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ABSTRACT

This paper investigates with a structural, quantitative macro model, whether the ECB should include the real exchange rate into its reaction function. The problem is considered from viewpoints of both the whole monetary union and a single member country with a national economy more open than the union economy on average. According to the results, the member country would benefit from the exchange rate stabilizing more than the rest of the union. It appears however, that the asymmetries of the external shocks facing the economies may be a more important factor behind the larger volatility of the inflation and output of the member country than the structural differences.

KEY WORDS: Euro-area, monetary policy rules, optimal currency areas.

JEL Classification: E32, E52, E58, F42

1. Introduction

During the first three years since its adoption, the euro has lost more than 20 % of its value against the US dollar. The depreciation of the euro has given birth to a lively debate among economists, whether the ECB should intervene the currency markets to support the weakening euro. The opponents of the intervention highlight that the primary goal of the ECB is to target inflation, and not to take care of the exchange rate. According to the proponents, on the other hand, when inflation is measured as CPI inflation the rise in the prices of imported goods because of the depreciation of the euro make it also more difficult to reach the inflation target. A prolonged deviation of the euro from its equilibrium rate may also disturb the world financial markets and the exchange rate uncertainty may dampen investment and employment.

The problem whether the ECB should pay attention to stabilizing the exchange rate of the euro is also a part of the discussion whether the Euro area can be considered as an optimal currency area. Because of the asymmetries in both the monetary transmission mechanisms and in the business cycle pattern between the member countries, the same monetary policy does not necessarily fit for all member countries. For example, there are considerable differences in the degree of openness of the member countries, measured as the share of foreign trade with countries outside the union. Moreover, the exogenous shocks to aggregate demand and productivity don't hit the single member economies symmetrically. Still the ECB has to target only the union wide averages of these variables.

The research problem

In short, the research problem of this study is to investigate with a structural, quantitative macro model, whether the ECB should include the real exchange rate as a variable into its reaction function. The problem is considered both from a viewpoint of the whole monetary union and from that of a single member country with a national economy differing largely from the averages of the whole union. The differences between the single country and the union are related both to the openness and to the business cycle pattern of the economies. One of the goals of the study is also to examine whether the union's one-size-fits-for-all monetary policy can create significant welfare losses because of increased deviations of inflation and output in some of the EMU's member countries.

The study is conducted by specifying a quantitative, calibrated macromodel that is consistent with both economic theory and data. The macro model is a small "New Keynesian" model consisting of a simple monetary policy rule and equations covering the essential features of both the whole monetary union and a small member country. After the model is solved, it is simulated under a number of alternative parameters for the monetary policy rule with different weight put on stabilizing exchange rate variation. The performance of the rules can then be compared by calculating the unconditional variances of the inflation and output from the simulated series.

The paper proceeds as follows: The Chapter 2 presents a brief overview for the previous literature. The theoretical framework of the study is introduced in the Ch. 3, in which also the theoretical plausibility of the model is assessed with some deterministic policy simulations. Chapter 4 contains the results of the policy rule

evaluation when the focus is only on the performance of the economy of the monetary union as a whole. In the Chapter 5, then, the analysis is extended to cover also the performance of a single member country, in which the transmission process of the monetary policy somewhat differs from the union averages. Chapter 6 concludes.

2. The previous literature

Including a direct exchange rate target to the monetary policy rule has been discussed e.g. by Ball (1998), Taylor (1999) and Svensson (1998)¹. Each of the studies approach the problem from slightly different viewpoint but a common feature of all these studies is that the central bank policy rule is assumed to be of the form

$$2.1.) \quad i_t = \alpha\pi_t + \beta y_t + \lambda_0 e_t + \lambda_1 e_{t-1}, \text{ where}$$

π_t = inflation, y_t = output, e_t = real exchange rate and α , β , λ_0 and λ_1 are parameters.

Ball uses a small macromodel 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. For the parameter λ_0 Ball's study implied an optimal value of -0.37 and for λ_1 a value of 0.17 . The alternative policy rule considered in Ball's study for comparison, the pure inflation targeting, would instead create large fluctuations in exchange rate and output. .

Taylor (1999) in turn, simulates ECB interest rate rules in a dynamic stochastic multicountry model for seven large countries. In the study the euro area was modeled by assuming fixed exchange rates between Germany, France and Italy and a single short term interest rate. When the performance of the original Taylor rule was compared with that of a rule that contained also the nominal euro/USD exchange rate as an argument, with $\lambda_0 = -0.25$ and $\lambda_1 = 0.15$, neither of the rules strictly dominated the other. Instead, for some countries (France and Italy) the policy rule with the exchange rate target led to better performance, while for Germany, this policy rule implied poorer performance.

Svensson (1998) compares several variants of inflation targeting in an open economy setting. The different rules considered include targeting of CPI and domestic inflation, strict and flexible inflation targeting, and inflation-targeting reaction function and the Taylor rule. For equation 2.1.) Svensson's study assumed values $\lambda_0 = -0.45$ and $\lambda_1 = 0.45$. Analyzing the optimal monetary policy responses to many different shocks the author concludes that flexible CPI targeting stands out as successful in limiting the variability of CPI inflation, output gap and real exchange rate.

To sum up the conclusions of all the three studies, the exchange rate does not seem to play very important role in the policy rule of even open economies. Adopting an exchange rate target implied only small reductions in the volatilities of inflation or

¹ For discussion about these papers, see also Taylor (2001).

output, although some of the models assumed rather large values for λ_0 and λ_1 . In Svenssons study the exchange rate actually seemed to imply a slight increase in the volatility of output. The intuition behind this result is based on the indirect effect of the exchange rate on the interest rate, that was built in to the models by assuming rational expectations and some inertia.

The desirability for the central bank to react to exchange rate changes ultimately depends on the nature of the exchange rate shocks. If the exchange rate change reflect only changes in economic fundamentals, there is no need for central bank intervention. The ultimate causes for the depreciation of Euro has recently been examined eg by Grauwe (2000). The study fails to find any stable link between the fundamentals and the euro/USD exchange rate. Instead, the euro/USD rate seems to be driven by the investors' expectations² so that the strong weakening of the Euro rather results from more or less irrational behavior among investors than from the productivity differences between the US and the euro area. If Grauwe's reasoning is correct, one consequence is that the effectiveness of the central bank' interventions may be weaker than commonly believed, since the investors' expectations become more difficult to affect.

Wallius (2001) criticizes Grauwe's choice of data, since Grauwe's estimations are made using the realized values of the fundamentals for measuring market participant's expectations. By using data consisting of the expectations rather than the realized values, Wallius provides some informal evidence that shocks to some fundamentals, particularly the short term real interest rates, after all, can explain the weakening of the Euro. Rogoff (2001), in turn, argues in terms of a theoretical model that because of trade friction, both the global goods and capital markets are much less integrated than commonly believed. It follows that under highly segmented goods market, only a small change in fundamentals is needed to create large but fully rational changes in the exchange rate. In addition, the changes in the exchange rate has much less feedback to the real economy than is usually expected.

Investors' portfolio adjustments provide for the weakening of euro an interpretation that does not hinge on either the fundamentals or investors' irrational expectations. The possible role of the portfolio decisions behind the exchange rate dynamics of the euro has been discussed eg by IMF (2001) and IFO (2002). The former of the studies highlight the importance of the increase in the supply of the euro-dominated assets, while the latter of the studies focuses more on the effects of the rapid decline of the demand of the euro area currencies. Both studies conclude that the portfolio diversification issues may account for a sizable share of the recent depreciation of the euro.

The importance of exchange rate shocks on the economic stability of EMU area depends also on the openness of its economy. E.g. Peersman and Smets (1998) argue

² There is a great uncertainty among investors about the relation between the exchange rates and fundamentals. Because of this uncertainty, the exchange rate movements themselves "frame" the investors beliefs of the fundamentals of the economies. Using these frames, agents tend to concentrate on looking only at those economic fundamentals that can corroborate their initial perception of the fundamental strengthness of the economy. This process can continue until the discrepancy between the investors' beliefs and reality grows too large and the agents have to find another fundamental to look at.

in favor of considering the euro-area as a closed economy like the US and Japan, since the ratio of exports to the euro area-wide GDP is only about 14%. On the other hand, some researchers have argued that the relatively low degree of openness of the Euro area does not necessarily imply an insignificant role for exchange rate. Mayes & Viren (1998), for instance, estimate Monetary Condition Indices for groups of EMS countries. The results suggest that the significance of the exchange rate channel for the monetary policy transmission to both inflation and real variables may be much larger in the Euro area than could be concluded from the share of foreign trade. The authors conclude that the transmission mechanism of the exchange rate changes is not based solely on foreign trade but is a more complicated process. Also the tentative results of Ranki (2001) suggest that the degree of pass-through may be much larger than would be expected in light of the openness of the Euro area.

