



The importance of interest rates for forecasting the exchange rate

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The talk is based on the two papers (1) Bjørnland H. and H. Hungnes (2003) "*The importance of interest rates for forecasting the exchange rate*", Discussion Papers No. 340, Statistics Norway and (2) Bjørnland H. and H. Hungnes (2002) "*Fundamental determinants of the long run real exchange rate: The case of Norway*", Discussion Papers No. 326, Statistics Norway. All other references quoted here can be found in either of these two papers.



Overview

- ❑ **Can a dynamic exchange rate model that combines PPP with UIP in the long run outperform a random walk model in an out-of-sample forecasting exercise?**
- ✓ Persistent deviations from PPP explained by real factors that work through the interest rate differential in the long run.
- ✓ Applied to Norway. Despite a huge and growing international literature, relatively few empirical analysis for Norway.
- ✓ Long run relationship embedded in a parsimonious exchange rate model.
- ✓ Forecasting performance using two alternative structural models and a random walk.



Purchasing Power Parity (PPP)

- ✓ Since Meese and Rogoff (1983), the role of economic fundamentals in explaining exchange rate behaviour has been scrutinized.
- ✓ The behaviour of the real exchange rate should be closely related to the behaviour of deviations from purchasing power parity (PPP).
- ✓ The PPP condition has its roots in the goods market. Nominal exchange rates adjust to offset changes in relative prices.



Testing for PPP

- ✓ The expression for PPP states that domestic prices would equal foreign prices multiplied by the exchange rate (or in log-form) :

$$v_t = p_t - p_t^* \quad (1)$$

- ✓ However, since trade is costly, PPP will not hold continuously. It is therefore informative to define the real exchange rate as

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

- ✓ If PPP shall hold, this will imply that the real exchange rate is stationary and fluctuates around a fixed value in the short run.



Why do we care about PPP?

- ✓ Developing countries facing large price differentials, use PPP to predict future exchange rate developments.
- ✓ Policy advice will therefore depend on the validity of PPP.
- ✓ But PPP is relevant in policy discussions for Norway as well. Norges Banks mandate on inflation target from 2001, specify in § 1.:
“Pengepolitikken skal sikte mot stabilitet i den norske kronens nasjonale og internasjonale verdi, herunder også bidra til stabile forventninger om valutakursutviklingen...”
- ✓ In a letter from Norges Bank to the Ministry of Finance in 2001, Norges Bank clarify this link between the inflation target and exchange rate stability further: *“Kronen flyter, og kronens verdi svinger periodevis... Det beste bidraget pengepolitikken kan gi til stabile forventninger om valutakursutviklingen, er å sikte mot å oppfylle målet om lav og stabil inflasjon”*. (<http://www.norges-bank.no>)



Does PPP hold?

