies that although PPP is not by itself a stationary process, it becomes stationary when combined with the interest rate differential. Hence, the long-run interactions between the goods and capital markets cannot be ignored.

In the analysis we have used quarterly interest rates. To get a proxy for the annual interest rate, we therefore need to multiply the quarterly interest rate by four. Hence, if we had used an annual interest rate, the coefficient for the interest rate difference would be ¼ of the one reported in (8), i.e. about 2.5.[7] This is somewhat larger than what was reported in a similar study by Bjørnland and Hungnes (2002), but may reflect the fact that in 2001 Norway adopted a new monetary policy regime, were rather than targeting the exchange rate, the inflation rate is now targeted. This may just have been captured given that we now have a longer sample (ending in 2002 rather than in 1999 as in Bjørnland and Hungnes (2002)). In addition, the choice of variables varies somewhat and here we use quarterly data, versus monthly data in Bjørnland and Hungnes (2002).

4. A parsimonious representation

The next step after determining the long run equilibrium relationship is to establish a parsimonious representation for the exchange rate that includes the long run equilibrium. The econometric methodology used here is a general-to-specific approach. The familiar equilibrium correction form of the exchange rate from the VAR model specified above as

$$\begin{aligned} \Delta v_t = {} & \sum_{j=1}^{p-1} \gamma_{1j} \Delta v_{t-j} + \sum_{j=0}^{p-1} \gamma_{2j} \Delta p_{t-j} + \sum_{j=0}^{p-1} \gamma_{3j} \Delta p^*_{t-j} + \sum_{j=0}^{p-1} \gamma_{4j} \Delta i_{t-j} + \sum_{j=0}^{p-1} \gamma_{5j} \Delta i^*_{t-j} \\ & + \rho_1 (v - p + p^*)_{t-1} + \rho_2 (i - i^*)_{t-1} + \phi D_t + \varepsilon_t \end{aligned} \tag{9}$$

where p=4, D_t contains all the deterministic components (constant, centred seasonal dummies and impulse dummies). The exchange rate model therefore contains three lags of the difference of each of

[7] If i_q is the quarterly interest rate and i_a is the annual interest rate, the relationship between them is given by $(1+i_a)=(1+i_q)^4$. Solving for the annual interest yields $i_a=4i_q+6i_q^2+4i_q^3+i_q^4>4i_q$. The factor we have to multiply the quarterly interest rate is therefore a bit higher than 4 (and depending on the interest rate), and the corresponding coefficient for the interest difference measured in annual terms is slightly less than 2.5.

the variables of our model; exchange rate, domestic and foreign prices and domestic and foreign interest rates. In addition, the equilibrium correction term is included, lagged one period. The equilibrium correction term is the same as that specified above, but rather than imposing one cointegrating vector consisting of PPP and the interest rate differential together, we split the cointegration vector into two parts: Pure PPP and the interest rate differential. The data will then determine if they are significant together, which will be a test of the above results.

We first test the unrestricted model for potential misspecifications to ensure data coherence. If that is satisfied, the model is simplified by eliminating statistically insignificant variables. Simplifications from the general to specific model, is performed using PcGets1 (see Hendry and Krolzig (2001)). Note also that we now allow for impulse dummies, which are chosen by the model based on an outlier detection procedure (rather than imposed by us a priori).[8] Given that the reduction does not yield any invalid simplification, the final choice will not loose any significant information about the relationship for the data sample that is available. The final choice therefore parsimoniously encompasses the unrestricted model and is not dominated by any other model. The reduction procedure yields the model presented in equation (10), with standard errors in parenthesis below the coefficients

$$\begin{aligned}\Delta v_t = {} & \underset{(0.04)}{0.21} + \underset{(0.26)}{1.25}\,\Delta p_t + \underset{(0.25)}{0.65}\,\Delta p_{t-2} - \underset{(0.41)}{1.56}\,\Delta p_t^* - \underset{(0.41)}{1.31}\,\Delta p_{t-3}^* + \underset{(0.73)}{2.72}\,\Delta i_t - \underset{(1.09)}{2.47}\,\Delta i_{t-2}^* \\ & - \underset{(0.05)}{0.27}(v - p + p^*)_{t-1} - \underset{(0.35)}{1.86}(i - i^*)_{t-1} \\ & + \underset{(0.01)}{0.07}\,D93Q1_t - \underset{(0.01)}{0.04}\,D97Q1_t - \underset{(0.01)}{0.05}\,D02Q2_t + \underset{(0.004)}{0.01}\,S_t + \hat{\varepsilon}_t\end{aligned} \tag{10}$$