The viewpoint of a single small member country to the optimal policy rule of a monetary union is actually part of the discussion of the optimal currency areas (henceforth, OCA). Whether the euro area can be considered as an optimal currency area or not, is discussed in Bayoumi and Eichengreen (1992) (and Dornbusch & al. (1998). Bayoumi and Eichengreen study the symmetry of the structural shocks in the EC area by estimating a set of structural VAR models to the 11 EC countries to identify the demand and supply shocks hitting these economies. The authors conclude that only the core countries of the EC experienced shocks with roughly the same magnitude and cohesion than the US regions. Particularly the supply shocks hitting the EC periphery tend to be both larger and less correlated with the shocks hitting the neighboring countries. Thus, the results suggested that operating a monetary union may be more difficult in the Euro area than in the US.

Dornbusch & al. (1998) provide a survey of the symmetry of the monetary transmission mechanism in EMU area. The authors conclude that due to the differences in the financial systems, the wage-price processes and also in the degree of openness of the EMU countries, the monetary processes differ widely among the member countries. Because of the already ongoing restructuring of the financial processes and the adaptation of the labor markets of the member countries to the changing environment, the transmission mechanisms in the member countries are however, likely to converge.

Schelkle (2001) provides an alternative standpoint for the whole OCA literature. If the exchange rates no more reflect only economic fundamentals, but are more or less driven by (rational or irrational) bubbles, the exchange rate adjustment does no more provide a shelter for economic shocks. Accordingly, the presence of asymmetric shocks is no more an acceptable argument against monetary unification, and eliminating the exchange rate instability becomes rather a benefit than a cost.

3. The theoretical model

From the methodological point of view, the study at hand represents an approach that Taylor (2001, p. 263) calls “new normative macroeconomic research”. This approach includes building a macroeconomic model containing a monetary policy rule, solving the model numerically, examining the stochastic behavior of the model variables and choosing the monetary policy rule with most satisfactory performance. Further, as the macroeconomic model of this study assumes nominal rigidities, it is an example of

what Clarida & al. (1999) calls “New Keynesian models”. It is typical for the New Keynesian models that they closely resemble the traditional ISLM models, while they still are derived from the behavior of optimizing agents³. As McCallum & Nelson (1997) have demonstrated, the models correspond to linear reduced form of a fully-optimizing general equilibrium models. The models are also similar in spirit with the more complicated macroeconomic models used by the central banks⁴. A typical New Keynesian model consists of a Taylor type monetary policy rule, an IS-curve type relation that links the interest rate movements to the changes in aggregate demand and an equation(s) describing the supply side of the economy. The model may also include an LM curve equation describing the equilibrium condition in the money market and in an open economy setting the model is often supplemented by an uncovered interest parity condition for determining the exchange rate.

The model of this study, in particular, is based on a macro model developed by Batini and Haldane (1998). Batini’s and Haldane’s original model is meant to capture the basic structure of a small open economy (the UK) and it was used to evaluate properties of inflation forecast-based monetary policy rules. Our model is modified from the original one-country model to cover two economies, that is, the monetary union as a whole and a single member country. (For convenience, the single member country is henceforth referred as simply “member country”). More formally, the model is a linear difference equation system of ten equations, so that the equations 1) – 6) below characterize the whole monetary union, while the equations 7) – 10) describe solely the economy of the member country. The equations characterizing the whole union follow very closely the model of Batini & Haldane, whereas the rest of the equations describing the small member country form the “new” part of the model. Note that there is only one way feedback between the blocks: The single member country takes the interest rates as given and a relatively large share of its foreign trade is assumed to consist of intra-union trade. The member country is, however, assumed to be so small relative to the union that the union’s variables are unaffected by the performance of the economy of the single country.

The main features of the model include firstly, that the model implies stickiness to consumer prices, and hence some persistence to consumer price inflation. Secondly, the model is forward-looking in nature and the expectations are assumed to be rational. The forward looking features of the model appear in many forms. Firstly, in the policy rule the central bank reacts to anticipated inflation. Secondly, the IS equation may be interpreted as a linearized Euler equation, where the present consumption is affected by the expected marginal utility from the consumption of the next period. Thirdly, in the uncovered interest rate parity equation the nominal exchange rate adjusts according to the expected future paths of the domestic and foreign short term interest rates. Finally, in the wage contracting equation the workers set their wage demand partly according to the expected wage level of the future wage contracts.

The macro model.

³ Recent surveys of these “New Keynesian” models are provided by Clarida, Gali and Gertler (1999) and Taylor (2000).

⁴ See also Woodford (1999).

The monetary union

$$3.1.) r_t = \gamma_{t-1} + (1-\gamma)r_t^* + \theta_1 [E_t \pi_{t+1} - \pi^*] + \theta_2 (y_t - y_t^*) + \theta_3 (q_t - q_t^*)$$

$$3.2.) y_t - y_t^* = \alpha_1 y_{t-1} + \alpha_2 E_t (y_{t+1}) + \alpha_3 [r_t] + \alpha_4 (q_t) + \varepsilon_{1t}$$

$$3.3.) e_t = E_t (e_{t+1}) - i_t + i_t^f + \varepsilon_{2t}$$

$$3.4.) p_t^d = 1/2 [w_t + w_{t-1}]$$

$$3.5.) w_t = \chi_0 [E_t (w_{t+1})] + (1-\chi_0) [w_{t-1}] + \chi_1 (y_t - y_t^*) + \varepsilon_{3t}$$

$$3.6.) p_t^c = \phi p_t^d + (1-\phi) e_{t-1}$$

The small country

$$3.7.) y_t^m - y_t^{m*} = \beta_1 y_{t-1}^m + \beta_2 E_t (y_{t+1}^m) + \beta_3 [r_t^m] + \beta_4 (q_t) + \beta_5 (y_t) + \varepsilon_{1t}^m$$

$$3.8.) p_t^{md} = 1/2 [w_t^m + w_{t-1}^m]$$

$$3.9.) w_t^m = \psi_0 [E_t (w_{t+1}^m)] + (1-\psi_0) [w_{t-1}^m] + \psi_1 (y_t^m - y_t^{m*}) + \varepsilon_{3t}^m$$

$$3.10.) p_t^{mc} = \kappa p_t^{md} + \vartheta p_t^d + (1-\kappa-\vartheta) e_{t-1}$$

All variables, except interest rates, are in logarithms. Inflation variables of both the union and the single country, π_t and π_t^c , are defined as consumer price inflation. That is, $\pi_t \equiv p_t^c - p_{t-1}^c$ and $\pi_t^m \equiv p_t^{mc} - p_{t-1}^{mc}$, where p_t^c and p_t^{mc} are the price levels of the consumption goods of the union and the member country. The nominal exchange rate (e_t) is defined as the domestic price of foreign currency. Accordingly, the real exchange rate is defined as $q_t = e_t + p_t^{cf} - p_t^c$, where p_t^{cf} is the price level outside the union. The variables of the single member country are separated from the union variables by superscript m.

Equation 3.1) represents **the ECB:s reaction function**. It is assumed that while the ECB:s policy instrument acually is the nominal interest rate, i_t , it actually tries to adjust the *ex-ante real rate of interest* ($r_t \equiv i_t - E_t \pi_{t+1}$) of the whole union⁵ through its forecast of the future inflation⁶. While the aim of the study is to compare the performance of several policy rules with slightly differing specification or parameter values, the common feature for all specifications is that the central bank responds at least to deviations of the expected inflation and output from their desired levels, $E_t \pi_{t+1} - \pi^*$ and $y_t - y_t^*$. The desired levels of the output y_t^* , is implicitly assumed to be the natural rate of output so that there are no kind of Barro-Gordon bias built in into the model. The differences between the policy rule candidates are related to the extent to which the central bank reacts to deviations of the real exchange rate from its target⁷, that is, to $q_t - q_t^*$.

