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The Exchange Rate Targeting of Central Banks Revisited: The Role of Long-term Interest Rates*

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ABSTRACT

Using a New Keynesian macro model, the paper reconsiders the question, whether the central banks should directly respond to exchange rate movements. It is assumed that the transmission of monetary policy to output is carried out by the long-term interest rate, which is determined as a sum of expectations of short-term interest rates and a non-negligible term premium. The second key feature of the model is the assumption that the pass-through of the nominal exchange rate to consumer prices follows a slow distributed-lag process. According to the results, the central banks could gain from stabilizing the exchange rate movements more than suggested in the previous literature. The welfare gains are more clearly seen in the reduced volatility of inflation than stabilization of output, however.

JEL:E32,E52,E58

Open economy, Exchange rate determination, Monetary policy

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INTRODUCTION

There has lately been discussion on whether the central banks, particularly the European Central Bank (ECB), should give up its ignorance towards exchange rate targeting. This is especially the case if the misalignment of the exchange rate, compared to its estimated long-run equilibrium level, gets very large. The basic logic for including exchange rate target explicitly in the central bank's target function that motivates this paper is the fear that freely floating exchange rates are "badly behaved", i.e. prone to losing touch with the fundamentals.[1] Including the exchange rate as an indicator for monetary policy should perform the function of crystallizing market expectations of where the equilibrium rate lay, and thus made expectations stabilizing at the time horizons relevant for influencing market behavior.

Previous theoretical analyses on including a direct exchange rate target in the monetary policy rule are, among others, provided by Svensson (1998), Ball (1999), Taylor (1999), and Leitemo and Södeström (2005). Svensson (1998) compared several variants of inflation targeting in an open economy setting. Analyzing the optimal monetary policy responses to many different shocks the author concluded that flexible CPI targeting stands out as successful in limiting the variability of CPI inflation, output gap and real exchange rate. Ball (1999) uses a small macro model to argue that in an open economy the central bank should take the exchange rate into account in its policy by including the monetary condition index (MCI), that is, a weighted average of the interest rate and the exchange rate, into its reaction function.

Taylor (1999), in turn, simulates ECB interest rate rules in a dynamic stochastic multicountry model. When the performance of the original Taylor rule was compared with that of a rule that also contained the nominal exchange rate as an argument neither of the rules strictly dominated the other. Leitemo and Södeström (2005) compare an optimized standard Taylor rule and Taylor rule with the exchange rate explicitly included.[2] They conclude that as long as there are no extreme parameterizations of the exchange rate uncertainty adding the exchange rate gives only small improvements in term of economic stability.

In light of the four studies referred to above, the exchange rate should not play a very important role in the monetary policy rules of open economies.[3] Adopting an exchange rate target implied only small reductions in the volatilities of inflation and output. The most important difference between our model and the previous studies on the subject is based on the notion that most firms and households work with long-term interest rates (one-year and longer) when making decisions about their level of consumption and investment.[4] The central bank can thus achieve its stabilization goals only insofar its actions affect these long term rates.

As a benchmark we use the standard Taylor rule. We then analyze two types of exchange rate rules, i.e. the level of nominal exchange rate target and the level of real exchange rate target. Two different specifications concerning the joint determination of the exchange rates and the long-term interest rates are also considered. In both specifications, the non-negligible term premium plays an important role in the join determination of the exchange rate and the long interest rates. In the first specification, the relatively large and persistent exogenous term premium increases the volatility of the nominal exchange rate through the long rate uncovered interest rate parity (UIP) relation. In the second of the specifications, the causality runs other way round, as the large and persistent short term UIP shocks feed up to the term premium through regressive expectations.

Our model is calibrated to fit particularly to the Euro area data so that the conclusions apply in particular for the gains for the ECB to target the trade weighted Euro exchange rate.[5] According to our results, the central banks could gain from stabilizing the exchange rate movements more than suggested in the previous literature. There seems to be a rather strong trade-off between the ECB's possibilities to stabilize inflation and output, however.

THE MODEL

Our analysis is based on two slightly different versions of a standard New Keynesian macro model. The first specification is represented by equations (1) – (6), and the second specification by the equations (7) – (13). The models follow closely the model of Batini and Haldane (1998) with the main differences that our both model versions contain the long-term interest rate and the pass-through of nominal exchange rates into consumer prices are modeled differently. The model is forward-looking in nature and the expectations in the model are assumed to be rational. The list of equations, including both specifications, reads as follows

Specification 1

(1) $$r_t = \gamma r_{t-1} + (1-\gamma)r^* + \theta_1[E_t(\pi_{t+1}) - \pi^*] + \theta_2(y_t - y^*) + \theta_3(e_t - e^*) + \varepsilon^1_{rt}$$

(2) $$y_t - y^* = \alpha_1 y_{t-1} + \alpha_2 E_t(y_{t+1}) + \alpha_3(R_t - E_t\pi_{t+1}) + \alpha_4 q_t + \varepsilon^1_{yt}$$

(3) $$p^d_t = 1/2(w_t + w_{t-1})$$

(4) $$w_t = \chi_0\left[E_t(w_{t+1})\right] + (1-\chi_0)w_{t-1} + \chi_1(y_t - y^*) + \varepsilon^1_{wt}$$

