



UiO : **University of Oslo**

Exchange rate volatility and pattern wage bargaining

Ragnar Nymoen

29 November 2024

Outline

- 1 Introduction and outline**
- 2 Definitions and stylized facts**
- 3 The exchange rate's walk through pattern wage bargaining**
- 4 Empirical responses to a foreign inflation shock**
- 5 Summary**

Inflation-depreciation spiral?

The weakening of the krone after COVID-19 has led to new questions about the virtues of pattern wage bargaining of the Norwegian type.

A point raised is that if there is a inflation shock among trading partners, pattern wage bargaining becomes a supply line of inflation impulses to the Norwegian economy .

Moreover, if the higher inflation goes together with depreciation, wage growth will get a second push upward, because of improved ability to pay in firms that take part in the wage-leading settlements (aka front-runner).

A consequence can be an inflation-depreciation spirals.

Which would have to be broken by forceful monetary policy, as the argument goes.

Outline

In this contribution I assess the relevance and force of the idea about a wage-formation driven inflation-depreciation spiral.

As a background, I review what the international literature has to say about the typical properties of nominal exchange rates under float-regimes.

It boils down to:

Near random walk and a certain disconnection from other macroeconomic variables.

I check empirically whether the properties of the Norwegian krone are different, and draw a blank.

Which does not resolve the disconnection puzzle; the nominal exchange “must” affect prices in the small open economy.

Outline cont'd

I therefore set up a simple theory model of inflation generation, where the random walk properties of the nominal exchange rate operates within a system characterized by pattern wage bargaining.

The model is used to analyse the potential for a inflation-depreciation spiral, but also the realistic possibility of limited pass-through from the exchange rate changes to wages and prices.

Finally, since propagation of foreign inflation is not only a function of wage formation, I simulate an empirical macro model that includes more variables and relationships than was practical to include in the theory model.

Delayed and incomplete pass-through of exchange rate shocks, appears to be a robust feature of the system under the present exchange rate, wage-setting and policy regimes.

Definitions and stylized facts

Nominal exchange rate, V_t

Bilateral exchange rate: a relative price, the price of foreign currency in units of kroner.

In macroeconomic analysis, the effective exchange rate is the relevant concept, they are indices for baskets made up of several bilateral rates.

In Norway, the I-44 index is the most cited effective exchange rate.

Bank of International Settlements (BIS) maintains a huge data bank of effective exchange rates ('Narrow (15) and Broad (64) baskets).

In the empirical modelling in his paper, I have used I-44 as the main definition, but have BIS data to check robustness with respect to measurement system.

V_t : Regime-dependency

The temporal properties of $v_t = \log(V_t)$, Δv_t and $\Delta_4 v_t$ depend on exchange rate policy regime, cf. Itskhoki (2021).

The main distinction is between fixed and floating exchange rate regime.

Norway: Soon 25 years with float.

The regime dependency extends to how the exchange rate hangs together with other time series.

Literature: Random Walk and “disconnect”

- 1 $v_t = \log(V_t)$ is well approximated by random-walk without drift.
- 2 Δv_t and $\Delta_4 v_t$ are excessively volatile
- 3 There are no robust empirical relationships between rates of depreciation and other macroeconomic variables.

1, in the meaning that:

$$v_t \sim \text{low frequency unit-root, } I(1).$$

is not very special; Common assumption for modellers.

Originally, 3. meant absence of significant contemporaneous correlation (Meese-Rogoff (1983) puzzle) .

But today we see that $v_t \sim I(1)$ together with “disconnect” means absence of cointegration.

Implying weak support for PPP.

Is NOK different?

The short answer is “No”.

Low frequency unit root is a dominant feature in the DGP of v_t (log of the effective rate I-44).

Figure 1 demonstrates the huge difference in volatility between depreciation and inflation.

Indicates low correlation with CPI-inflation and core inflation.