⁵ Accordingly, the real interest rate of the single member country is given by $r_t^m \equiv i_t - E_t^m \pi_{t+1}$.

⁶ According to the deterministic analysis, the results were not sensitive on whether the variable in the left hand side of the equation is the nominal or the real interest rate.

⁷ The exchange rate could be defined e.g. as the trade-weighted exchange rate or the exchange rate between the Euro and the USD.

The theoretical motivation for inflation and output gaps as the central bank's objectives can be found e.g. from Woodford (1999). With a simple optimizing model Woodford shows that it is possible to motivate a quadratic loss function with inflation and output gap as arguments as a second-order Taylor-series approximation to the expected utility of the economy's representative household. Some of the assumptions of Woodford's model, regarding eg the definition of the output gap, are somewhat special so that some minor qualifications would actually be needed to justify the stabilization goals of the Taylor rule using Woodford's model. For instance, the natural rate of output should be defined as an equilibrium level that is obtained under perfectly flexible prices, and which varies as a response to the shocks facing the economy.

The right hand side of the policy rule equation also includes the lagged real interest rate, which reflects the central bank's urge to smooth its interest rate changes⁸. This kind of interest rate smoothing element has become a mainstream assumption in the literature and it can be motivated e.g. by central banks' attempt to stabilize financial markets. Alternatively, the sluggishness in the interest rate changes can reflect central banks' caution in the face of the uncertain information on which the central banks has to build their decisions.

Equation 3.2) represents **the IS curve** of the economy, relating the deviation of the real output, y_t from its potential level y_t^* , to the ex ante real interest rate and the real exchange rate as well as to the lagged and lead term of the output ($\alpha_3, \alpha_4 > 0$). It would have been possible to include also the long-term interest rates to the model. This was not done however, to avoid making the model that already consists of ten equations, excessively complex. The RHS of the equation contains both a lagged and a lead term of output. This is a novel feature compared to the traditional specification of the IS curve with the current output in the RHS instead. The lead term is motivated by McCallum and Nelson's (1997) work that shows the similarities between the ISLM models and a fully optimizing general equilibrium model. The lead term of the output becomes understandable when the IS equation is thought as representing a linearized version of the Euler equation that relates the expected marginal utilities of the current consumption and the consumption in the following period. The lagged output is more an *ad hoc* increment to the model that tries to capture the sluggishness of the output, created by adjustment costs.

Equation 3.3) is an **uncovered interest parity condition**. This parity condition does not contain any explicit foreign exchange risk premium, although any noise in the foreign exchange rate market including shocks to the exchange risk premium, is included into the shock vector. An alternative way of modeling the exchange rate determination might have been an equation that would have explicitly taken into account the changes in the fundamentals like output, behind the exchange rate changes. Our specification of the determination of the exchange rate is chosen mainly because of its simplicity and because the scope of the paper is limited to short-run considerations. The chosen approach to modeling the exchange rate of course lacks dynamic aspects of the exchange market that becomes important in the long run, such as the wealth effects of current account imbalances and the intertemporal budget

⁸ See e.g. Kozicki (1998), p. 8.

constraints. Put in another way, the implicit assumption in our model is that the equilibrium exchange rate e^* remains constant over time.

Equation 3.4) is the **mark-up equation** 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. Equation 3.5) is **the nominal wage-contracting equation**. 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 3.5) captures the tightness of the labor market. The specification differs from that of Batinis and Haldanes study, in which the wage setting was modeled rather with real wage contracting. The nominal wage specification was chosen here because it implied more plausible impulse responses. In addition, 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 & Wieland (2000). The study compared 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.

Equation 3.6) defines the **consumption price index** of the monetary union as a weighted average of the prices of domestic goods and imported foreign goods. The correct formulation of 3.6) is crucial for the results, since it is the most important determinant of the pass-through of the nominal exchange rate rates. The role of the exchange rate in the transmission process of the monetary policy as a whole is actually based on two channels. At first, the changes in the real exchange rates are transmitted indirectly, as the change in net exports affects the output gap, which in turn partly determines inflation. The impact through the equation 3.6) is the direct effect: A rise in the prices of imported goods raises the consumer prices, but the extent to which the consumer prices are affected ultimately depends on the competitive structure of the goods markets. Note that now 3.6) implies full but not immediate pass-through of the exchange rate into consumption prices, since the exchange rate emerges in the equation only with lag. The theoretical background for the specifications with less than full or other than immediate pass through is primarily based on the recent pricing to market literature⁹.

The basic structure of the equations 3.7) – 3.10) is largely similar to the corresponding equations characterizing the whole union. The equations 3.8) and 3.9) are completely analogous to their union-wide counterparts. In the IS equation (3.7) that determines the output demand of the member country, there is now an additional explanatory variable y_t reflecting the dependence of the output demand of the country from the intra-union trade. Accordingly, in equation 3.10) the consumption prices of the member country are now defined as a weighted average of production prices of goods produced in the home country, inside the monetary union and outside the union.

⁹ See e.g. Goldberg & Knetter (1997).

Thus, the differences between the structures of the economies of the single member country and the whole union is modeled through the parameter values in the equations of the two blocks. The most important differences are related to parameters determining the degree of openness of the economies, that is, the parameters $\alpha_4, \beta_4, \beta_5, \phi, \kappa$ and ϑ .

The model does not contain a LM equation characterizing the equilibrium in the money market. In fact, the money supply is totally ignored from the model.¹⁰ As McCallum (1999, p. 9 – 11) argues, leaving a LM relation out of the model is justified only if at least two assumptions are fulfilled. At first, there is the assumption that the central bank really conducts the monetary policy only with interest rate changes and does not pay attention to the monetary aggregates¹¹. The second assumption is that the monetary aggregates do not appear in the other behavioral equations of the model. In the case of the IS relation that would mean that the transaction-cost function, which describes the way that money facilitates transactions, must be separable in money and income.

3.2. Solving the model

Solving the model is based on an assumption that all the behavioral relationships above represent deviations from equilibrium. Hence, the (log) natural rates of output of both the union and the member country, the (log) price level of the goods produced outside the union, the interest rate outside the union, the implicit mark-ups in (3.5) and (3.9) and foreign interest rate premium in (3.3) are normalized to zero. The values for the parameters were primarily searched for from the previous empirical studies. Specifically, the parameter values of equations (3.7) – (3.10) that determine the openness of the small member country are selected so that the member country could be considered as representing e.g. Finland. When there were no direct estimates of the parameter values available, the parameter values were obtained by calibration so that they at least gave plausible impulse responses.

The model was solved by the method proposed (and software provided) by Uhlig (1999). Uhlig's method is based on solving for the recursive equilibrium law of motion with the method of undetermined coefficients¹². In this method, the model variables are divided into three subgroups: \mathbf{x}_t , \mathbf{y}_t and \mathbf{z}_t . Now \mathbf{x}_t is a vector of endogenous state variables of size $m \times 1$, which is identified as the set of variables that is given at date $t-1$. \mathbf{y}_t is a $n \times 1$ sized vector of the other endogenous variables, while \mathbf{z}_t is a $k \times 1$ vector of exogenous stochastic processes that hit the economy. The equilibrium relationships between these variables can be characterized as follows:

¹⁰ Batini's and Haldane's model contained a LM equation but it was found to be largely redundant as the changes in money supply were assumed to be accommodated by money demand at any given level of interest rates

¹¹ One objection to the choice of dropping the money supply from the model could be that controlling broad money is, *de jure*, the second of the two "pillars" used to achieve the ECB's price stability objective.