(5) $$e_t = E_t(e_{t+1}) - R_t + R^f_t + \varepsilon^1_{et}$$

(6) $$R_t = (1-k)i_t + kE_t R_{t+1} + \varepsilon^1_{Rt}$$

Specification 2

(7) $$r_t = \gamma r_{t-1} + (1-\gamma)r^* + \theta_1[E_t(\pi_{t+1}) - \pi^*] + \theta_2(y_t - y^*) + \theta_3(q_t - q^*) + \varepsilon^2_{rt}$$

(8) $$y_t - y^* = \alpha_1 y_{t-1} + \alpha_2 E_t(y_{t+1}) + \alpha_3(R_t - E_t\pi_{t+1}) + \alpha_4 q_t + \varepsilon^2_{yt}$$

(9) $$p_t^d = 1/2(w_t + w_{t-1})$$

(10) $$w_t = \chi_0 \left[E_t(w_{t+1}) \right] + (1-\chi_0) w_{t-1} + \chi_1 (y_t - y^*) + \varepsilon_{wt}^2$$

(11) $$e_t = E_t(e_{t+1}) - i_t + i_t^f + \varepsilon_{et}^2$$

(12) $$R_t = (1-k) i_t + k E_t R_{t+1} + \varepsilon_{Rt}^2$$

(13) $$\varepsilon_{Rt}^2 = a(e_t + p_t^{cf} - p_t^c)$$

All variables in the models, except interest rates, are in logarithms. Inflation is defined as consumer price inflation, $\pi_t \equiv p_t^c - p_{t-1}^c$, where p_t^c is the price level of the consumption goods. The nominal exchange rate (e_t) is defined as the domestic price of foreign currency. Accordingly, the real exchange rate is defined as $q_t = e_t + p_t^{cf} - p_t^c$. p_t^{cf} denotes to consumer prices of the rest of the world and it follows an unit root process of $p_t^* = p_{t-1}^* + \varepsilon_t^*$, where ε_t^* is an i.i.d. white noise shock.

The consumption prices are a weighted average of prices of domestic goods and imported foreign goods: $p_t^c = \phi p_t^d + (1-\phi) p_t^m$. In both specifications, we either assume that the exchange rate is fully reflected in import prices after a lag of one period, so that $p_t^m = e_{t-1}$, or that the pass-through follows a geometric distributed lag process of $p_t^m = \kappa e_t + (1-\kappa) p_{t-1}^m$, where $0 < \kappa \leq 1$. For simplicity, the import prices in the foreign currency are normalized to zero.

The potential output (y^*), the equilibrium real interest rate of the European monetary union (r^*), the central bank's targets for inflation (π^*), and nominal and real exchange rates (e_t^* and q^*), are assumed to remain constant over time. Thus, they are standardized as zeros.

Equations (1) and (7) represent central bank's policy rules of the two specifications. Although the central bank uses the short nominal interest rate i_t as its policy instrument, the central bank actually attempts to adjust the ex-ante real rate of interest ($r_t \equiv i_t - E_t\pi_{t+1}$) through its forecast of the future inflation. Using ex ante real interest rate rather than the nominal interest rate in modeling the policy rule addresses the role of forecasts as the basis for monetary policy decisions for the central banks. In all policy rule specifications examined, the central bank responds to deviations of the expected inflation and output from their desired levels, ($E_t\pi_{t+1} - \pi^*$) and ($y_t - y^*$).

In our both alternative model specifications, the central bank also reacts to deviations of the exchange rate from its equilibrium level. In the first specification, Eq. (1), the exchange rate target in the policy rule is defined in terms of the nominal exchange rate $(e_t - e^*)$, whereas the second specification, Eq. (7), assumes a real exchange rate target ($q_t - q^*$).[6] The right hand side (RHS) of the policy rule equations also include the lagged real interest rate, which reflects the central bank's urge to smooth its interest rate changes.

Equations (2) and (8) represent the IS curves of the economies of the models. The equations relate the deviation of the real output from its potential level to the ex-ante real long-term interest rate instead of the short rate as in standard specifications, like the original model of Batini and Haldane (1998). Since in our model the monetary policy is transmitted through the long-term rates rather than the short-term rates, central bank's ability to control the economy is weaker than in the models without the long-term rates included, depending on the extent the central bank can affect the long-rate through the current and expected future short-term real interest rates.

In addition to the long-term interest rate, the output gap depends on the real exchange rate as well as the lagged and the lead term of the output. The lead term of the output is motivated by McCallum and Nelson (2000) that shows the similarities between the IS-LM models and a fully optimizing general equilibrium models[7]. The lagged output is more an *ad hoc* increment to the model, and it tries to capture the sluggishness of the output, created by adjustment costs. The shock term ($\varepsilon_{yt}^{1,2}$) is a mixture of shocks to the domestic aggregate demand and the shocks to the foreign output.