And shows that no-drift is a plausible feature of v_t

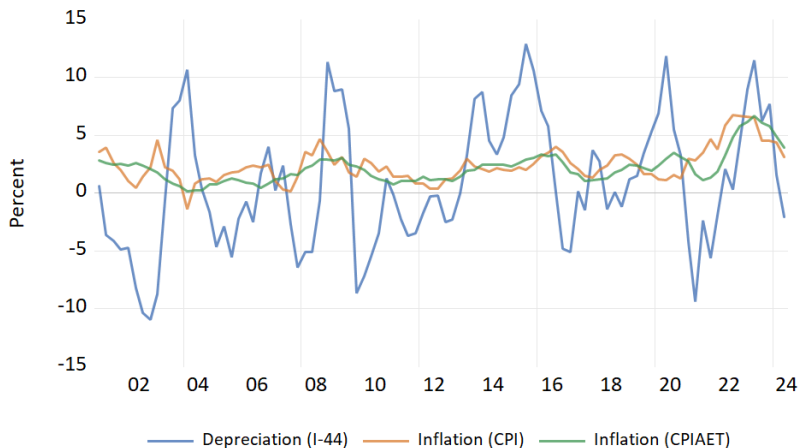


Figure 1: Depreciation of effective exchange rate (I-44) and inflation, annual changes 2001q1-2024q2.

NOK depreciation properties

Table 1: Annual change in I-44 (effective rate), NOK/USD, CPI and CPIAET, 2001q1-2024q2. Units in percent, except coefficient of variations, which is in percentage points.

	I-44	NOK/USD	CPI	CPIAET
Mean	0.8	1.4	2.4	2.1
Median	0.1	-0.3	2.2	2,0
St.dev	5.6	11.4	1.5	1.3
Variation	23.9	32.2	8.2	6.8
$\chi^2_n(2)$	2.3[0.32]	6.1[0.05]	18.7[0.00]	49.0[0.00]

Note the (almost) order of magnitude difference in st-deviations. Also typical says the literature.

Several studies have showed that oil-price growth, interest-rate differences, and indicators of “risk-premia” can be explanatory variables in empirical models of the exchange rate, Bjørnland (2009), Akram (2020), Klovland et al. (2021), Benedictow and Hammersland (2023), Risstad et al. (2023), and others.

These empirical findings do not contradict that v_t has the typical RW-property.

After all, finding the Y_t is cointegrated with X_t does not imply that Y_t “becomes” stationary and stops being Random Walk like.

Also the international literature holds many examples of departures from complete independent RWs.

Testing of robustness, and constancy and invariance, of relationships then become interesting.

PPP and UIP

In Norway, as elsewhere, the econometric treatment of exchange rate time series has revolved around the PPP and UIP hypotheses.

Relevant for inclusion of PPP and UIP-mechanisms in the empirical macro- econometric models.

The paper includes a bunch of tests, of weak relative PPP in particular.

Relative PPP, reconsidered

PPP is a system property. Simplest case: v_t and log of price index ratio: $p_t^u - p_t$.

$$\mathbf{y}_t = \begin{pmatrix} v_t \\ p_t^u - p_t \end{pmatrix}$$

For simplicity, drops notation for deterministic variables:

$$\Delta \mathbf{y}_t = \mathbf{\Pi} \mathbf{y}_{t-1} + \mathbf{A} \Delta \mathbf{y}_{t-1} + \varepsilon_t, \quad (1)$$

$$\varepsilon_t \sim \text{IIN}(0, \Sigma) \quad (2)$$

Assuming $\mathbf{y}_t \sim I(1)$, a necessary condition for weak relative PPP:

$$\text{rank}(\mathbf{\Pi}) = 1$$

If found defensible, $\text{rank}(\mathbf{\Pi}) = 1$ implies:

$$e_t = v_t + \beta_{12}(p_t^u - p_t) \sim I(0) \quad (3)$$

The economic principle about long-run nominal homogeneity implies a particular restriction:

$$\beta_{12} = 1 \quad (4)$$

Note that, finding the two conditions of weak relative PPP to acceptable, entails

$$q_t = v_t + p_t^u - p \sim I(0),$$

meaning that the log of the real exchange rate, q_t , should be stationary, and have temporal properties that are markedly different from RW-ness of v_t .

From test-results in paper. VAR(4), sample period: 2001q1-2024q2.

$H_0: \text{rank } \Pi \leq$	Trace-test	p-value
0	13.7	0.09
1	0.8	0.38

$$\hat{e}_t \equiv \hat{\beta}' y_t = v_t + 4.6(p^u - p)_t \sim I(0),$$

The test of the null hypothesis that the true coefficient is 1 (consistent with PPP) gave a test value of $\chi^2(1) = 10.9[0.001]$, weak relative PPP is therefore not supported.