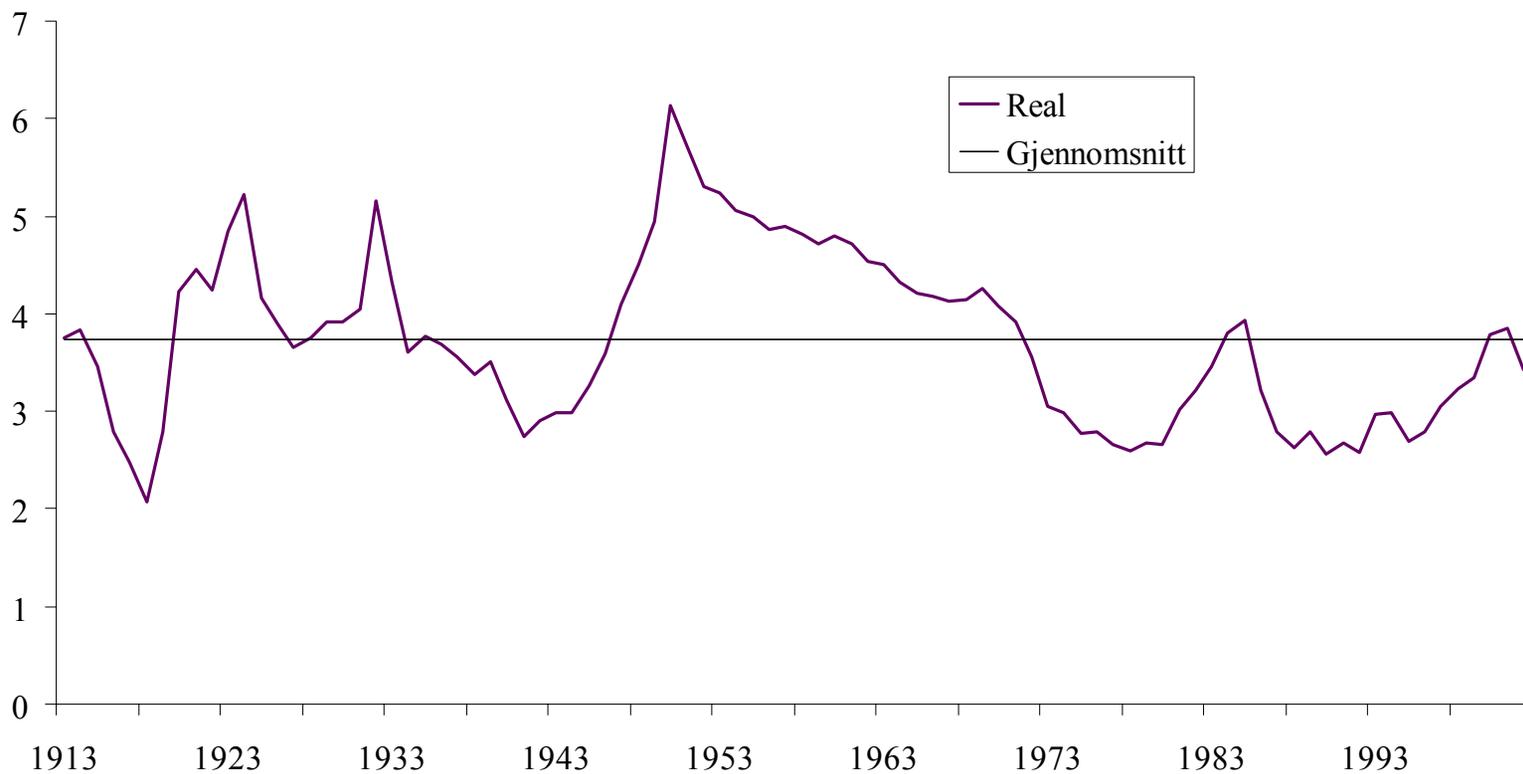
- ✓ Substantial evidence that deviations from PPP have occurred since the abandonment of the Bretton Woods fixed exchange rate system (Sarno and Taylor 2002, for recent survey).
- ✓ In many cases when PPP is accepted, speed of reversion to slow to be consistent with PPP (Rogoff 1996).
- ✓ Studies spanning longer periods of time more favourable, although many studies reject PPP (Serletis and Zimonopoulos 1997; Engel 2000; Rogoff et al. 2001 and Rapach and Wohar 2002).
- ✓ Some evidence of PPP for high inflation countries, (but see Holmes 2001 for refusal).
- ✓ Evidence of non-linearities and chaos (Serletis and Gogas 2000).



Empirical evidence of PPP in Norway

- ✓ Previous studies 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
 - In the short run: Papell (1997), Chortareas and Driver (2001), and Murray and Papell (2002) (Half life 3.38 years).
 - In the long run: Serletis and Zimonopoulos (1997), Rapach and Wohar (2002) and (to some extent) Taylor (2002).
 - ✓ using multivariate studies: Jore et al. (1998) and Alexius (2001).
- ✓ Akram (2000,2002) on the other hand, using multivariate cointegrating framework, finds evidence of PPP for Norway.
- ✓ But even though PPP should hold in the long run, the real exchange rate can deviate from PPP (its mean) for prolonged periods (decades), (see figure).

Real exchange rate, Norway versus the U.S., 1913-2002





What can we do when PPP fails?

Need real factors

- ✓ Persistent deviation from PPP casts doubt on Dornbusch (1976) open macroeconomic (overshooting) model, that explains short run real exchange rate volatility with sticky prices and monetary disturbances.
- ✓ Long run deviation from PPP suggests the influence of real shocks with large permanent effects. Consistent with rejection of unit root.
- ✓ Many explanations, from Ballassa-Samuelson hypothesis; Productivity differentials between traded and non-traded sector, to more recently MacDonald ad Ricci (2002); New Trade theory.
- ✓ Norges Bank Watch: Phase in of oil revenues lead to permanent real appreciation of the krone.



Uncovered Interest Parity (UIP)

- ✓ Another central parity condition for the exchange rate that plays a crucial role in capital market models is the uncovered interest parity.
- ✓ A test of UIP, refers to a test of the interest rate differential as an optimal predictor of the rate of depreciation, providing the conditions of rational expectations and risk neutrality are satisfied:

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

- ✓ Empirical evidence has generally led to a strong rejection of the UIP condition in the Post Bretton Woods period.
- ✓ Little evidence supporting this parity condition for Norway (see Holden and Vikøren 1994, Nessen 1997, Jore et al. 1998, and Flood and Rose 2001 for rejections).