Equations (3) and (9) are the mark-up equations, according to which domestic output prices are a constant mark-up over the average of the nominal wage rate of the current and the preceding period. Here the mark-up is standardized as zero. Together with the mark-up equations, the nominal wage-contracting equation (4) and (10) form the supply sides of the specifications. According to the nominal wage contracting equations, the consumption wage today is a weighted average of the nominal wages of the previous period and the expected wages during the next period. The crucial assumptions of this equation is that wage contracts last two periods and a given cohort of workers is interested in nominal wages relative to the nominal wages of the other cohorts of the labor force. The output gap term on the RHS of (4) and (10), in turn, capture the tightness of the labor market.[8]

The key differences between the two model specifications are the exact specifications for UIP and the expectations hypothesis of term structure (EHTS) relations. There appears to be overwhelming empirical evidence against short-term UIP.[9] Some recent papers have results more in line with the UIP using long-term interest rates.[10] The first main difference between the two model specifications is that specification 1 assumes UIP holds in the long-run while specification 2 is based on the empirical failure of short-term UIP.[11] In both specifications, both the foreign exchange premium and shocks to the foreign interest rates are implicitly included into the shock vector ($\varepsilon_{et}^{1,2}$).

Equations (6) and (12) determine long-term interest rates. Derivation of the equations starts from the assumption that the short nominal rate (i_t) and the long nominal rate (R_t) are related by the Expectations Hypothesis of $i_t = R_t - D(E_t R_{t+1} - R_t)$, where the RHS of the equation denotes the one-period return of holding the long-term bond for one period. Equation (7) is derived simply by re-arranging the terms and defining $k \equiv \frac{D}{1+D}$. The parameter D is defined so that D+1 equals McCaulay's duration. The existence of term premium $\varepsilon_{Rt}^{1,2}$ in (6) and (12) reflects the fact that the EHTS does not seem to hold very well empirically.[12] This can be explained e.g. by a time-varying term premium or a depreciation risk premium faced by the foreign investors.

Moreover, the second main difference between the two specifications is just based on the exact way the term premiums (ε_{Rt}^{1}, ε_{Rt}^{2}) are determined. Specification 1 simply assumes a fairly large and persistent exogenous term premium. Specification 1 also assumes the UIP to hold between exchange rates and the long-term interest rates. The term premium feeds to the exchange rate, which becomes more volatile, the larger and more persistent the term premium is. Responding to exchange rate movements, however, helps to reduce the volatility of exchange rates.

Consistent with the Taylor rule, short-run interest rate will respond to the deviations of the nominal exchange rate from the underlying purchasing power parity (PPP) target in the specification 2. Specification 2 also assumes that the term premium is determined endogenously, as a linear function of the deviation of the nominal exchange rate from its PPP value. More formally, the term premium is determined according to Eq. (13), that is, $\varepsilon_{Rt}^{2} = a(e_t + p_t^{cf} - p_t^{c})$, where parameter a determines the extent to which the deviation from PPP affects the term premium. Intuitively, the more the exchange rate deviates from its equilibrium value, the larger is the exchange risk from holdings of domestic bonds for foreign investors. Deviations from the equilibrium described by PPP may be large and persistent but it is hard to think that there is a virtually complete lack of any market expectation that the exchange rate will revert toward the equilibrium level within any time horizon relevant to market participants.[13] Specification 2 also assumes a short-term UIP with relatively large and persistent exchange rate shock (ε_{et}^{2}), which can be interpreted as a risk premium, a portfolio preference shock or an expectational error.[14] The long-term interest rate becomes more volatile with large ε_{et}^{2}.[15] Responding to exchange rates becomes now motivated for the central bank as it also helps to reduce the volatility of long-term interest rates, which makes it easier for central bank to control the economy.

Thus, the joint determination of long rates and the exchange rate in both model specifications introduces novel roles for the exchange rate in the transmission process of monetary policy to inflation rates and outputs, in addition to the traditional expenditure switching effect on output and the direct and indirect effects on consumer prices. In both specifications, the exchange rate can be seen as including such additional information about the state of the economy that is not fully reflected in output and expected inflation.

CALIBRATING THE MODEL

The model is calibrated to fit to the European Monetary Union data. The exchange rate is defined as the trade-weighted euro exchange rate. The parameter values are in most cases based on the studies by and Batini and Haldane (1998), Peersman and Smets (1999) and Ball (1999). The policy rule equation, the optimal values for coefficients of inflation (θ_1), output gap (θ_2) and the nominal or real exchange rates (θ_3) are discussed in the next Chapter. Parameter γ is always set equal to 0,6, which suggests a rather strong interest rate smoothing motive for the central bank, where we follow

Peersman and Smets (1999). The parameters α_1 and α_2 of the IS equation of the European Monetary Union are set equal to 0.8 and 0.2, following the example of Batini and Haldane (1998). Hence, the agents are assumed to be mostly backward looking. The parameters α_3 and α_4 that describe the elasticities of the union total demand to real interest rate and the real exchange rate, respectively, are given values of -0.6 and 0.2, where we follow Ball (1999).[16]