Cross-check: “Conditional + marginal model” of VAR with real-exchange rate replacing $\hat{e}_t$.

	Conditional	Marginal
	Δv_t	$(\Delta p_t^u - \Delta p_t)$
$\Delta p_t^u - \Delta p_t$	-0.903*	
$\Delta p_{t-1}^u - \Delta p_{t-1}$	0.473	0.004
$\Delta p_{t-2}^u - \Delta p_{t-2}$	-0.452	-0.068
$\Delta p_{t-3}^u - \Delta p_{t-3}$	0.0358	0.043
Δv_{t-1}	0.119	-0.005
Δv_{t-2}	0.115	0.021
Δv_{t-3}	-0.061	-0.039
q_{t-1}	-0.036	-0.008
Constant	-0.001	-0.001
Significance tests of q_{t-1} :		
In conditional equation:	$\chi^2(1) = 0.93[0.33]$.	
In marginal equation:	$\chi^2(1) = 0.92[0.34]$.	
Joint test:	$\chi^2(2) = 1.85[0.39]$	

Solved out static long run conditional equation:

$$\Delta v = \underset{(1.07)}{-1.03}(\Delta p^u - \Delta p) - \underset{(0.05)}{0.04}q - \underset{(0.005)}{0.001}$$

which might invite a relative PPP (in differences) interpretation.

But note insignificance of $(\Delta p^u - \Delta p)$.

Which also changes sign when the measurement system is changed from NAM data bank to BIS data. So not robust.

In contrast, all the other results are robust with respect to change in the measurement system.

Modified relative PPP

We then have in mind cointegration for the modified $\mathbf{y}_t$ vector with elements v_t , $(p_t^u - p_t)$ and difference between the real interest rates: $(r_t - r_t^u)$.

$H_0: \text{rank } \Pi \leq$	Trace-test	p-value
0	53.01	0.00
1	16.36	0.04
2	0.63	0.42

$$\hat{\beta} = \begin{pmatrix} 1 & 0 \\ 1 & 7.5 \\ -0.46 & 1 \\ (0.01) & (1.5) \end{pmatrix}$$

The first column in $\hat{\beta}$ can be interpreted as a modified PPP:

$$v = -(p^u - p) + 0.46(r - r^u)$$

Or does it?

$$v = -(p^u - p) + 0.46(r - r^u)$$

$(r - r^u)$ has the “wrong-sign”.

And closer inspection of results bring out that v_t is weakly exogenous:

$$\hat{\alpha} = \begin{pmatrix} \boxed{\begin{matrix} -0.004 \\ (0.05) \end{matrix}} & \begin{matrix} -0.001 \\ (0.02) \end{matrix} \\ \begin{matrix} -0.04 \\ (0.01) \end{matrix} & \begin{matrix} -0.02 \\ (0.005) \end{matrix} \\ \begin{matrix} -4.3 \\ (1.5) \end{matrix} & \begin{matrix} -2.29 \\ (0.71) \end{matrix} \end{pmatrix}$$

Also this set of results is robust with respect change in the measurement system.

UIP

Implemented UIP as a conditional relationship between Δv_t and difference between nominal interest rates $(\bar{r} - \bar{r}^u)$.

Autometrics, with IIS and gauge 0.01 gave:

$$\widehat{\Delta v_t} = \underset{(0.76)}{-4.55(\bar{r}_t - \bar{r}_t^u)} + \underset{(1.3)}{6.63(\bar{r}_t - \bar{r}_{t-1}^u)} - \underset{(0.78)}{2.20(\bar{r}_t - \bar{r}_{t-2}^u)} + \underset{(1.9)}{10.3I_{2008(4)}} \\ + \underset{(2.1)}{5.7I_{2023(2)}} + \boxed{\text{no constant term}}$$

Estimation method: OLS-IIS. Sample: 2001(1)-2024(2)

$$F_{ar}(5,84) = 1.1 [0.37] \quad F_{arch}(4,86) = 0.27 [0.90] \quad \chi_n^2(2) = 2.52 [0.28] \\ F_{hetx^2}(6,85) = 0.159 [0.99] \quad F_{hetxz}(9,82) = 0.86 [0.56] \quad F_{f-form}(2,87) = 2.61 [0.08]$$