Fundamentals and long run real exchange rate

- ✓ Links between goods and capital markets imply that one should model the whole system jointly. Better able to capture the interactions between the nominal exchange rate, the price differential and the interest rate differentials.
- ✓ The balance of payment constraint - 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.
- ✓ Massive movements in capital flows in response to interest rate differentials can keep the exchange rate away from PPP for long.



Model

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

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

- Assume that Δv_{t+1}^e is a function of the deviation of v_t from its equilibrium value \bar{v}_t , then (3) can be replaced by:

$$\begin{aligned} \Delta v_{t+1}^e &= i_t - i_t^* \\ &= -\lambda(v_t - \bar{v}_t). \end{aligned} \quad (4)$$

- In the long run, equilibrium exchange rate is given by PPP, hence $\bar{v}_t = p_t - p_t^*$. Substituting for the equilibrium exchange rate in (4):

$$v_t = p_t - p_t^* - \upsilon(i_t - i_t^*) \quad (5)$$

- where $\upsilon=1/\lambda$ (speed of adjustment).

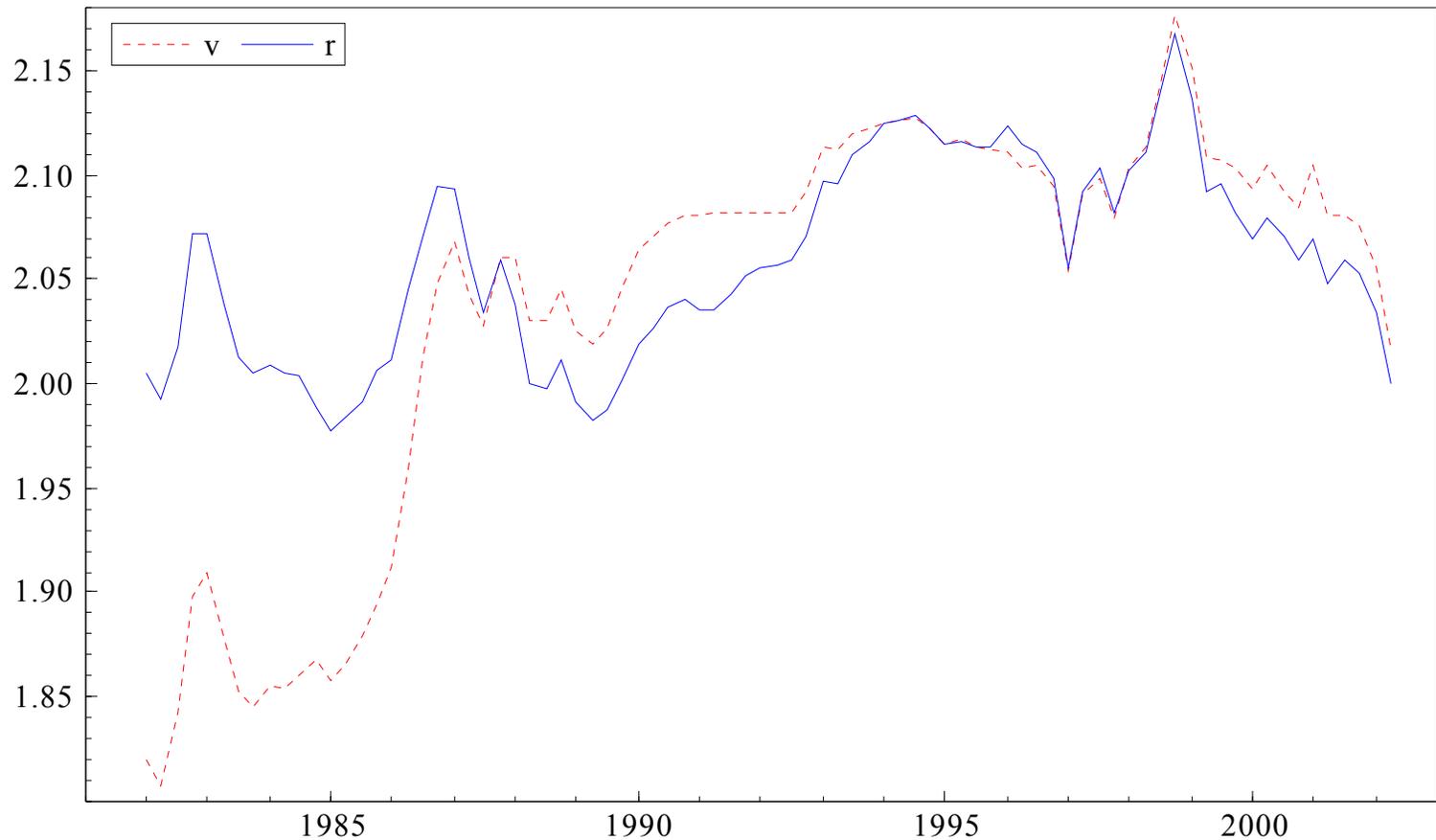


Sum up fundamentals

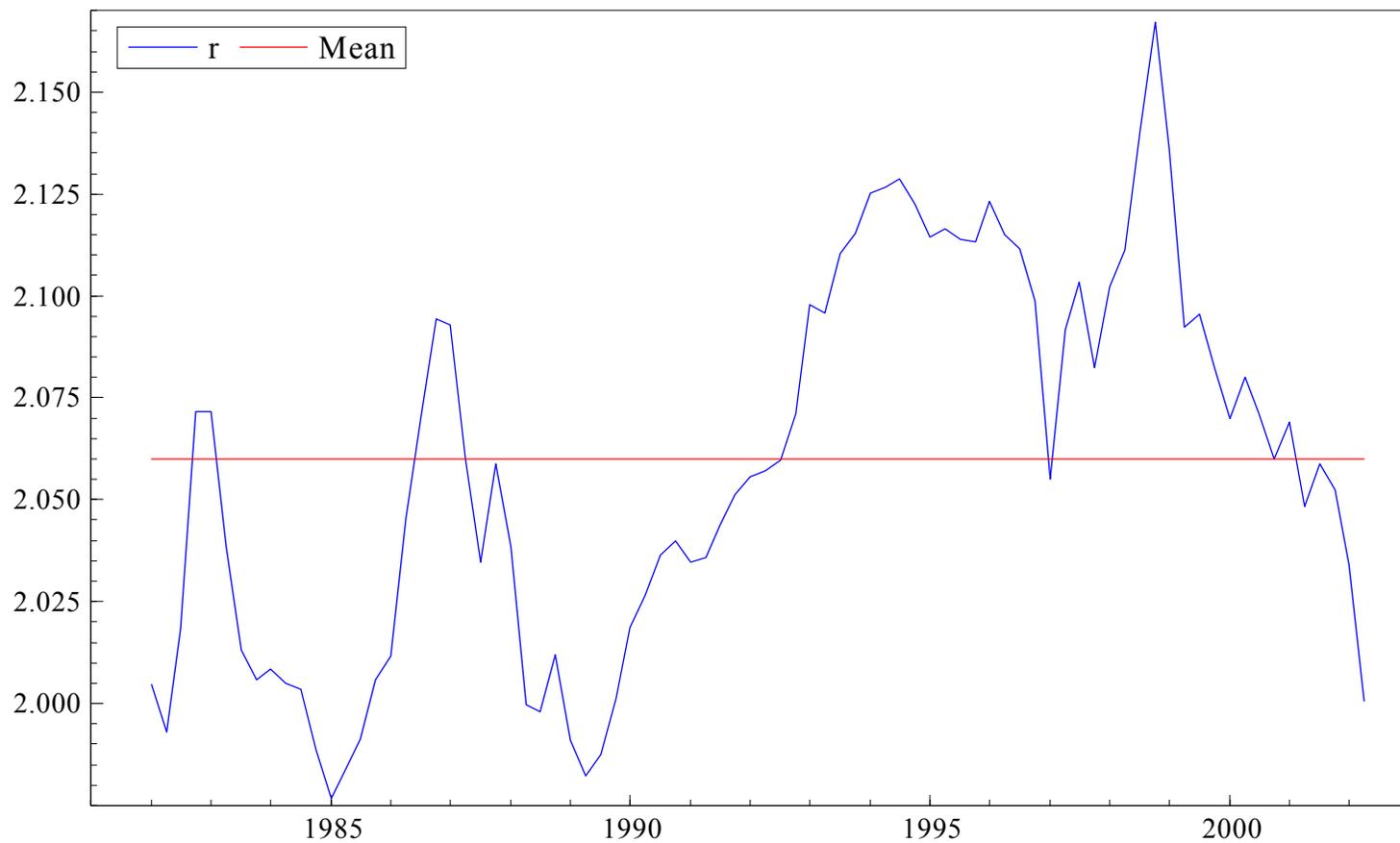
- ✓ The nominal exchange rate is a function of both the price level differential and the interest rate differential.
- ✓ The non-stationarity of the real exchange rate ($v_t - p_t + p_t^*$) can be removed by the non-stationarity of the interest rate differential ($i_t - i_t^*$).
- ✓ All the real shocks that force the real exchange rate away from PPP, may not be captured through the interest rate differential.
- ✓ For an oil producing country like Norway, the oil price may also have important effects on the real exchange rate that may lead to deviations from PPP not captured in the interest rates in the long run.
- ✓ Test for “petrocurrency”.