Unfortunately, there were not available any empirical studies about the European labour market that would have directly offered the parameter values for the contracting equation. Thus, these values had to be set more or less arbitrarily. In the wage contracting equations of the model, Eq. (4) and Eq. (10), the parameter χ_0 is set to 0,5, which implies equal weights for backward and forward lookingness. The parameter χ_1 that measures the sensitivity of output to nominal wages is set to 0,1. Parameter k that determines the duration of the long-term rate is set as 0,5. Parameter ϕ, which tells the weights of domestic and import prices, is set equal to 0,8 in both specifications. To control the robustness of the results, the key parameters κ and a are given a set of different values in the estimations. The parameter a is varied using small negative values, which implies that a consensus is only gradually built among market agents that the exchange rate is misaligned as the exchange rate moves away from the equilibrium.[17]

When the model was solved, some of the variables, namely the price variables, the nominal exchange rate and nominal wages turned out to contain unit root. The presence of the unit roots implies that the variables converge to new equilibrium levels instead of the old steady states after a temporary shock. The unit root in some of the variables is, however, well in accordance with the empirical evidence of the time-series properties of these variables. Otherwise the model appeared as dynamically stable so that the variables returned quickly to their long-run equilibrium values after the shocks.[18]

Totally six different shocks were considered in the simulations in the cases of both specifications. The shocks include the monetary policy shocks (ε_{rt}^{1} and ε_{rt}^{2}), mixtures of the domestic demand and foreign output shocks in the IS equations (ε_{yt}^{1} and ε_{yt}^{2}), the labour market shocks (ε_{wt}^{1} and ε_{wt}^{2}), the UIP shocks (ε_{et}^{1} and ε_{et}^{2}), discussed in detail above, the shock to the foreign price level ε_{t}^{*}, and the term premium shocks in the long-term interest rate (ε_{Rt}^{1} and ε_{Rt}^{2}).

The series for the IS shocks and the labour market shocks were generated using an estimate of the covariance matrix of the shocks, which, as well as the autocorrelations of the shocks, was calculated using forecast errors from the NiGEM model. It is a large structural econometric model on the world economy.[19] The forecast errors were created by aggregating the forecast errors from the corresponding equations of five large European Monetary Union countries (Germany, France, Spain, Italy, Netherlands) to single European shocks. The covariance and autocorrelation structures for the rest of the shocks, unfortunately, had to be set more or less arbitrarily. The covariance and autocorrelation matrix of the shocks is provided in Tables 1-4 (Appendix).

RESULTS

Regardless of the model specification used, the dynamic analysis follows the same two-step procedure that is based on the assumption that the central bank attempts to minimize a loss function with the unconditional variances of inflation and union output as its arguments. Formally, the loss function takes the form of $L = \mathrm{var}(\pi_t) + \lambda\,\mathrm{var}(y_t)$, where π_t denotes to the inflation and y_t to the output. Parameter λ that tells the relative weight put on stabilizing output is given values of 0,5 or 1.

We first find the values of the policy rule parameters θ_1 and θ_2 that minimize the loss function, assuming that the central bank does not respond to the exchange rate at all, that is, setting θ_3 = 0. The assumption of zero exchange rate response is then relaxed and new optimal values for the policy rule coefficients, now also including θ_3, are found. Comparing the values of the loss functions corresponding to these two "optimal" rules, for the two alternative values given to the weight λ, tells the loss resulting from excluding the exchange rate from the policy rule[20]. The optimal values for θ_1 and θ_2 (and later also for θ_3) were searched for using a simple grid-search algorithm. Each step of the algorithm required that the model was first solved for the new values for the policy rule parameters and then 100 series of 100 observations were simulated. Since the algorithm was computationally rather time-consuming, the search was limited to the range of values between 0 and 3, with the step of 0.1. This range may seem as rather narrow, but also in the previous literature on monetary policy rules the values of these parameters have tended to remain inside this range. Furthermore, in most of our simulations, the optimal parameter values were located strictly inside the range. The sole exceptions are some cases where the optimal value of θ_2 was equal to zero.

Model specification 1

The specification 1 is based on the assumptions that the exchange rate is determined by the long term UIP and that there is a relatively large and persistent term premium affecting the long rates. The simulation results for the model are shown in Table 5 below, for both λ=0,5 and λ=1. Note that the exchange rate is defined in terms of nominal, instead of the real exchange rate target, since the nominal target turned out to perform better than the real rate target in the tentative simulations.

For controlling the robustness of the results, the results are reported for a set of different values given to two key parameters driving the dynamic relation between the exchange rate and the long-term interest rates. The first of the two parameters is the AR(1) coefficient of the UIP shocks that are assumed to follow a first order autoregressive process. The second parameter is κ, which determines the speed of pass-through of exchange rates to consumer prices. The first two sub-tables in Table 5 show the results when the AR(1) coefficient of the UIP shock is given values of 0,8, 0,6 and 0,4, while a complete pass-through after one lag is assumed. The next two sub-tables report the results when the AR(1) coefficient of the UIP shocks is given a constant value of 0.8 and the speed of pass-through varies from almost immediate pass-through to the slow distributed lag processes with $\kappa = 0,5$ or 0,7. The left hand sides of the tables report the results assuming that the central bank also is responding to the exchange rate, while the results in the right hand side are based on the assumption of no direct exchange rate response.