Re-parameterization:

$$\widehat{\Delta v_t} = \underset{(0.76)}{-4.55\Delta(r_t - r_t^u)} + \underset{(0.78)}{2.20\Delta(r_t - r_{t-1}^u)} - \underset{(0.13)}{0.10(r_t - r_{t-1}^u)} \\ + \underset{(1.9)}{10.3I_{2008(4)}} + \underset{(2.1)}{5.7I_{2023(2)}} + \boxed{\text{no constant term}} \quad (5)$$

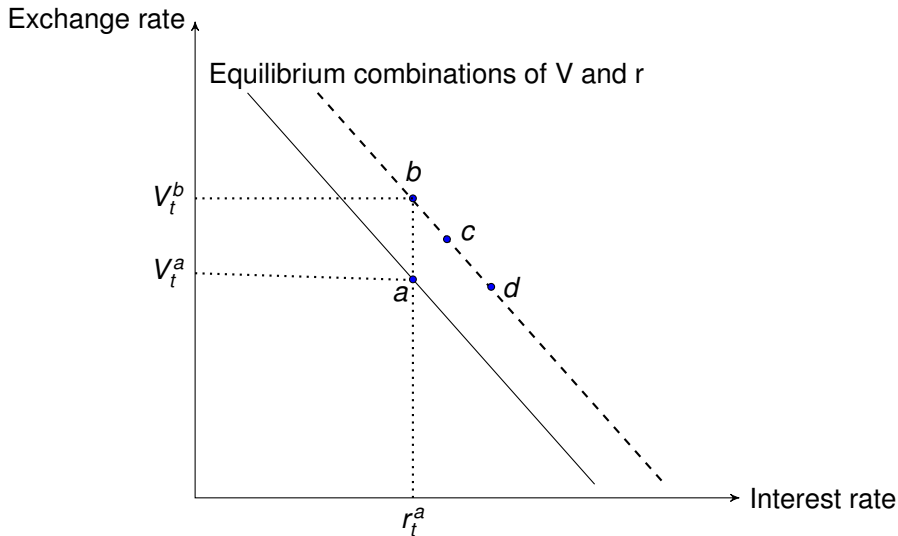


Figure 2: Instantaneous equilibrium exchange and interest rates in a float-regime.

Summary so far

Little reason to reconsider the idea that the DGP of v_t :

- 1 Has a low frequency unit root (which dominates its time series properties)
- 2 Has been without drift.

However, property 1. is neither special nor very limiting.

It does not disallow explanatory variables in equation for Δv_t ,

But care must be taken to avoid (jointly) non-zero means.

So the only puzzle remaining is the disconnection property.

As a general and literal property, it cannot be right.

Exchange rate disconnect, Type-II error?

By definition domestic prices and wages hang together with the nominal exchange rate in a small open economy.

So the disconnect property must be a product of propagation mechanisms that reduces the strength of the connection.

Limited or postponed exchange rate pass-through for example, is a well documented phenomenon.

As we know, relationships can be difficult to find empirically, even when they exist (opposite of spurious regression and data mining).

To analyse how the random-walk properties of the NOK exchange rate can be propagated, we can study theoretical and empirical models of pattern wage setting .

The exchange rate's walk through pattern wage bargaining

Theory model (with estimation-like coeffs)

“Front-runner” wage equation:

$$\Delta w_{1,t} = 0.6\Delta p_t + 0.2\Delta p_{t-1} + 0.2\Delta w_t^* - 0.1(w_{1,t-1} - w_{t-1}^*) - 0.1ur_{t-1} + \epsilon_{w_{1,t}}$$

ur : the unemployment rate. w_t^* : main-course (scope):

$$w_t^* = q_{1t}^f + \boxed{v_t} + z_{1t} + \text{constant}$$

q_{1t}^u is producer price in the industry, z_{1t} is labour productivity.

Δp_t denotes (consumer price) inflation. Simply given by:

$$\Delta p_t = 0.5\Delta q_{2t} + 0.5\Delta(pi_t^f + \boxed{v_t})$$

q_2 : product price in wage-follower industry. pi^f price of imports.