The model shows that the coefficients in front of PPP and the interest rate differential are highly significant, and should therefore be combined as suggested by the cointegration analysis. Dividing the coefficient on the interest rate term on that in front of PPP, yields a coefficient of 7, which is close to the one reported in the cointegration analysis above.

In addition, contemporaneous and lagged values of domestic and foreign prices, a contemporaneous value of the domestic interest rate, a lagged value of foreign interest rate, a centred seasonal dummy (S) and the three estimated impulse dummies, in 1993Q1, 1997Q1 and 2002Q2, are found to be significant. Interestingly, the dummies in 1993 and 1997 correspond well with the chosen dummies in Bjørnland and Hungnes (2002), and represent respectively a change to a floating exchange rate regime in December 1992/January 1993 after a period of speculation, and a severe appreciation pressure against the Norwegian krone in the first quarter of 1997. The final dummy in 2002Q2 is chosen by the

[8] We specify the outlier detection size of marginal outlier (in standard deviation) to be 1.9 in PcGets, in contrast to the default of 2.56.

model to account for the severe appreciation of the Norwegian krone in excess of its fundamentals. As mentioned above, it is only recently that Norway adopted the new monetary policy regime of inflation stabilisation, so that the expectation formation may not have changed accordingly.

The model implies that the short run price elasticities are higher than unity, which is consistent with overshooting. In particular, higher domestic prices and interest rate will cause the exchange rate to depreciate in the short run, and a higher foreign price and interest rate will imply an appreciation of the exchange rate. Historically, Norges Bank has increased the interest rate when there have been a depreciating pressure, and reduced the interest rate when there was an appreciation pressure. An increase in the interest rate differential has therefore often coincided with a weaker exchange rate, while an interest rate increase may have prevented the exchange rate from falling even further (see Norges Bank 2000, p. 16.). In the long run however, the exchange rate will eventually move towards equilibrium. The equilibrium correction terms have the expected sign, so that the exchange rate adjusts in the right direction.

Table 1. Misspecification tests[1]

	Value	Significance probability
$F_{\text{Chow(1992:4)}}$	1.01	0.49
$F_{\text{Chow(2000:3)}}$	0.54	0.80
$\chi^2_{\text{Normality test}}$	5.01	0.08
$F_{\text{AR 1-4 test}}$	1.74	0.15
$F_{\text{ARCH 1-4 test}}$	1.30	0.28
$F_{\text{Hetero test}}$	20.07	0.45

1) *Chow (1992:4)* and *Chow (2000:3)* are the breakpoint tests, where the first periodtest fraction is chosen by PcGets at the periods 1992Q4 and 2000Q3 respectively; the *normality test* checks whether the residuals are normally distributed; *AR 1-4* is a test of 4th order residual autocorrelation, *ARCH 1-4* is a test for 4th order autoregressive conditional heteroscedasticity in the residuals; and *Hetero test* is a test for residual heteroscedasticity, see Hendry and Krolzig (2001).

No misspecification test rejects the selected model (see Table 1), and underlines that the parameters are constant. The model is also congruent, and provides a parsimonious representation for the exchange rate.

Recursive graphics are shown in Figure 1 and 2 below. Figure 1 emphasises that most coefficients seem constant, although some are significant only at the end of the sample (for instance the coefficient for Δp_{t-2}). The equilibrium correction terms are clearly significant and seem fairly stable, although the interest rate differential is vaguely more significant at the end of the sample.