¹² The brief description of the method presented here is based on Uhlig (1999), p. 35 – 45.

$$3.11.) \mathbf{0} = \mathbf{A}\mathbf{x}_t + \mathbf{B}\mathbf{x}_{t-1} + \mathbf{C}\mathbf{y}_t + \mathbf{D}\mathbf{z}_t$$

$$3.12.) \mathbf{0} = \mathbf{E}_t[\mathbf{F}\mathbf{x}_{t+1} + \mathbf{G}\mathbf{x}_t + \mathbf{H}\mathbf{x}_{t-1} + \mathbf{J}\mathbf{y}_{t+1} + \mathbf{K}\mathbf{y}_t + \mathbf{L}\mathbf{z}_{t+1} + \mathbf{M}\mathbf{z}_t]$$

$$3.13.) \mathbf{z}_{t+1} = \mathbf{N}\mathbf{z}_t + \boldsymbol{\varepsilon}_{t+1}; \mathbf{E}_t[\boldsymbol{\varepsilon}_{t+1}] = \mathbf{0},$$

where $\mathbf{A}, \mathbf{B}, \mathbf{C}, \mathbf{D}, \mathbf{F}, \mathbf{G}, \mathbf{H}, \mathbf{J}, \mathbf{K}, \mathbf{L}, \mathbf{M}$ and \mathbf{N} are coefficient matrices of appropriate size. The matrices have to fulfill the following restrictions: Firstly, \mathbf{C} is of size $l \times n, l \geq n$ and of rank n . Secondly, \mathbf{F} is of size $(m+n-l) \times n$, and thirdly, \mathbf{N} has only stable eigenvalues.

The matrix equation 3.11.) describes the deterministic equations of the model, whereas 3.12) is built of the expectational equations. Eq. 3.13) in turn, describes the behavior of the stochastic processes of the economy as AR(1) –process. The ultimate aim of solving the model is to find the recursive equilibrium law of motion, which takes the form

$$3.14.) \mathbf{x}_t = \mathbf{P}\mathbf{x}_{t-1} + \mathbf{Q}\mathbf{z}_t$$

$$3.15.) \mathbf{y}_t = \mathbf{R}\mathbf{x}_{t-1} + \mathbf{S}\mathbf{z}_t$$

Here the vector of the endogenous state variables \mathbf{x}_t consists of $[r_t, y_t, e_t, w_t, p_t^c, i_t, r_t^*, y_t^*, w_t^*, p_t^{c*}]$, while the vector of other endogenous variables \mathbf{y}_t reads as $[\pi_t, p_t^d, q_t, \pi_t^*, p_t^{d*}]$. The vector of exogenous stochastic processes of the model is $\mathbf{z}_t = [\boldsymbol{\varepsilon}_{1t}, \boldsymbol{\varepsilon}_{2t}, \boldsymbol{\varepsilon}_{3t}, \boldsymbol{\varepsilon}_{1t}^m, \boldsymbol{\varepsilon}_{2t}^m]$. The matrices $\mathbf{P}, \mathbf{Q}, \mathbf{R}$ and \mathbf{S} are such that the equilibrium described by these rules are stable. The values for the elements of the matrices $\mathbf{P}, \mathbf{Q}, \mathbf{R}, \mathbf{S}$ and \mathbf{Z} were found using the software package written for MATLAB by Uhlig (1999). After the equilibrium law of motion has been solved, the unconditional variances of the inflation and output variables implied by the model can be calculated either by simulations (see the APPENDIX A, or analytically, as Uhlig (1999) shows.

3.3. Calibrating and assessing the plausibility of the model

The parameter values for our model are partly based on the studies by Peersman & Smeds (1999), Ball (1997) and Batini and Haldane (1999). Where a direct empirical estimate of a parameter value was not available, the plausibility of the impulse responses was used as a criterion to choose between the different values. Note that the parameter values presented below represent only a kind of baseline parameterization of the model so that the robustness of the results of the stochastic analysis to small parameter changes is carefully examined later in the study.

The coefficient of inflation in the central bank reaction function (θ_1) is set equal to 0.5. Note that because it is the real interest rate in the right hand side of the policy

rule, this coefficient value does not contradict the well-known Taylor principle¹³. Taylor principle tells that the inflation coefficient in the Taylor rule type central bank reaction function should exceed unity or otherwise the monetary policy becomes destabilizing.¹⁴ The coefficient for the output gap (θ_2), in turn, is set equal to 1. The relatively high value for the coefficient value of the output gap is roughly in line with the findings of Peersman & Smeds (1999) and Ball (1997). According to these studies the efficient monetary policy rule should put higher weight on output gap than the weight of 0.5 that was used in the Taylor's original specification¹⁵. The parameter γ is set equal to 0.6, which suggests a rather strong interest rate smoothing motive. This follows again Peersman and Smets (1999) and their estimates for the coefficients of the efficient rule. The coefficient for the real exchange rate (θ_3) is set to 0.25 in the deterministic simulations, while in the stochastic simulations many alternative values were tested.

The parameters α_1 and α_2 of the IS equation of the union, as well as the corresponding parameters β_1 and β_2 of the IS equation of the member country, 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 β_3 that describe the elasticity of total demand to real interest rate, both get values of -0.6. The parameters α_4 , and β_4 , in turn, that measure how the demand reacts to changes in the real exchange rate, get values 0.2 and 0.3. The difference between the values α_4 and β_4 reflects the assumption that, compared to the union as a whole, a greater share of the aggregate demand in the member country consists of exports outside the union. The parameter values are in line with those adopted by Ball (1998), which are based on estimates for small to medium-sized open economies, such as Canada or Australia. These parameter values sound, however, plausible for also EMU area since 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 3¹⁶.

The parameter β_5 that measures the elasticity of the member country aggregate demand to changes in the demand in the union area, is set equal to 0.2. This number corresponds roughly to the share that the exports from the union area contributes to the aggregate demand of Finland. The value of β_5 implies that the goods markets of the single country and the rest of the union are only moderately connected to each

¹³ Rearranging the terms of the equation 3.1.) would in fact reveal that it is equivalent to a policy rule for the nominal interest rate with $\theta_1 = 1.5$.

¹⁴ For a discussion about this theoretical result. see Taylor (1999), Clarida & al. (1999) and Woodford (2000 and 2001). On the other hand, Benhabib (1999) puts into question the stability of the Taylor rule even in the case when the inflation coefficient exceeds unity

¹⁵ On the other hand, Taylor (1999) compares the performance of alternative monetary policy rule specifications with the US model using a number of different macro models finding that the rules with more weight put on stabilizing output do not outperform the benchmark rule with a coefficient of 1.5 to inflation and 0.5 to output. Moreover, the policy rules with the lagged interest rate do not seem to dominate the benchmark rule, although the interest rate smoothing seems to work better in the models with than without rational expectations.

¹⁶ See e.g. Ball (1998) p.5 or Mayes and Viren (1998).

other. Therefore, our model economy doesn't look like an optimal currency area, at least when it comes to the integration of the goods market.

Also the labor markets are modeled similarly in the union area and the member country. Unfortunately, there were not available any empirical studies about the European labor market that would have directly offered the parameter values for the contracting equation. So, these values had to be set more or less arbitrarily. Luckily, the chosen parameter values seemed to provide plausible dynamic responses to the shocks to the economy. In both wage contracting equations of the model (eq. 3.5 and 3.9), the parameters χ_0 and ψ_0 are set to 0.5, which implies equal weights for backward and forward lookingness. (For comparison, in Batini and Haldane (1998) χ_0 was set to 0.2.) The parameters χ_1 and ψ_1 that measure the output sensitivity of nominal wages are set to 0.1.

The most important asymmetry between the union and the small member country comes with the equations 3.6 and 3.10, which determines the consumer prices as weighted averages of the prices of both domestic and imported goods. For the whole union, the weighting parameter ϕ is set to 0.9 so that $(1-\phi)$, reflecting the share of trade to outside the union, gets a value of 0.1. For the small member country the parameter describing the weight of the domestically produced goods (κ) gets a value of 0.5, while the parameter ϑ that captures the cost effects of the imports from inside the union is set to 0.2. Hence, it is assumed that 30 % of consumption of the member country consists of goods produced outside the union. For the union as a whole, the corresponding figure is 10 %, so the single member country considered indeed is assumed to be more open than the union on average.

When the model was solved, it turned out to be dynamically stable so that the variables returned quickly to their long-run equilibrium values after the shocks. On the other hand, the matrix \mathbf{P} of the recursive equilibrium law of motion appeared to contain a unit root. The presence of the unit roots implies that the consumer and producer prices, the nominal exchange rate and nominal wages converge to new equilibrium levels instead of the old steady states after a temporary shock. The unit root in some of the nominal variables is however, well in accordance with the empirical evidence of the time-series properties of these variables.