Wage and price setting in the wage-following sector:

$$\Delta w_{2,t} = 0.7\Delta w_{1t} - 0.2(w_{2t-1} - w_{1t-1} - w^{**}) + \epsilon_{w_{2,t}}$$

$$\Delta q_{2,t} = 0.65(\Delta w_{2t} - \Delta z_{2t}) - 0.1(q_2 - w_2 - z_2)_{t-1} + \epsilon_{q_{2,t}}$$

w^{**} : relative wage norm.

There is no way that the exchange rate can become completely disconnected from wage and price inflation in this model.

However, some dampening of exchange rate shock in wage-setting (!)

Example of the wider phenomenon of incomplete pass-through, which can be more forceful than captured in the super-stylized model.

Closing the model:

DGP for v_t : $I(1)$ (random-walk like) with no drift.

Baseline: $\Delta v_t \sim \text{AR}(1) \Rightarrow v_t \sim I(1)$

$$v_t = v_{t-1} + 0.4\Delta v_{t-1} + \epsilon_{v,t}.$$

As part of the model, the DGP breaks into “Inflation-exchange rate spiral mode”

$$v_t = v_{t-1} + 0.4\Delta v_{t-1} + S_t 0.15\Delta p_{t-1} + \epsilon_{v,t}$$

S_t : Step-indicator variable for break-point.

DGPs for: $q_{1t}^f, z_{1t}, pi_t^f, z_{2t}$: Autonomous $I(1)$ -series with positive drift.

v_t , p_t , w_{1t} and w_{2t} are generated as $I(1)$ -series, with or without drift to match the typical time series properties.

It is reasonable that u_t and r_t are generated as stationary variables:

$$\begin{aligned}\Delta ur_t &= 0.1(r_{t-1} - \Delta p_{t-1}) + 0.8\Delta ur_{t-1} - 0.2ur_{t-1} + \epsilon_{ut} \\ \Delta r_t &= 0.25\Delta_2 p_t - 0.1ur_{t-1} - 0.2r_{t-1} + \epsilon_{rt}\end{aligned}$$

The Δur -equation represent the demand-side of macro-model

The Δv -equation is used to mimic a monetary policy response function.

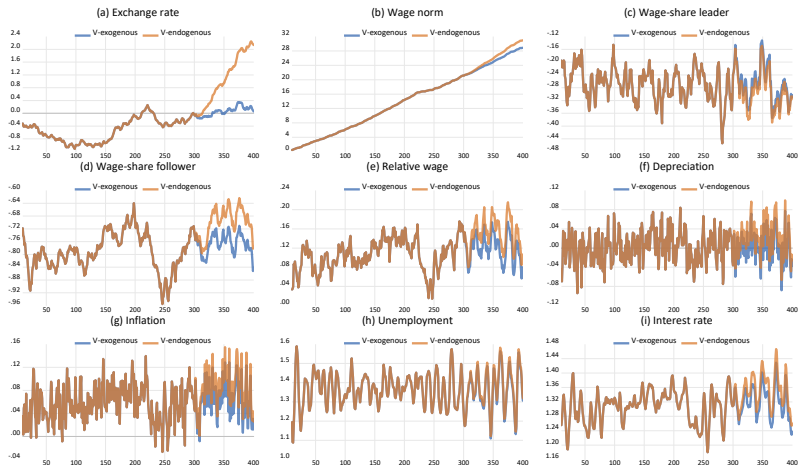


Figure 3: Simulated solution with break in period 300.

- The break in the DGP for v_t implies a marked drift (trend) in the v_t simulated data
- Followed by change in slope of trend in wage-norm (wage-scope)
- The functional income distribution in front-runner industry is robust to the change (except in the short-run)
- Front-follower relative wage more affected
- Higher inflation, since mean depreciation is positive after the break.
- No sign of additional unit-root (or explosive root) after the break in this calibration of the stylized model.
- Next slide: Simulated responses to a shock in import price and product price in wage-leading industry.