Nominal (v) and real exchange rate (r) against Norway's trading partners.

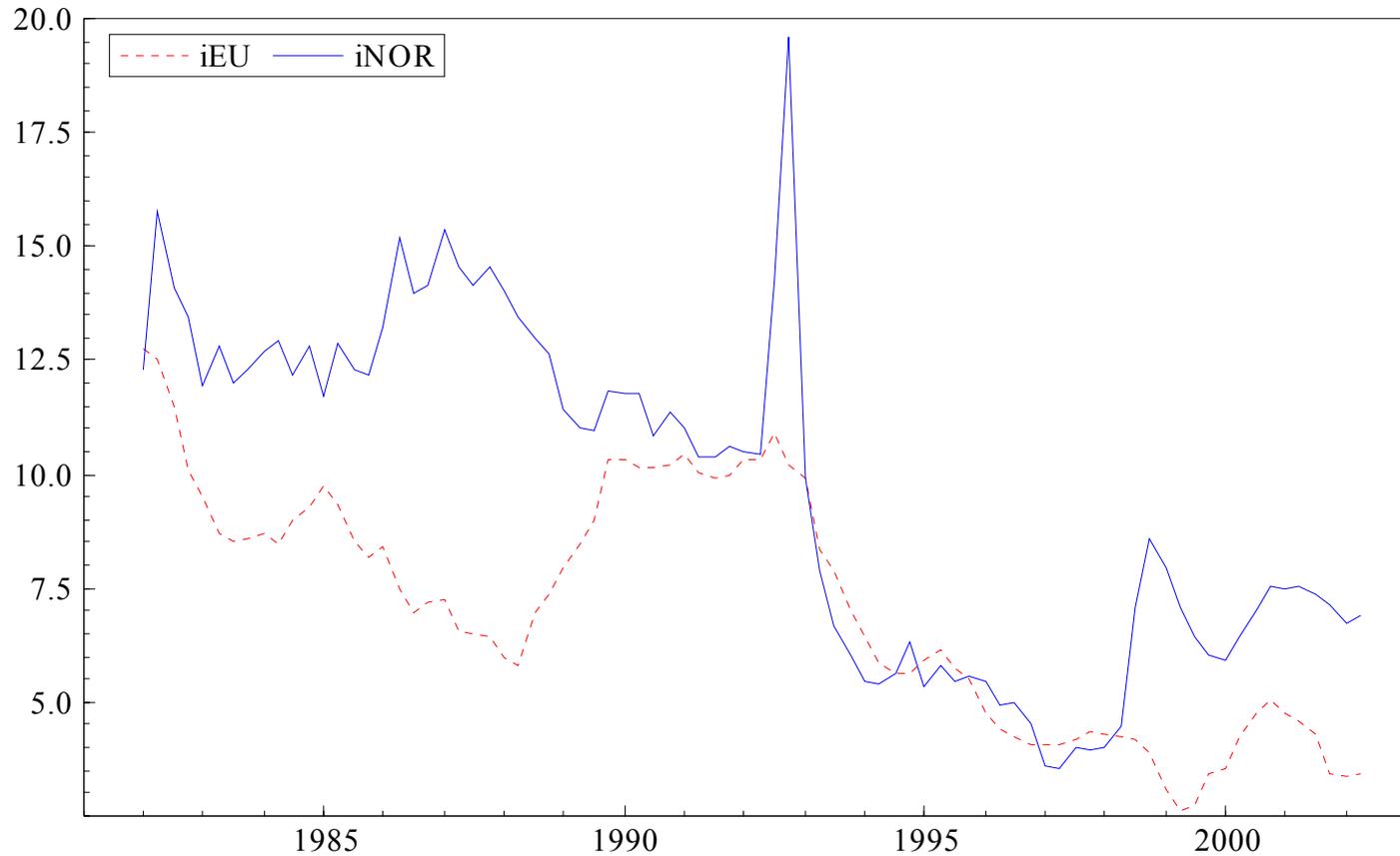
Logarithms, Increasing values imply a depreciation



Real exchange rate (r) and its mean



Norwegian interest rate (iNOR) and that of the trading partners (iEU)





Econometric model

- Define the vector stochastic process as $z_t = (v_t, p_t, p_t^*, i_t, i_t^*, oil_t)'$
- The process can be reparameterised as a VEqCM:

$$\Delta z_t = \mu + \Gamma_1 \Delta z_{t-1} + \Gamma_2 \Delta z_{t-2} + \dots + \Gamma_{p-1} \Delta z_{t-p+1} + \Pi z_{t-1} + \gamma t + \Psi D_t + u_t, \quad (6)$$

- The null hypothesis of r cointegrating vectors is formulated as:

$$H_0 : \Pi = \alpha \beta'$$

- where α and β are $6 \times r$ matrices of rank r , ($r < 6$), $\beta' z_t$ comprises r cointegration $I(0)$ relations, and α contains the loading parameters.