The overall plausibility of the model was examined by deterministic analysis, which includes calculation and analysis of impulse responses to exogenous shocks. The impulse responses were calculated by setting $\mathbf{x}_0 = \mathbf{0}$, $\mathbf{y}_0 = \mathbf{0}$, $\mathbf{z}_0 = \mathbf{0}$ and $\varepsilon_t = 0$ for $t \geq 2$. Using the recursive law of motion, the values for \mathbf{z}_t and then \mathbf{x}_t and \mathbf{y}_t are calculated recursively using the values \mathbf{x}_{t-1} , \mathbf{y}_{t-1} , \mathbf{z}_{t-1} and ε_t for $t = 1, \dots, T$. The magnitude of the shock was assumed to be 1 percentage point.

The shocks examined included an IS shock and a real wage shock for both the monetary union and the member country, as well as a monetary policy shock and an exchange rate shock facing symmetrically both the union and the member country. The general conclusion was that the dynamic patterns of the impulse responses corresponded fairly well with what should be expected in light of previous theoretical and empirical research. All the deterministic analyses were carried out with the same

basic parameterization of the model that was presented above. A more detailed description of the results of the deterministic analysis is provided below for the monetary policy shock and the wage shock in the union and the member country demand shock.

Interest rate shock

The effects in the union

The contractionary monetary policy shock is defined as a temporary 1 percentage point increase in the real interest rate for a period of one quarter. Thereafter, the policy rule determines path of the real rate. From the point of view of the whole union area, in particular, the effects of a monetary policy shock are very short-lived, as it is seen in the Figures 1 – 3 of APPENDIX B. The union variables reach their steady states in two years, and the member country variables four years after the shock. The effects of the shock are also modest in size, since none of the impulses exceeds 0.6 % in magnitude in absolute values.

After the shock, both the ex ante real and the nominal interest rate seem to move largely hand in hand. Both interest rate variables rise right after the shock, (nearly 0.5 % at its maximum), and then visit temporarily below the baseline as the central bank temporarily reacts to the decreased output, appreciated currency and decline in inflation lowering the interest rates. Finally, the interest rates return to their base levels after about seven quarters. As expected, the nominal exchange rate reacts with a permanent appreciation. The real exchange rate appreciates on impact, depreciates then temporarily and converges then to the old steady state in about six quarters. The output reacts to the shock by declining some 0.4 %, but the effect is temporary, as the output has converged to very near the old steady state in only one year¹⁷. Inflation declines slightly, about 0.15 %, but reaches its old level in six quarters. Accordingly, also the rest of the nominal variables, namely the nominal wages, the nominal producer and consumption prices converge to their new steady states in appr. six quarters.

The effects in the member country

As expected, the influence of the monetary policy shock is somewhat more persistent in the member country than in the monetary union as a whole, as the central bank does not directly target the member country variables when it is setting its policy stance. This notion applies also to the other shocks examined. It is seen in Figures 4 – 5 of APPENDIX B that it takes 10 –12 quarters for the member country GDP, inflation and real interest rate to settle down to their steady state levels after the initial monetary policy shock. On the other hand, the shape and magnitude of the responses of these member country variables resemble closely those of the union variables. The responses of the member country price variables and nominal wages are hump shaped with minimum values little below those of the respective union variables. The new steady states are reached in about four years.

The wage shock

¹⁷ In fact, according to the common view, the monetary policy should affect with a lag of several quarters and the pattern of the response should be hump shaped. For a review of empirical research of real effects of monetary policy shocks, see e.g. Walsh (1998), Ch. 1.

The union

The shock to the contracting equation of the union can be interpreted as a supply shock, like a disturbance to the natural rate of output. Like the aggregate demand shock, also the wage shock is considered asymmetric so that it does not hit the member country at all. This kind of asymmetric productivity shock could be a consequence e.g. of inflationary wage settlements made in the union area. As it is seen in the Figure 6 in the APPENDIX II, the time path of the union nominal wages reaches its new steady state level very soon, in about two quarters. To begin with, the wage shock results in a rapid but temporary, about one percentage point increase in inflation, which lasts some two quarters. The increase in inflation sharply depreciates the nominal exchange rate immediately, although the real exchange rate depreciates only modestly, some 0.1 percentage point, for a period of about one year.

The increase in union inflation makes the central bank to tighten the monetary policy, which, because of the increase inflation, is seen only as a slight increase in the real interest rate. The net effect of the depreciation of the real exchange rate and the increase in the real interest rate is a temporary 0.2 percentage point decline in the union output about. The output however converges the original level in about one year. The consumer and producer prices show very different responses on the impact of the shock. The consumer prices increase sharply due to the depreciated currency, whereas the producer prices remain nearly unaffected.

The member country

The accelerated union inflation is transmitted also to the inflation of the member country, both through the depreciated nominal exchange rate and the increased prices of the imports from the union area. After about one year, on the other hand, the inflation turns into an about two year period of slight deflation in the member country. The time path of inflation is directly reflected in both the real interest rate and exchange rate of the member country. As it is seen in the figure, an initial sharp decrease in the real interest rate is followed by a modest but rather persistent increase, before the return to the original level. The real exchange rate of the member country has not been drawn into the figure but comparing the graphs of the nominal exchange rate and the member country producer prices, it is easily concluded that at first it depreciates, then temporarily appreciates after which it corresponds its original level again. The net effect is a positive peak of about 1.2 % in the member country output, lasting for almost two years. Also the inflation rate and the real interest rate reach their original levels about the same time. The prices and the nominal wages rise and stabilize into a new permanent level after about four years.

The total demand and wage shocks in the member country

The shocks facing the single member country do not have any effects in the union area, because the member country is expected to be so small relative to the union. Qualitatively, the mechanism of the transmission of the shocks is otherwise the same as the transmission mechanism of the shocks hitting the whole union, except that now the central bank does not try to stabilize the effects of the shocks. In the Figure 11 – 14 in the APPENDIX II, two features of the impulse responses are noteworthy. At first, both the total demand and the wage shock seem to have relatively strong and long lasting effects. Secondly, the prices and nominal wages stabilize to their initial levels after the shocks, whereas after the union wide shocks these nominal variables

converged to new steady state levels. This is of course possible if and only if the inflationary (deflationary) periods after the shocks are always offset by deflationary (inflationary) periods. Etc, etc...

4. THE STOCHASTIC ANALYSIS

4.1. Calculation of the exogenous shocks

The stochastic simulations requires estimates of the covariance matrix and autocorrelation structure of the structural shocks hitting both the member country and the rest of the union. Five different shocks are considered. The shocks include a demand shock and a labor market shock that hit the member country, a demand shock and a labor market shock that hit the rest of the union (but not the member country) and an exchange rate shock¹⁸¹⁹.

Batini & Haldane (1998) propose three ways to estimate the covariance matrix of the structural shocks for the simulations. One way would be to estimate the structural shocks and their covariance structure from a VAR model. The VAR models have rich dynamic structure but the approach suffers from the difficulties in imposing the correct set of identifying restrictions to the model. The opposite strategy then would be to estimate the IS equations, the wage contracting equations and the interest rate parity equation of the model and measure the structural shocks as residuals of these equations. Because of the inadequate dynamic structure of the equations, however, the estimated residuals would not represent pure structural shocks but instead some linear combinations of the shocks and model specification errors. Also the handling of the expectational variables could be problematic.

Batini & Haldane (1998) avoided these problems by choosing the third way in the middle of the two extreme approaches. They calculated the covariance matrix and the autocorrelations of the structural shocks from the residuals of a large structural forecasting model. Here the example of Batini and Haldane is followed by measuring the structural shocks by the forecast errors taken from Nigem model used by The Research Institute of the Finnish Economy. The series for the demand and labor market shocks of the member country are forecast errors of the equations describing the goods and labor markets of Finland. The series of the demand and labor market shocks of the rest of the union are created by aggregating the forecast errors from the corresponding equations of five large EMU countries (Germany, France, Spain, Italy, Netherlands) to single European shocks. The exchange rate shocks are drawn from the forecasting equations for the nominal exchange rate between ECU/USD. The period from which the forecasting errors are calculated is 1984:1 – 2001:1.

¹⁸ Including to the model also a shock to foreign price level might have made the model even more realistic, as also in reality the central bank face the problem of separating between different kind of shocks.