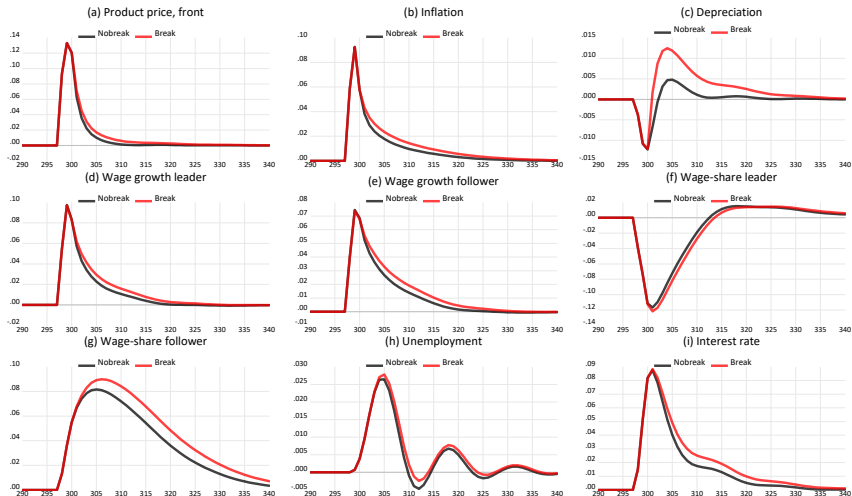


Figure 4: Theoretical responses to a shock to foreign inflation.

In the case where depreciation is affected by domestic inflation, the effect from inflation to depreciation gives larger responses in wages and prices. No surprise there!

However, it is easy to imagine other changes in wage-and price setting that, all things equal, will also imply larger responses:

For example: Weakened coordination in wage-setting.

A reminder that the inflation response to shock is a system property.

Important to model empirically, as well as possible, the many mechanisms of the system.

Empirical responses to a foreign inflation shock

Simulation using NAM (Norwegian Aggregate Model)

NAM includes pattern wage bargaining, estimated econometrically (the model above is a stylized version)

And many other functional relationships of the Norwegian macroeconomic system.

Including a model equation for the policy interest rate, with inflation gap and rate of unemployment among the arguments.

The exchange rate market in NAM

Autometrics, with IIS and target level 0.01 for Type-I error:

$$\widehat{\Delta v_t} = \underset{(0.62)}{-3.44} \Delta(r_t - r_t^u) - \underset{(0.24)}{0.87} (r_{bt-1} - r_{bt-1}^u) - \underset{(0.01)}{0.1} \Delta p_{oilt} \\ - \underset{(0.02)}{0.1} \Delta \Delta(pa - paw)_{t-3} - \underset{(0.02)}{0.06} l_{2020(2)} \quad (6)$$

Sample period: 2001(1) – 2024(3). (7)

Estimation method: Autometrics OLS-IIS.

Lagged PPP deviation be “put-back”, gets coefficient –0.03 (insign).

Inflation shock in Norway's trading partners

3 percentage point increase in the first period of the shock (2023q1).

Increasing to a 7 pp difference from baseline after four quarters.

Then dies off monotonously, panel (a) in Figur 5.

For increased realism, used an ad-hoc policy response function that implies a higher policy rate as part of the response picture.

Pattern wage bargaining is part of the operational model.

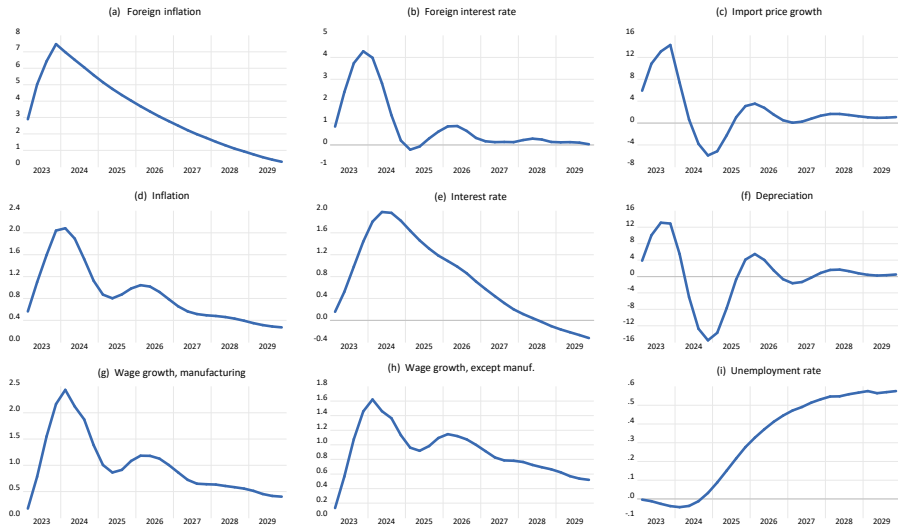


Figure 5: Simulated responses in NAM to foreign inflation shock.