Figure 1. Recursive Least Squares: Parameter constancy graphs

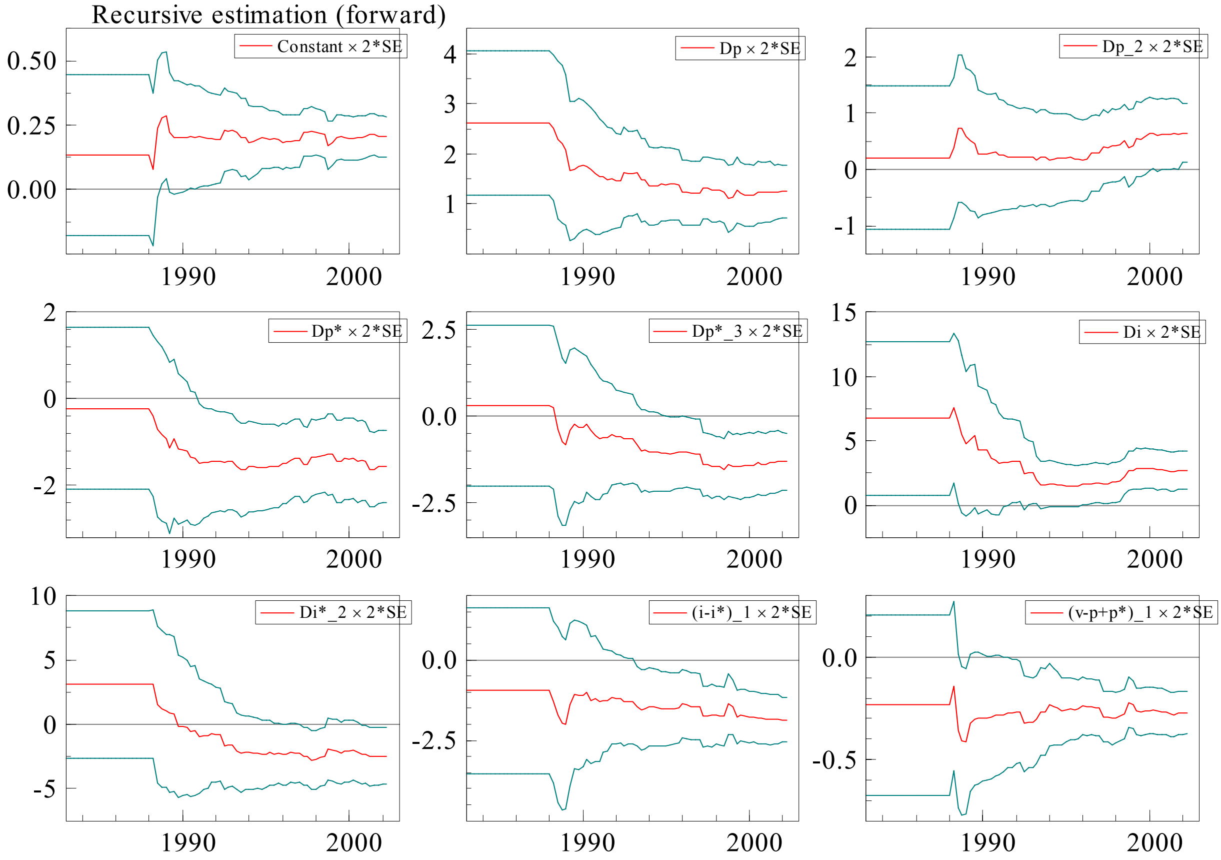


Figure 2 reports the constancy statistics. Panel a (upper left) shows the RSS at each observation and panel b (upper right) shows the 1-step residuals plotted with a two standard error bands on either side of zero. Thus any observation outside the band represents an outlier. Note that it the model residuals are graphed until 1988, after which the one-step-prediction errors are plotted. Clearly there are three large observed outliers throughout the sample, in 1993, 1997 and 2002, and two minors, in 1988 and in 1998/1999. The three large outliers are picked up by three outlier dummies in the model (see the discussion above), and used in the final estimation that covers the whole period. The band itself seems fairly constant.

The Chow test is graphed in panel c (bottom left) and the associated p-value (with the 5% critical value shown as a straight line) are shown in panel d (bottom right). Both of these panels confirm the constancy of the model, since all observations lie above the 5% critical value.