Testing strategy

I Test of pure (strong-form) PPP

$$\beta' = (1, -1, 1, 0, 0, 0)$$

II Test of interest rate differential (implied by UIP)

$$\beta' = (0, 0, 0, a, -a, 0)$$

III Test of no oil price

$$\beta' = (1, *, *, *, *, 0)$$

IV Test of PPP augmented by interest rate differential and oil price

$$\beta' = (1, -1, 1, a, -a, *)$$



Empirical results

- ✓ Model specification;
 - Quarterly (or monthly data), 1983Q1- 2002Q2 (exclude turbulence in international interest rate markets in early 1980s).
 - Unit roots. Can not reject the hypothesis of $I(1)$ in favour of the (trend) stationary alternative. Reject the hypothesis $I(2)$ for all variables.
 - Well specified VAR (4 lags). Tests indicate one cointegration vector at the 1 pct. significance level.

Test results, Norway's trading partners*

Tests		LR	[Prob]
Ia	Test of pure PPP	35.7	[0.00]
Ib	Augmented PPP	1.90	[0.59]
IIa	Test of interest rate differential	18.6	[0.00]
IIb	Augm. Interest rate differential	4.38	[0.11]
III	Test of no oil price (monthly data only)	2.42	[0.30]
IV	PPP, UIP, no oil	6.01	[0.11]

*) All results reported below refer to a model using quarterly data, unless otherwise specified.



Test on the cointegrating vectors

- We can reject the hypothesis of pure PPP (hypothesis I)
- We can reject the hypothesis of the interest rate differential (based on pure UIP) (hypothesis II).
- Neither PPP nor UIP can be rejected when the rest of the cointegrating vector is unrestricted, implying that PPP and UIP should be combined.
- The null restrictions on the oil price (hypotheses III) cannot be rejected.
- A joint test of these restrictions on the cointegration vector is accepted (hypothesis IV).



Long run properties

- ✓ Although PPP is not by itself stationary, becomes stationary when combined with the interest rate differential. Hence, the long-run interactions between the goods and capital markets cannot be ignored.
- ✓ A high Norwegian interest rate (relatively to trading partners), equilibrium real exchange rate low (appreciated).
- ✓ We can reject the hypothesis of weak exogeneity for the nominal exchange rate and domestic and foreign prices.