Summary

For an economist used to models of small open economies, the most puzzling fact about nominal exchange rates in the international literature is the disconnect fact.

The puzzle can be resolved (at least in part) by setting up a dynamic model of pattern wage bargaining, that allows for limited pass through of exchange rate changes.

Excessive exchange rate volatility does then not carry over to domestic prices, and correlations become muted (as in the facts).

The model solution based on

$$v_t \sim \text{AR}(2), \text{ with unit-root}$$

without constant, produced time series properties of exchange rate, wages and prices, that were in line with the stylized facts.

A structural break to

$$v_t \sim \text{AR}(2) \text{ with unit-root} + \text{dist lag}(\Delta p_t)$$

generated positive drift in the nominal exchange rate. Inconsistent with the facts.

However, the wage-price responses to the foreign inflation shock did not change in a qualitative way (for the chosen parameterization).

Simulation of a foreign price shock in NAM showed common traits with the stylized model.

The simulations indicated that limited pass-through plays an important role in the system, together with gradual adjustments of wages and prices.

Non-instantaneous and maybe incomplete pass of exchange rates in curiously consistent with results from data from the previous century, see Menon (1995), Naug and Nymoen (1996) and Wolden Bache (2002).

In sum: finding arguments for rejecting the null hypotheses of no inflation-depreciation spiral in the Norwegian data turned out to be difficult.

On the other hand, empirical discovery of a structural break towards a inflation-depreciation spiral seems feasible, since we now have operational methods for monitoring such an event.

References I

- Akram, Q. F. (2020). Oil Price Drivers, Geopolitical Uncertainty and Oil Exporting Currencies. *Energy Economics*, 89.
- Benedictow, A. and R. Hammersland (2023). Transition Risk of Petroleum Currency. *Economic Modelling*, 128, 106496.
- Bjørnland, H. C. (2009). Monetary Policy and Exchange Rate Overshooting: Dornbusch was Right After All. *Journal of International Economics*, 79(1), 74–77.
- Choo, H. G. and T. Kurita (2015). A monetary perspective on inflation dynamics in Norway. *International Journal of Economic Research*, 12(3), 583–606.
- Gjelsvik, M. L., R. Nymoen and V. E. Sparrman (2020). Cointegration and Structure in Norwegian Wage Price Dynamics. *Econometrics*, 8, 29.

References II

- Itskhoki, O. (2021). The Story of the Real Exchange Rate. *Annual Review of Economics*, 13, 423–455.
- Klovland, J. T., L. Myrstuen and D. Sylte (2021). Den svake norske kronen-fakta eller fiksjon? *Samfunnsøkonomen*, 135(2).
- Meese, R. and K. Rogoff (1983). Exchange Rate Model of the Seventies. Do they Fit out of Sample. *Journal of International Economics*, 14, 3–24.
- Menon, J. (1995). Exchange Rate Pass-Through. *Economic Surveys*, 9, 197–231.
- Naug, B. and R. Nymoen (1996). Pricing to Market in a Small Open Economy. *Scandinavian Journal of Economics*, 98(329—350).

References III

- OECD (2019). Norway. Overview December 2019. Economic surveys, OECD. [Http://www.oecd.org/economy/surveys/Norway-2019-OECD-Economic](http://www.oecd.org/economy/surveys/Norway-2019-OECD-Economic)
- Risstad, M., A. Thodsen, K. A. Thune and S. Westgaard (2023). On the Exchange Rate Dynamics of the Norwegian Krone. *Journal of Risk and Financial Management*, 16, 308.
[Https://doi.org/10.3390/jrfm16070308](https://doi.org/10.3390/jrfm16070308).
- Wolden Bache, I. (2002). Empirical Modelling of Norwegian Import Prices. Working Paper 2002/1, Norges Bank.



UiO : University of Oslo



Ragnar Nymoen



**Exchange rate volatility and
pattern wage bargaining**