Finally, Figure 3 contains the actual residuals (estimated non-recursively). The graph emphasises the constancy of the model when all the three dummies are included in the estimation.

Figure 2. Recursive Least Squares: Constancy statistics

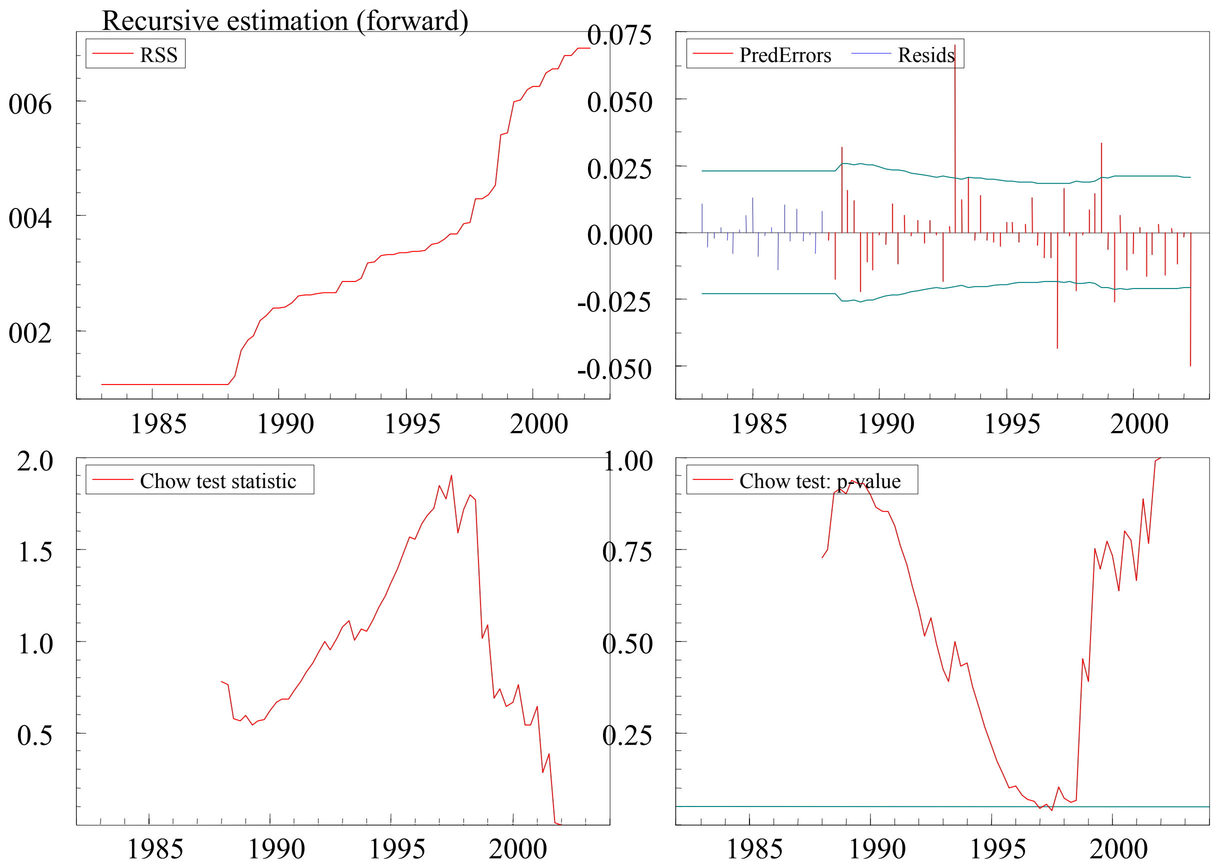
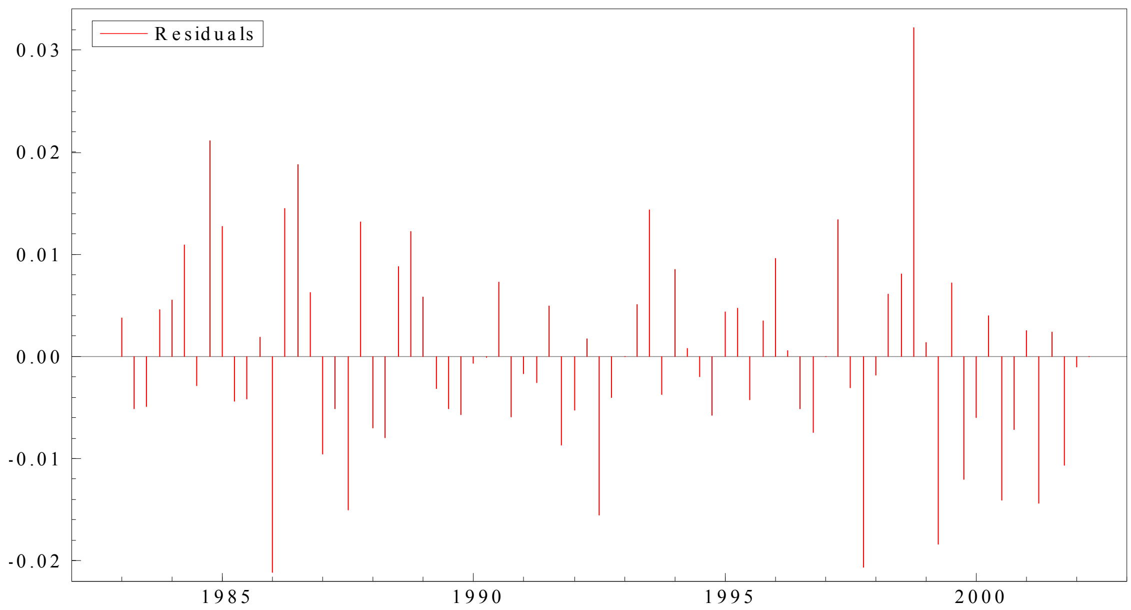