TABLE 5

Results of the model specification 1[21]

Specification 1, Nominal exchange rate target						
lambda = 0.5, pass-through with one lag						
	Exch. Rate Target			No exch. Rate Target		
AR(1)	0.8	0.6	0.4	0.8	0.6	0.4
relative loss	**0,72**	**0,74**	**0,77**			
loss	2,01	2,00	2,05	2,77	2,72	2,64
vol. Infl.	1,19	1,14	1,19	1,84	1,74	1,29
vol. Outp.	1,63	1,72	1,71	1,86	1,95	2,70
theta1	3,30	3,20	3,20	3,50	3,50	3,40
theta2	2,90	2,60	2,60	2,30	2,30	0,80
theta3	1,50	1,50	1,50			
lambda = 1, pass-through with one lag						
	Exch. Rate Target			No exch. Rate Target		
AR(1)	0.8	0.6	0.4	0.8	0.6	0.4
relative loss	**0,77**	**0,79**	**0,78**			
loss	2,75	2,77	2,72	3,58	3,52	3,48
vol. Infl.	1,37	1,36	1,35	2,12	2,02	2,08
vol. Outp.	1,38	1,41	1,37	1,46	1,50	1,40
theta1	1,00	0,80	0,80	2,70	2,70	2,50
theta2	3,00	3,00	3,00	2,90	2,90	3,00
theta3	1,50	1,50	1,50			
lambda = 0.5, AR(1)=0.8						
	Exch. Rate Target			No exch. Rate Target		
pass-through	one lag	kappa = 0.7	kappa = 0.5	one lag	kappa = 0.7	kappa = 0.5
relative loss	**0,72**	**0,49**	**0,45**			
loss	2,01	2,84	2,38	2,77	5,80	5,33
vol. Infl.	1,19	1,81	1,64	1,84	5,07	4,54
vol. Outp.	1,63	2,05	1,48	1,86	1,45	1,58
theta1	3,30	0,90	0,10	3,50	0,10	0,10
theta2	2,90	1,20	2,70	2,30	2,90	2,70
theta3	1,50	1,50	1,50			
lambda = 1, AR(1)=0.8						
	Exch. Rate Target			No exch. Rate Target		
pass-through	one lag	kappa = 0.7	kappa = 0.5	one lag	kappa = 0.7	kappa = 0.5
relative loss	**0,77**	**0,51**	**0,51**			
loss	2,75	3,35	3,10	3,58	6,51	6,10
vol. Infl.	1,37	1,94	1,69	2,12	5,09	4,58
vol. Outp.	1,38	1,41	1,41	1,46	1,42	1,52
theta1	1,00	0,10	0,10	2,70	0,20	2,60
theta2	3,00	3,00	3,00	2,90	3,00	2,70
theta3	1,50	1,50	1,50			

According to the tables, considerable welfare gains are available to the central bank from responding to the nominal exchange rate. In case of relatively smaller weight put on stabilising output (λ=0.5), the value of central bank's loss function decreases to the levels of 45% – 72 % of the loss in the case that the central bank only responded to inflation and output. In the case of λ=1 the relative loss is now reduced to the levels between 51% and 79%. Although the central bank gains from the active exchange rate policy regardless of the speed of pass-through and the persistence of the UIP shocks, the gains are at their largest, when the exchange rate passes slowly to consumer prices, that is, with κ = 0,5 or 0,7. In these cases, the relative losses are reduced to the level around 50 %, regardless of the value of λ.

The degree of the welfare gains depends of the speed of pass-through, since the gains are rather due to stabilizing inflation than stabilizing output. Naturally, when it takes several periods for the exchange rate to be fully reflected in prices, the effects of exchange rate shocks to inflation is more persistent. The central bank's possibilities to reduce output volatility by active exchange rate policy, however, seem to remain rather modest, regardless of the speed of pass-through and the persistence of the UIP shocks. This is an interesting finding, when we consider the nature of the joint transmission mechanism of the exchange rate and the long term interest rate to the economy. As the nominal exchange rate in the model is determined by the long-term UIP, the volatility of the exchange rate is mainly due to the large and persistent term premium, which makes the long-term rates volatile. Thus, the term premium affects output directly, by destabilising long rates, and consumer price inflation indirectly, by making the exchange rates more volatile. It would be therefore expected that, in the case of the rapid pass-through, when exchange rates have a lesser impact on inflation, the direct output effect of the exchange rate policy would be more important relative to the indirect effect on inflation.

Regarding the optimal exchange rate response, it can be seen that the optimal value for θ_3 is 1.5, the highest value in the range given to that parameter in the simulations. The values of θ_1 and θ_2 are more sensitive on the values of the key parameters, although it is notable that the optimal response to output, in particular, seems to be fairly strong with all parameter values. Moreover, although it is expected that the optimal response to output becomes stronger, when a higher weight is put on the output in central bank's loss function, this clearly seems to be the case only when the central bank also is allowed to respond to the exchange rate. In these cases, the strong exchange rate response seems to be at least a partial substitute for the direct inflation response as a mean to stabilize inflation. The conclusion is supported by the notion that in cases of slow pass-through, the coefficient for inflation relative to that of output, is particularly low.