¹⁹ A more detailed description of the procedure used for the stochastic simulation is provided in the Appendix X.

The covariance matrix is presented in the Table X below. It is seen that the member country (Finland) is hit by considerably larger shocks than the rest of the union. The variance of the supply shocks is roughly eight times larger and that of the demand shocks still four times larger than the corresponding union wide shocks. The demand and supply shocks are however still relatively small when compared to the size of the exchange rate shocks with their estimated variance of 23.7 %. The large volatility of the ECU/USD rate is well-known fact, while the large difference in the size of the supply and demand shocks between the member country and the rest of the union is a more surprising finding. Although also Eichengreen and Bayoumi (xxxx) found considerable asymmetries between the supply shocks of the core and periphery countries of the EC, the shocks hitting the periphery were only two times larger than the shocks of the core countries. A partial explanation for the large variance of the Finnish shocks is provided by the years of the deep depression in the Finland during the sample period. Also the more specialized production structure of Finland provide an intuitively appealing explanation for the larger shocks.

The signs of the off-diagonal elements of the covariance matrix reveal that the shocks to labor market and aggregate demand are positively correlated between the whole union and the single country. The covariances between the union labor market and single country total demand and, respectively, union total demand and single country labor market, are in turn negative.

The autocorrelation structure of the shocks was examined by modeling the series as AR(1) models. The highest coefficient for the AR(1) term – appr. 0.5 in both cases – were found from the shocks to union aggregate demand and union wages. The exogenous shocks to aggregate demand and wages in the member country showed less persistence with the AR(1) coefficients of 0.12 and 0.35. The exchange rate shock to euro show rather low autocorrelation with the estimate of the first order autoregressive coefficient of 0.24.

To summarize the discussion above, it is concluded that the differences in the structural shocks is a source of considerable additional asymmetry between the member country and the rest of the union.

Table X. The covariance matrix of the structural shocks.

	e	Y^U	W^U	Y^M	W^M
e	23.7	0.321	-0.746	-0.235	-1.40
Y^U	0.321	0.578	-0.109	0.267	-0.45
W^U	-0.746	-0.109	0.322	-0.0862	0.46
Y^M	-0.235	0.267	-0.0862	2.56	-0.46
W^M	-1.4	-0.45	0.465	-0.463	2.66

4.2. The simulations

The simulations include calculating 100 artificial series of 100 periods (quarters). In all the simulations the variability of the inflation and output is measured as standard deviations and all the simulations are made for Hodrick-Prescott filtered series to remove the effects of possible seasonality to the results. The performance of the different rules in the simulations was compared by the performance frontiers. A performance frontier means a locus of output – inflation variability points that is drawn by changing the values of one (or two) parameters while holding the rest of the variables constant. Although we don't apply any explicit social welfare function to rank the outcomes of the different policies, it is evident that the points to the south and west in the figures are welfare superior, while the points to the north and east are inferior.

The Union

The stochastic analysis is started by looking at the effects of changing the values of the exchange rate coefficient of the policy rule (θ_3) on the stability of the union area. In the performance frontier of Figure 4.1 the parameter θ_3 gets values of 0, 0.1, 0.25, 0.5, 0.75, 1, 1.5, while the rest of the parameters remain unchanged. There is a cluster of points in the other lower end of the frontier, showing that if θ_3 is given fairly modest values in the range of 0.1 to 0.5, the monetary policy results in superior performance for both inflation and output stabilization. At this level of θ_3 the standard deviation of output stands at about 1% and the standard deviation of inflation about at 1.8%. Note that when θ_3 gets a value of 0, neither the volatility of inflation nor output is at its lowest. On the other hand, if θ_3 exceeds 0.5 the volatilities of both inflation and output start to increase hand in hand so that with $\theta_3=1.5$, the standard deviations of both inflation and output exceed 2.5 %. Thus, from the point of view of the whole union it seems to pay for the central bank to put moderate weight between 0.1 and 0.5 on targeting the exchange rate. With this policy the volatility of both the inflation and output take its lowest value. The volatility of output, however is reduced more than that of inflation.

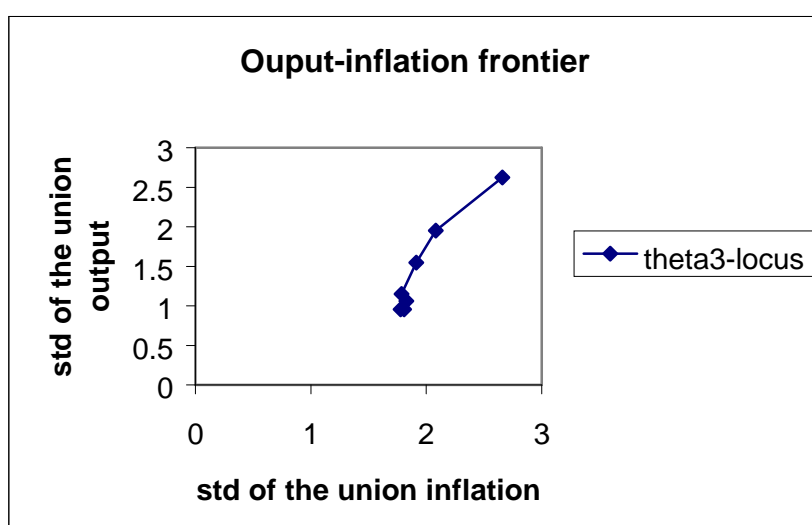


Figure 4.1. The performance frontier of the monetary union.

The interaction of θ_3 with the other two parameters in the reaction function, θ_1 and θ_2 , is discussed with the Figure 4.2. As the policymaker can freely choice also the values of θ_1 and θ_2 , it can control the effects of an exchange rate change on inflation and output also indirectly. Because the inflation in the reaction function is defined in consumer prices, the inflationary (deflationary) pressures induced by depreciation (appreciation) of the Euro might be possible to offset simply by more aggressive inflation targeting. Of course, there is a danger that the price stability would then be attained with the cost of larger output instability. This was actually the case in the studies by Clarida & al. (2001). The performance frontiers in Figure 4.2 are drawn assuming that when sliding along a frontier, the parameter pair (θ_1, θ_2) gets values (1.8 , 0.2), (1.5 , 0.5), (1.2 , 0.8), (1 , 1), (0.8 , 1.2), (0.5 , 1.5), (0.2 , 1.8). The different frontiers correspond then to the different value of the parameter θ_3 , that gets values of 0, 0.25, 0.5, 0.75 and 1. The figure shows that the optimal value of θ_3 lies somewhere at the level of 0.25 to 0.5 regardless of the values of the parameter pair (θ_1, θ_2) .

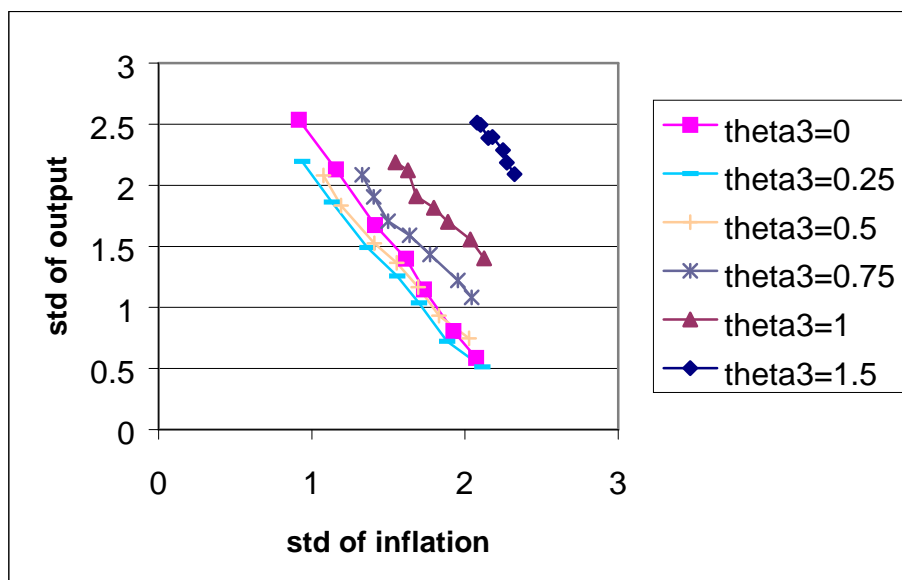


Figure 4.2. The performance frontiers of the union, when θ_1 and θ_2 are varied.