Figure 3. Actual residuals for the relative change in the exchange rate



5. Out-of-sample forecasting

Having identified a parsimonious model for the exchange rate, a natural question to ask would be if the structural model identified here can outperform the random walk in predicting the exchange rate. The random walk model would take the form

$$v_t = v_{t-1} + \varepsilon_t \tag{11}$$

which implies that the best prediction for the exchange rate next period, would be the same as this period's exchange rate .

In addition to our structural model, we also estimate an alternative fundamental EqCM, where the only difference is that now the equilibrium term is simplified to a pure PPP (v-p+p*), and instead the interest rate differential is allowed to matter in the short run only. The model is denoted PPP. The motivation for doing so is to investigate the importance of the long run interest rate differential for exchange rate determination explicitly. This has not been emphasised as important in recent studies of the exchange rate behaviour by Norges Bank (the central bank of Norway), see e.g. Akram 2000a, and Norges Bank (2000)[9]. Note that in this forecasting competition, all models are compared using levels on the left hand side, so that it is the forecast of (the log of) the actual exchange rate (and not its change) that are compared.

Following Meese and Rogoff (1983), we perform an out-of-sample forecasting exercise comparing the structural models to a random walk, using a rolling regression methodology. That is, the models are first estimated using data until the first forecasting period. We take the first 15 years, (1983Q1-1997Q4), as initial estimation period, which leaves us with a forecast period of almost five years, (1998Q1-2002Q2). The forecasts are generated at 1, 2, 3 and 4 quarters. These horizons are common in the literature and correspond well with the duration of standard forward contracts (see Meese and Rogoff 1983). In the next step, the estimation period is rolled forward by one quarter, keeping the total length of the estimation period (15 years) constant.[10] New forecast are then generated at 1, 2, 3 and 4 quarters, and so on. In the end, the square of the forecast errors at the different horizons are averaged using the root means square error (RMSE) and the mean absolute error (MAE). RMSE will be our principal criteria used for comparing forecasts. However, in some cases, MAE may be more appropriate than the RMSE, in particular if the exchange rate follows a non-normal stable Paretian

[9] In Norges Bank (2000, p. 16), the Central Bank argues that a higher domestic interest rate differential may render the Norwegian currency more attractive, although isolated, this effect will be small compared to other factors.