Model specification 2

The model specification 2 assumes that the main source of volatility in the nominal exchange rate now is the relatively large and persistent shocks to the short-term UIP. The size of the term premium is proportional to the deviation of the nominal exchange rate from its PPP equilibrium value. The more the nominal exchange rate varies around its PPP equilibrium value, the higher is the compensation the investors demand for carrying the higher risk related to the holding of bonds, which is measured by the term premium ε_{Rt}^2 in Eq. (12).

The results for the specification 2 are shown in Table 6 below. The results are reported for a set of different values for the key parameters, which now include the speed of pass-through of exchange rates to consumer prices, and the sensitivity of the term premium on the exchange rate misalignment from its equilibrium value (a in Eq 13). The exchange rate target is now defined in terms of the real exchange rate target, since the real exchange rate target both fits now better for the model specification and it also provided better results in our tentative tests, when different ways to define the exchange rate target were compared.

Table 6

Results of the model specification 2[22]

Specification 2, Real exchange rate target, a < 0						
lambda = 0.5, kappa = 0.5						
	Exch. Rate Target			No Exch. Rate Target		
a	-0.1	-0.2	-0.3	-0.1	-0.2	-0.3
relative loss	**0,66**	**0,67**	**0,68**			
loss	3,26	3,15	3,07	4,97	4,69	4,50
vol. Infl.	2,44	2,20	2,22	3,98	3,68	3,28
vol. Outp.	1,64	1,90	1,69	1,98	2,01	2,43
theta1	2,00	3,00	2,00	2,90	2,90	3,00
theta2	0,10	0,10	0,10	0,80	0,80	0,50
theta3	1,00	1,50	1,00	0,00	0,00	
lambda = 1, kappa = 0.5						
	Exch. Rate Target			No Exch. Rate Target		
a	-0.1	-0.2	-0.3	0.1	0.2	0.3
relative loss	**0,75**	**0,76**	**0,65**			
loss	4,08	4,04	3,91	5,43	5,30	6,00
vol. Infl.	2,44	2,34	2,22	4,58	4,69	4,06
vol. Outp.	1,64	1,70	1,69	0,85	0,61	1,94
theta1	2,00	1,70	2,00	0,10	0,10	2,60
theta2	0,10	0,10	0,10	1,50	2,90	2,10
theta3	1,00	1,00	1,00			
lambda = 0.5, a = -0.2						
	Exch. Rate Target			No Exch. Rate Target		
kappa	immediate	0.7	0.5	immediate	0.7	0.5
relative loss	**0,84**	**0,65**	**0,67**			
loss	1,96	3,53	3,15	2,34	5,41	4,69
vol. Infl.	1,02	2,65	2,20	1,28	4,91	3,68
vol. Outp.	1,88	1,75	1,90	2,11	1,00	2,01
theta1	2,70	2,50	3,00	3,00	0,10	2,90
theta2	0,10	0,10	0,10	0,60	1,30	0,80
theta3	1,00	2,50	1,50			
lambda = 1, a = -0.2						
	Exch. Rate Target			No Exch. Rate Target		
kappa	immediate	0.7	0.5	immediate	0.7	0.5
relative loss	**0,93**	**0,74**	**0,76**			
loss	2,71	4,39	4,04	2,90	5,91	5,30
vol. Infl.	2,17	2,71	2,34	2,14	4,91	4,69
vol. Outp.	0,54	1,68	1,70	0,76	1,00	0,61
theta1	0,40	2,00	1,70	1,90	0,10	0,10
theta2	2,90	0,10	0,10	2,90	1,30	2,90
theta3	0,75	1,00	1,00			

Considering our second model specification, the central bank still gains from responding to exchange rate. The relative loss ranges between 65% and 93% of the loss in the case of no exchange rate target. If we first limit ourselves to only consider the cases of slow pass-through, the welfare gains from the exchange rate stabilisation again mostly accrue from stabilising inflation rather than from stabilising output. With κ = 0,5 or κ = 0,7, the volatility of inflation is reduced from the levels of 3,28 – 4,91 to the levels of 2,20 to 2,71 percentage points. Interestingly, with λ=1, that is, when inflation and output are given equal weights in central bank's loss function, responding to the real exchange rate in fact tends to increase the volatility of output with most of the different combinations of parameter values considered.

Intuitively, the effectiveness of central bank's responses to real exchange rates in stabilizing inflation results from the nature of the distributed lag process through which the nominal exchange rate shocks are passed through to import prices and consumer prices. Since our model also assumes relatively persistent shocks to the short-run UIP, the deviation of import prices, consumer prices and the real exchange rate from their initial values can be very persistent. Thus, in contrast with the models with rapid pass-through, in which the central bank can effectively offset the impact of exchange rates on inflation indirectly through its inflation target, the exchange rates are now transmitted into consumer prices so slowly that a direct exchange rate response is called for to stabilize inflation.