The Figures C.1 – C.6. in the Appendix C are used to discuss, whether the optimal response to exchange rate is sensitive to the exact model specification or not. Each performance frontier in the figures is drawn by holding θ_3 constant and changing the some of the other parameter values, one at a time. Overall, this robustness analysis suggests that the conclusions we made about optimal exchange rate policy are not very sensitive on small changes in the parameterization of the model.

Figures C.1, C.2 and C.3 depict a set of performance frontiers that are calculated by varying the parameter values that characterize the openness of the union economy and the speed of the pass-through of the exchange rate to import prices. Figure C.1 depicts five inflation-output frontiers. Each frontier is drawn assuming that parameter θ_3 gets some of the values of 0, 0.25, 0.5, 0.75 or 1 while when moving along the frontiers the speed of pass-through of the exchange rate to import prices varies from immediate

to a pass-through lasting two quarters. The points in the extreme left represent the case of the lengthiest pass-through while the points at the extreme right end of the lines correspond to immediate pass-through. In terms of output stabilization the frontier corresponding to $\theta_3 = 0.25$ slightly dominates the other policies. The variability of the inflation, on the other hand, seems not to be affected by the value of θ_3 . The highest volatility for the output is clearly obtained when θ_3 gets its highest values of 0.75 or 1. Interestingly, it is difficult to say, which of the values of $\theta_3 = 0$ and $\theta_3 = 0.5$ results in better performance.

Figure C.2 tells the sensitivity of the results on the share of foreign prices of the consumption prices of the union, which depends on the value of parameter ϕ . When sliding along the frontiers, ϕ gets values from 1 (totally closed economy) to 0.6 (fairly open economy). There seem to be only negligible differences between the performances implied by the best two policies of $\theta_3 = 0$ and $\theta_3 = 0.25$, both in terms of inflation and output volatility. When the weight put on stabilizing the exchange rate is increased beyond 0.25, however, the volatility of the output starts to increase again. The extent of the indirect price effect of the exchange rate changes depends on the parameter α_4 . In Figure C.3 each of the frontiers is drawn by varying α_4 between the values 0.2, 0.4 and 0.6, holding θ_3 unchanged along each frontier. The frontiers corresponding to $\alpha_4=0$ were totally omitted from Figure C.3 because $\alpha_4=0$ implied instabilities in the simulations when combined with some values for θ_3 . The optimal monetary policy now incorporates giving θ_3 a value between 0.25 and 0.5. A closer look at Figure C.3 reveals however, that the standard deviation of inflation implied by the frontiers varies in a very narrow range between 1.75 and 1.9, while the more significant differences are related to the variability of the output.

The sensitivity of the result can also be discussed in light of the assumptions made about the rate of forward lookingness of the union economy. It depends on the values of parameter α_1 , which measures the forward lookingness of the goods markets and χ_0 , which captures the forward lookingness of the wage-price process. Figure C.4, which plots the performance frontiers for α_1 shows that the output seems to get its lowest standard deviation with θ_3 in a range of 0 to 0.5. The points of the frontiers corresponding to these values of θ_3 are clustered to very small area in the figure so that it does not seem to make a difference, which is the exact value for θ_3 in that range. When the value of θ_3 is increased beyond 0.5, the volatility of output start to increase. The volatility of inflation again does not depend very strongly either on the value of α_1 or θ_3 , remaining at the level of about 2 %, regardless the values of these parameters. The shape of the frontiers also reveals that in the more forward looking goods market the volatility of output is lower regardless of the value of θ_3 .

Figure C.5 shows performance frontiers when χ_0 is given values 0, 0.25 and 0.5²⁰ holding θ_3 constant. It is seen that the volatility of inflation seems to be sensitive on the forward lookingness of the job markets. The excessively backward looking wage-price process with $\chi_0 = 0$ correspond to the left ends of the frontiers, whereas the baseline case of $\chi_0 = 0.5$ corresponds to right ends of the frontiers. The fully backward looking wage-price process hence results in considerably higher volatility of inflation than the moderately backward looking process (0.7 % vs. 2 %). The result is explained by the important role of the contracting process in the determination of the prices in our model. When it comes to the optimal monetary policy, the frontiers of $\theta_3 = 0$ and $\theta_3 = 0.25$ again imply superior performance for the output stability. For the inflation stability the value of θ_3 does not seem to make a difference.

Figure 4.3 below finally sums up the previous discussions about the sensitivity of the results to the parameter values of the model. The Figure is drawn assuming that the union is both more open with $\phi = 0.8$, $\alpha_4 = 0.4$ and more forward looking with $\alpha_1 = 0.2$. The optimal value for θ_3 lies now somewhere between 0.25 and 1. The extreme policies of either $\theta_3 = 0$ or $\theta_3 = 1.5$ clearly result in inferior outcomes. The shapes of the performance frontiers do not change so that the negative trade-off between the volatilities of inflation and output remains nearly linear. All in all, our conclusions about the central bank's optimal policy seem to be robust to small changes in the parameterization of the model, although but for a more open monetary union our model suggests monetary policy with more weight on the direct exchange rate target.

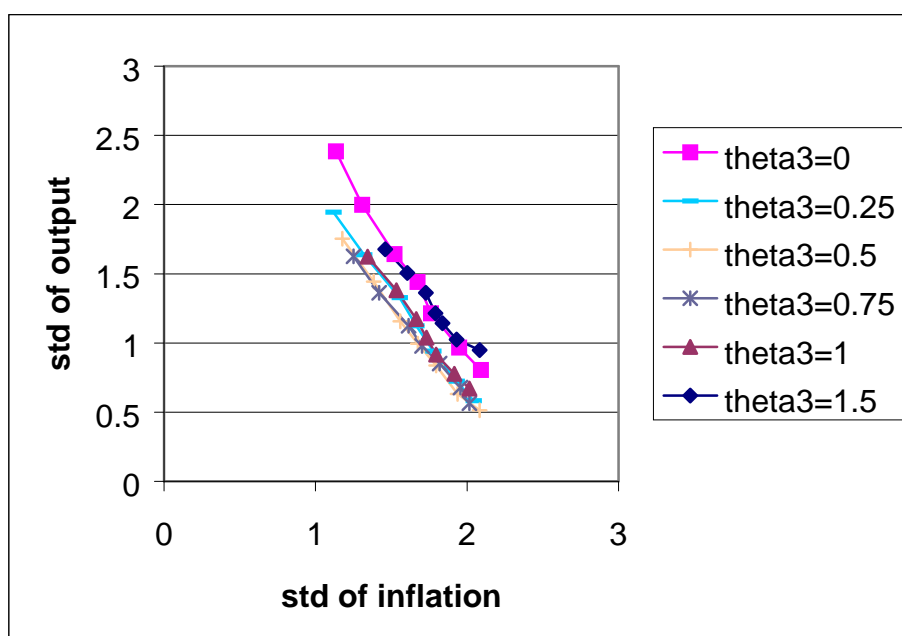


Figure 4.3 The performance frontiers of the union when several parameter affecting its openness is changed at a time.

²⁰ If χ_0 gets a value above 0.5, the model did no more have a sensible solution.

The member country economy

Figure 4.4 plots the performance frontiers of both the union and the member country in the same figure. It is seen that the frontier of the member country is located relatively far to north-east from the frontier of the whole union. Hence, although the structural differences between the member country and the rest of the union, after all, are rather small in the baseline parameterization, the member country seems to perform significantly poorer than the union on average. The relatively poor performance of the member economy is seen more clearly in the volatility of the output than in the volatility of inflation, since the former lies between 6% and 9%, and the latter between 2% and 3%.