$$v = p - p^* - \underset{(1.55)}{9.99}(i - i^*) \quad (7)$$



A parsimonious representation

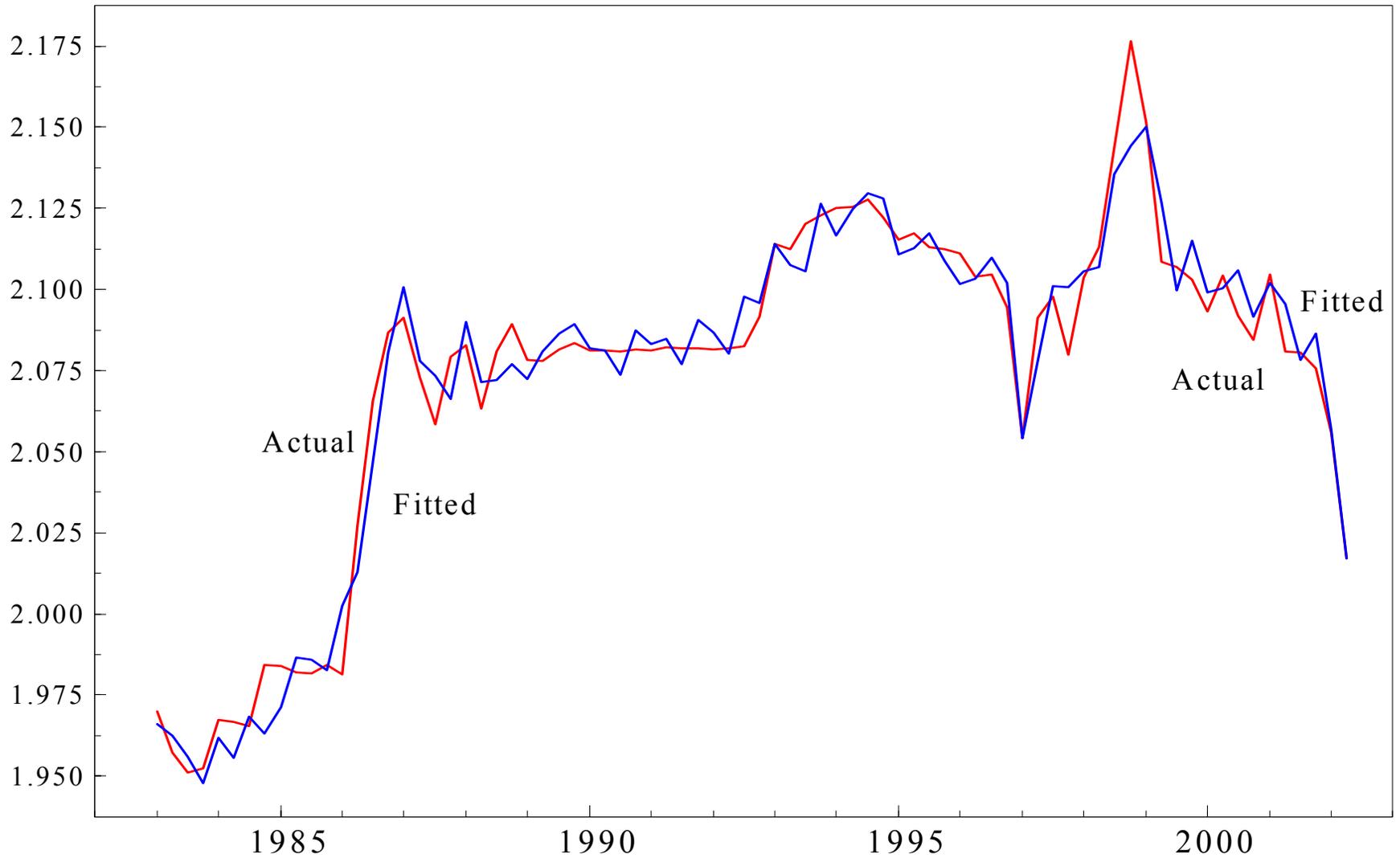
- ✓ Simplifications from the general to specific model, using PcGets1, see Hendry and Krolzig (2001).
- ✓ Allow for impulse dummies, which are chosen by the model based on an outlier detection procedure (rather than imposed by us a priori).
- ✓ Given that the reduction does not yield any invalid simplification, the final choice will not lose any significant information about the relationship for the data sample that is available.
- ✓ The final choice parsimoniously encompasses the unrestricted model and is not dominated by any other model.

The dynamic model

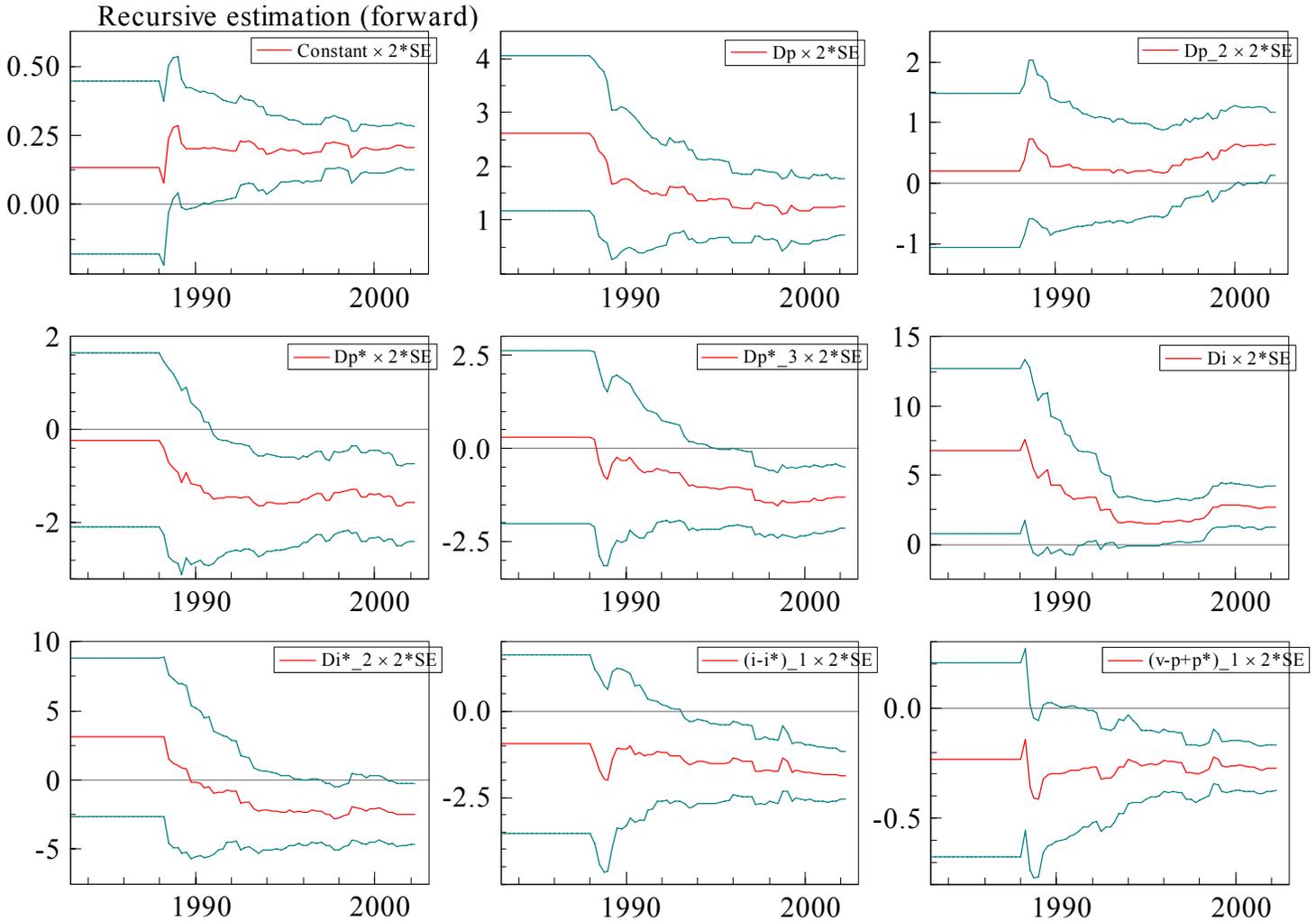
Equilibrium correction (EqCM)