[10] Of course, that is only important for the structural models, since the random walk model uses the last observation only when making forecasts.

process with infinite variance, or if the exchange rate distribution has fat tails but finite variance (see Meese and Rogoff 1983).

Table 2. Root mean square error (RMSE) (*100)

Horizon (quarters)	RW	EqCM	PPP
1	2.17	1.82	2.19
2	3.33	2.64	3.65
3	3.98	3.43	4.71
4	4.45	4.06	5.68

The evidence using the RMSE metric is reported in Table 2 and suggests that the structural EqCM model performs better than the random walk at forecasting the exchange rate at all horizons. The pure PPP model performs worst of all the three models at all horizons, and can therefore not outperform any other model in this forecasting competition.

Atlhough the structural EqCM model performs better than the random walk at all horizons, the relative difference between them is larger at the low horizon than at the high horizon (like one year). This is at odds with other similar studies, like Reiton and Ongena (1999), but may be due to the fact that our structural model has a dummy in the last observation (2002Q2), which is ignored in the forecasting competition. Hence, predictions using a forecast horizon of four quarters, where we will have fewer observations to base our forecast on than using for instance a one quarter horizon, will be dominated by the prediction failures at the end of our sample.

Table 3. Mean abolute error (MAE) (*100)

Horizon (quarters)	RW	EqCM	PPP
1	1.79	1.27	1.80
2	2.52	2.19	2.87
3	3.11	2.98	4.01
4	3.48	3.66	4.86

The evidence using the MAE metric (se Table 3) strengthens the results reported above. The structural EqCM performs the best of all the models at all horizons (with the exception of the horizon of four quarters, where the random walk model performs marginally better), whereas the pure PPP model can again not outperform any other model at any horizon. The reason that the structural EqCM performs marginally worse than the random walk model at the four quarter horizon, may as we discussed above, be due to the fact that we have relatively few observations at this horizon, so that they will be dominated by the prediction failures at the end of our sample. Nevertheless, the results emphasise the importance of the interest rate differential in the long run when predicting exchange rate behaviour, as in no cases does the pure PPP-model outperform any other model.

6. Conclusion

This paper has examined whether a parsimonious dynamic exchange rate model for Norway that combines the purchasing power parity condition with the interest rate differential in the long run, can outperform a random walk model in an out-of-sample forecasting exercise.

We show that the long-run results can be embedded in a parsimonious representation, which outperforms a random walk in an out-of-sample forecasting competition. Ignoring the long run interest differential (that is focusing only on PPP in the long run), however, the fundamental model can no longer outperform a random walk.

The results emphasise the importance of the interest rate differential in the long run when predicting exchange rate behaviour, as in no cases does a pure PPP-model outperform any other model. In fact, an economic modeller that ignores the long run effect of the interest rate differential on the exchange rate and focuses instead only on PPP in the long run, would be much better off had he/she instead used a random walk model for the exchange rate when making economic forecast.

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Appendix A

Data and model specifications

Data sources

All data are taken from KVARTS database, Statistics Norway. We use quarterly data, and the estimation period is 1983Q1-2002Q2. The data series are (with name of variables in brackets):

v	The nominal exchange rate relative to its trading partners (*KURVECU*)
p	Domestic consumer prices *(KPI)*
p*	Foreign consumer prices *(UKPINY)*
i	Domestic 3-months interest rates *(RNOK)*
i*	Foreign 3-months interest rates *(RUTL)*

Unit root test

Table A-1: Unit root tests

Variables	Level [a]	Variables	Differences [b]
v	-0.54	Δv	-4.82**
p	-1.95	Δp	-3.10*
p*	-1.01	Δp*	-3.57**
i	-2.37	Δi	-6.72**
i*	-2.01	Δi*	-4.13**
v-p+p* (PPP)	-1.33	Δ(v-p+p*)	-4.67**
i-i* (Interest rate differential)	-1.80	Δ(i-i*)	-4.33**

a) Constant and trend in the estimation. Critical vales: 5%=-3.47, 1%=-4.08.
b) Constant in the estimation. Critical values: 5%=-2.90, 1%=-3.52
(*) Significant at the 5 % level, (**) Significant at the 1 % level.

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