It is an interesting finding that central bank's exchange rate responses do not seem to play a more important role in stabilizing output, when we assume the slow pass-through, although the model assumes an additional indirect transmission channel from exchange rate to output, through the destabilizing effect of exchange rate shocks on long-term interest rates. If we assume almost immediate pass-through, however, the relative importance of output stabilization increases, since the exchange rate does no more make consumer prices so volatile that stabilizing inflation would fully dominate central bank's policy. Under the rapid pass-through, the welfare gains from the exchange rate stabilization are smaller so that the relative losses are reduced to levels of 84% and 93%. The relative importance of the exchange rate responses between the stability of inflation and output, however, now depends clearly on the value of λ so that with λ=1, the central bank now more stabilizes output than inflation.

When scrutinizing the values of θ_1, θ_2 and θ_3 in the "optimized" policy rules, it can be seen that if central bank also responds to exchange rate, the coefficient for output (θ_2) is assigned a value of only 0.1, almost regardless of the values given for a, κ and even λ. The only exception is again made by the special case of almost immediate pass-through, in which case the weight given on output increases from 0,1 to 2,9 with λ=1. In cases of no exchange rate response, in contrast, θ_2 gets significantly larger values, both in absolute terms and when compared to the values of θ_1. θ_2 is also increasing in λ, as would be expected.

The discussion above suggests that the trade-off between the volatilities of inflation and output depends on whether the central bank reacts to exchange rate movements or not. When the central bank responds to exchange rates, it seems to become more costly, in terms of higher inflation, to reduce output volatility by increasing θ_2, compared to the case in which the central bank only targets inflation and output. The results suggest that the direct objectives of stabilizing inflation and the real exchange rate work in a complementary way. When central bank both puts a relatively high weight on both objectives, it can significantly reduce the volatility of inflation.

CONCLUSIONS

Using a New Keynesian macro model, the paper reconsiders the old problem, whether the central banks should start to respond to the exchange rate movements. The model departs from the standard set-up, regarding its two features that make the model more realistic in light of the previous empirical evidence. At first, the transmission of monetary policy to output is carried out by the long-term interest rate, which is not determined by pure expectations hypothesis of the term structure. The joint processes in which the exchange rate and the long-term interest rate are determined in the model introduce new indirect channels to the New Keynesian model, through which the exchange rate movements can indirectly affect output. The second key feature of the model is the assumption that the pass-through of the nominal exchange rate to consumer prices follows a slow distributed-lag process.

According to our results, the central banks could gain from stabilizing the exchange rate movements more than suggested in the previous literature. The welfare gains in both specifications are more clearly seen in the reduced volatility of inflation than stabilization of output, however. Thus, regarding the relative importance of the two key assumption of our model for the results, the slow pass-through of exchange rates to prices, which makes the effects of exchange rate shocks on inflation very persistent, clearly dominates. The relative importance of the effects of the joint determination of long interest rate and the exchange rate on the volatility of output plays a minor role.

We exclude transaction cost. Transaction costs imply that the weight put on the exchange rate in the monetary policy rule would probably be rather low close to PPP. If transaction costs are included, as they should, the model would become nonlinear. This points to a need for further research.

APPENDIX

Table 1
The autocorrelations of the structural shocks in specification 1.

	ε^1_{yt}	ε^1_{wt}	ε^1_{et}	ε^1_{cft}	ε^1_{rt}	ε^1_{Rt}
ε^1_{yt}	0.5	0	0	0	0	0
ε^1_{wt}	0	0.5	0	0	0	0
ε^1_{et}	0	0	0.1	0	0	0
ε^1_{cft}	0	0	0	0.1	0	0
ε^1_{rt}	0	0	0	0	0.1	0
ε^1_{Rt}	0	0	0	0	0	0.80

Table 3
The autocorrelations of the structural shocks in specification 2.

	ε^2_{yt}	ε^2_{wt}	ε^2_{et}	ε^2_{cft}	ε^2_{rt}	ε^2_{Rt}
ε^2_{yt}	0.5	0	0	0	0	0
ε^2_{wt}	0	0.5	0	0	0	0
ε^2_{et}	0	0	0.6	0	0	0
ε^2_{cft}	0	0	0	0.1	0	0
ε^2_{rt}	0	0	0	0	0.1	0
ε^2_{Rt}	0	0	0	0	0	0

Table 2
The covariance matrix of the structural shocks in specification 1.

	ε^1_{yt}	ε^1_{wt}	ε^1_{et}	ε^1_{cft}	ε^1_{rt}	ε^1_{Rt}
ε^1_{yt}	0.58	0	0	0	0	0
ε^1_{wt}	0	0.32	0	0	0	0
ε^1_{et}	0	0	1	0	0	0
ε^1_{cft}	0	0	0	1	0	0
ε^1_{rt}	0	0	0	0	1	0
ε^1_{Rt}	0	0	0	0	0	10

Table 4
The covariance matrix of the structural shocks in specification 2.