$$\begin{aligned}
 \Delta v_t = & \underbrace{0.21}_{(0.04)} + \underbrace{1.25}_{(0.26)} \Delta p_t + \underbrace{0.65}_{(0.25)} \Delta p_{t-2} - \underbrace{1.56}_{(0.41)} \Delta p_t^* - \underbrace{1.31}_{(0.41)} \Delta p_{t-3}^* + \underbrace{2.72}_{(0.73)} \Delta i_t - \underbrace{2.47}_{(1.09)} \Delta i_{t-2}^* \\
 & - \underbrace{0.27}_{(0.05)} (v - p + p^*)_{t-1} - \underbrace{1.86}_{(0.35)} (i - i^*)_{t-1} \\
 & + \underbrace{0.07}_{(0.01)} D93Q1_t - \underbrace{0.04}_{(0.01)} D97Q1_t - \underbrace{0.05}_{(0.01)} D02Q2_t + \underbrace{0.01}_{(0.004)} S_t + \hat{\varepsilon}_t
 \end{aligned} \tag{8}$$

Actual & fitted values of the nominal exchange rate



Recursive estimation





Out-of-sample forecasts

- ✓ Can our structural model identified here (EqCM) outperform a random walk model in predicting the exchange rate?
- ✓ Meese and Rogoff (1983): A comprehensive range of exchange rate models were unable to outperform a random walk.
- ✓ The random walk (RW) model would take the form

$$v_t = v_{t-1} + \varepsilon_t \quad (9)$$

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



- ✓ In addition, estimate an alternative model, where the equilibrium term is simplified to a pure PPP ($v-p+p^*$). The interest rate differential is allowed to matter in the short run only.
- ✓ Motivation is to investigate the importance of the interest rate differential for exchange rate determination in the **long run**.
- ✓ Has not been found important in recent studies of the exchange rate determination (see e.g. Akram (2000), and Norges Bank (2000)).



- ✓ Use a rolling regression methodology.
- ✓ (1983Q1-1997Q4), is 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).
- ✓ 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 is our principal criteria used for comparing forecasts.

Table 1

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

Table 2

Mean absolute 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 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.
- ✓ The evidence using the MAE metric strengthens the results reported above (except at 4-quarter horizon).



Conclusion

- ✓ Examined whether a dynamic exchange rate model for Norway that combines PPP with the interest rate differential in the long run, can outperform a random walk in an out-of-sample forecasting exercise.
- ✓ Long-run results embedded in a parsimonious model; Outperforms a random walk in an out-of-sample forecasting competition.
- ✓ Ignoring the interest differential in the long run, the fundamental model can no longer outperform a random walk.
- ✓ Emphasises the importance of the interest rate differential in the long run when predicting exchange rate behaviour. By ignoring this effect (focusing on PPP only), better off using a random walk model for the exchange rate when making economic forecast.