	ε^2_{yt}	ε^2_{wt}	ε^2_{et}	ε^2_{cft}	ε^2_{rt}	ε^2_{Rt}
ε^2_{yt}	0.58	0	0	0	0	0
ε^2_{wt}	0	0.32	0	0	0	0
ε^2_{et}	0	0	10	0	0	0
ε^2_{cft}	0	0	0	3	0	0
ε^2_{rt}	0	0	0	0	1	0
ε^2_{Rt}	0	0	0	0	0	0

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[1] We do not try to explain the behavior of exchange rates, but perhaps foreign exchange markets are dominated by noise traders or other irrational speculators (e.g. De Long *et al.*, 1990, Jeanne and Rose, 2002,) whose actions implicitly reflect changes in risk premiums.

[2] Strictly speaking, our focus is on simple rather than optimal policy rules. In some sense, we can, however, use term "optimal rule" when we analyze our results, since our methodology is based on a simple numerical optimization method to find optimal coefficient values for a simple policy rule.

[3] Wollmershaeuser (2003) introduces a high degree exchange rate uncertainty about the true exchange rate model. He finds that open economy policy rules with an important feedback from movements in the real exchange rate are very robust to uncertainty about the true exchange rate model and become superior to simple policy rules that only react to inflation and output.

[4] See the similar argument in Goodfriend (1991).

[5] Obviously, good policy analysis takes account of the sources of exchange rate fluctuations. It is possible, for example, that the changes in the exchange rate may reflect changes in a productivity differential. These fluctuations should not be offset.

[6] The chosen targets turned out to perform better than the alternatives in tentative simulations.

[7] According to the authors, the IS equation can be thought as representing a linearised version of the Euler equation that relates the expected marginal utilities of the current consumption and the consumption in the following period.

[8] The specification differs from Batini and Haldane (1998), in which the wage setting was modelled with real wage instead of nominal wage contracting. Although nominal contracting admittedly implies to the model less inflation persistence than real wage contracting, our specification may be considered also empirically justified by the results of Coenen and Wieland (2000). The study compares the empirical fit of a nominal wage contracting model and three different versions of the relative real wage contracting model using aggregated European data. According to the results, both nominal and real wage version of the models fit the data fairly well, although the best fit was obtained with a real wage specification, which again also implied more persistence to the inflation process.

[9] As a survey see Engel (1996).

[10] See, for example, Alexius (2001), and Chinn and Meredith (2005).

[11] Note that we do not explain the empirical failure of short-term UIP using the endogeneous monetary policy mechanism first suggested by McCallum (1994).

[12] See, for example, Bekaert *et al.* (2002).

[13] Frankel and Froot (1987) conclude that those investors who think longer-term tend to be the ones who subscribe to regressive expectations, and those who think shorter-term tend to be the ones who subscribe to forecasts that are closer to static expectations. Cheung and Chinn (2001) also found that at the six month horizon 81 % of currency traders view PPP as irrelevant. At the long horizon 40% of traders agree that PPP has at least some influence.

[14] It is difficult to find an economic explanation for the forward risk premium anomaly for short-term interest rates. Neither the standard consumption-based capital asset pricing models with risk averse investors nor various versions of consumption based general equilibrium models can explain it. As shown in Engle (1996), estimated risk premiums are too small to account for the exchange rate anomaly. It seems to be case that the behavior of the deviation from UIP is at least partly inconsistent with rational risk premiums.

[15] A direct empirical support for our assumption is given by Juselius and MacDonald (2003). They show that the nonstationarity of the long-term interest rate spread is likely to be related to the nonstationary deviations from the steady-state value of the PPP rate.

[16] Ball's (1998) focus was actually small to medium-sized open economies, such as Canada or Australia. The parameter values adopted in the paper sound, however, plausible also for the euro area. They correspond to the consensus view, according to which the monetary condition index (MCI) that measures the relative sensitivity of output to changes in the interest rates and exchange rate for EMU takes a value of about 3. See e.g. Ball (1998).

[17] See, for example, Kilian and Taylor (2003).

[18] As noted in Uhlig (1999), the models that contain more than one country or one agent, in particular, may contain unit roots, since in this kind of models shocks may affect the relative stocks of wealth or capital. Even in these cases with permanent changes in the consumption paths present, as Uhlig notes, the method still gives useful results, which only should be used with some care.

[19] The forecast errors were originally provided by the Research Institute of the Finnish Economy.

[20] The policy rules implied by the optimization algorithm are not optimal rules in the strict sense of the word, since the optimality requires that the central bank directly responds to both the state variables of the model and the shocks the

economy faces. The lack of optimality of the central bank in the model can, however be maintained on the ground that the central bank cannot observe the structural shocks directly.

[21] On the RHS the simulation results for the model with a central bank that does not respond to the exchange rate. Lambda tells the weight put on output in the central bank's loss function, kappa is the parameter determining the speed of pass-through according to $p_t^m = \kappa e_t + (1-\kappa) p_{t-1}^m$. AR(1) tells the persistence of the term premium, which follows the first order autoregressive process. The values of the loss function in row labeled "loss" are standardized as 1:s, when there are no exchange rate responses. "vol. inflation" and "vol. output" tell the standard deviations of inflation and output. theta1, theta2 and theta3 in the tables tell the optimal values for the coefficients of inflation, output and exchange rate in the policy rule of the central bank.

[22] The parameter a tells the sensitivity of the long-term interest rate on the deviation of the exchange rate from its PPP equilibrium value.