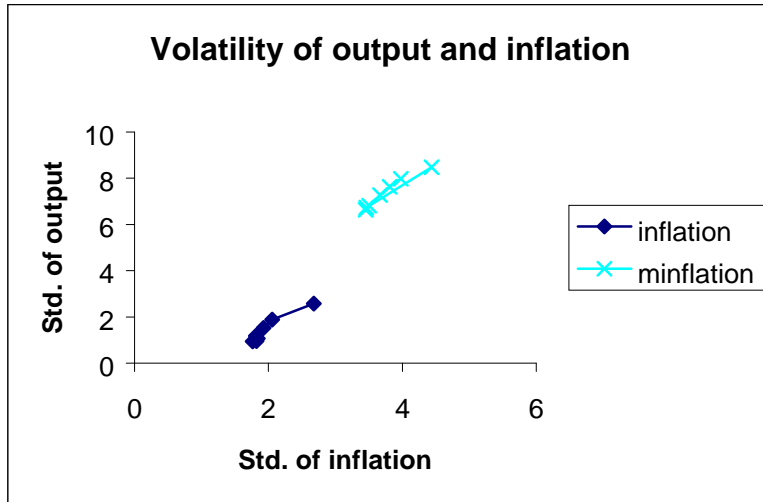


Figure 4.4. The performance frontiers of the member country in the rest of the union.

It is also evident by the figure 4.4 that the central bank has only limited possibilities to improve the performance of the member country economy by adopting an exchange rate target. From the point of view of the member country the optimal weight of the exchange rate in the reaction function lies somewhere at the level between 0.75 or 1. This value for θ_3 would reduce the output variability of the member country appr. 1.5 percentage points and the inflation variability a half of a percentage point compared to the case of no direct exchange rate target at all. Increasing θ_3 beyond 1.0 however becomes destabilizing also from the point of view of the member country as the volatility of both its inflation and output start to increase.

The interaction of θ_3 with θ_1 and θ_2 is illustrated by Figure 4.5, now from the point of view of the member country. Note that putting more weight on stabilizing inflation should not be now a substitute for targeting the exchange rate since the central bank targets the inflation and output of the union, not that of the member country. Putting more weight on exchange rate stabilization makes now both the output and inflation of the member country less volatile, whatever values θ_1 and θ_2 take. The distance between the best (corresponding to $\theta_3 = 1$) and the worst ($\theta_3 = 0$) performance frontier reveals that the central bank can reduce the output volatility of the member country roughly two percentage points and that of inflation roughly one percentage point by adopting the optimal weight to the direct exchange rate target. The volatility of output, in particular, remains however still far above that of the whole union.

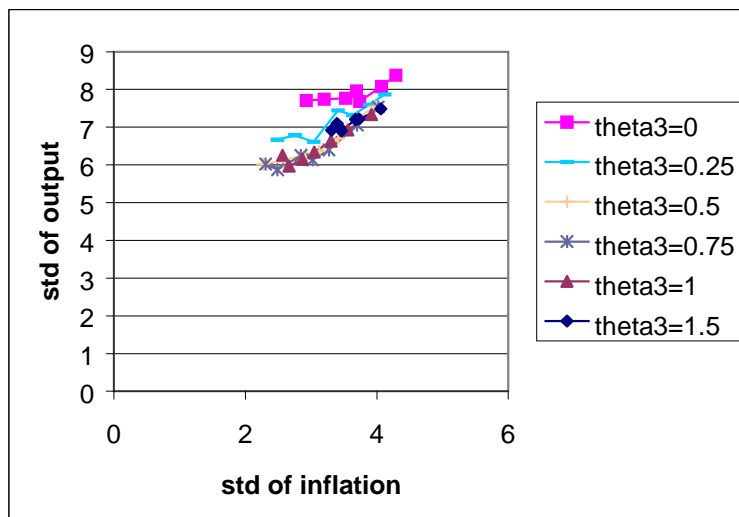


Figure 4.5 The performance frontiers of the member country when θ_1 and θ_2 are varied.

Why is then the macroeconomic performance of the member country relatively insensitive to the exchange rate policy? One explanation could be provided by the asymmetry in the shocks that hit the union and the member country. Since the differences in the parameter values between the union and the member country were relatively small, the differences in the performances of the two economies seem to be caused also by the differences in the business cycle pattern between the member country and the rest of the union. According to the estimated covariance matrix of the structural shocks, the shocks to the goods and labor markets of the single country seem to have considerably larger variance than the shocks facing the rest of the union. The issue of the asymmetric shocks is returned later, when the sensitivity of the results on the covariance matrix of the shocks is examined.

The sensitivity of the results to the changes in the parameter values describing the member country is discussed with Figures C.6 – C.11. The effects of varying the parameters determining the openness is first discussed with the Figures C.6 – C.8. These figures tell us whether the weight that the central bank puts on stabilizing exchange rate becomes more important to the single country as it becomes more open against the world outside the union. The openness is measured as the share of goods from outside the union in its consumption bundle κ , the sensitivity of its export demand on the exchange rate of euro, β_4 , and the speed of the pass-through of exchange rate to consumption prices. The figure C.9, in turn, illustrates the sensitivity of the results to the degree of integration of the goods market between the member country and the rest of the union. The degree of integration is measured by value of β_5 that determines how sensitive the aggregate demand of member economy is on the output of the union.

Overall, the previous qualitative results do not seem to be sensitive on small changes in the parameter values describing the openness of the member economy. The volatility of both the inflation and output are at their lowest when θ_3 gets a value of 0.75 or 0.5, whereas the performance frontier corresponding to $\theta_3 = 0$ clearly shows less favorable outcomes for the monetary policy. Also quantitatively the results

remain roughly unchanged for all the alternative parameter values. Regardless of the openness of the small member country of the model, the optimal response of the central bank to exchange rate changes lead to decrease of about 2 percentage points in the standard deviation of output and roughly 1 percentage point in that of inflation. Overall, the robustness of the results on the degree of openness of the member country backs up the previous conclusions that the main cause for the inferior performance of the member economy lies in the asymmetry of the shocks rather than in the asymmetry in the transmission process.

Parameter β_5 determines how deeply the goods markets of the member country are integrated with the goods markets of the rest of the union. The sensitivity of the performance of the member country economy to changes in β_5 is shown in Figure C.9. It is seen that neither can the volatility of inflation nor output of the member country be significantly reduced by integrating the goods markets closer together. All the points of the frontiers are concentrated close together. This finding is against the basic result of the literature of optimal currency areas, according to which integrating the goods markets of the countries of a currency area closer together effectively protects them from the problems of asymmetric economic shocks. Our previous conclusions concerning the optimal monetary policy however still remain valid. By adopting relatively active exchange rate policy with θ_3 set as 0.5 or 0.75 the central bank can reduce the standard deviation of member country inflation from around 4% to about 3% and the standard deviation of output from the level of 8% to the level of 6%.

Figures C.10 to C.11 finally, tell the robustness of the results to the assumptions about the degree of forward lookingness of the goods and labor markets of the member country. Figure C.10 at first shows that irrespective of the rate of forward lookingness of the goods market (values for β_1), active exchange rate policy reduces the volatility of inflation and output. Moreover, in highly forward looking goods markets the central bank seems to have better possibilities to improve the performance of the economy than in the backward looking goods market. The points of all the five frontiers that correspond to low values of beta are much closer to each other than the points that correspond to the lowest values of β_1 .

Although the rate of forward lookingness of the goods market does not have strong implications to optimal monetary policy, the overall performance of the member country is still rather sensitive on the forward lookingness. In simulations with $\alpha_1 = 0.8$ and $\psi_0 = 0.5$ the standard deviation of inflation took values around 3% - 4% and that of output between 6% and 8%, irrespective of the parameter values describing either the monetary policy or the openness of the economy. When either goods markets or labor markets were made more forward looking, the volatility of both inflation and output however decreased sharply. When either $\alpha_1 = 0$ or $\psi_0 = 1$, the standard deviation of inflation was reduced near 2% and the standard deviation of output near the level of 4%.

Figure C.11 then confirms the robustness of our previous results to the assumptions made of the forward-lookingness of the labor markets. The worst outcomes again seem to result from the policy with no exchange rate target at all, while the best

performance seems to be achieved with θ_3 set either to 0.5 or 0.75. In the simulations the value of ψ_0 ranged only between 0.5 and 1, because at values below 0.5 the system exploded.

Figure 4.6 below finally tries to sum up the discussions about the sensitivity of the results on the member country parameter values. The performance frontiers are now drawn with three parameter values differing from the baseline specification. The member country is now assumed to be both more open so that $\beta_4 = 0.5$ and $\text{phim} = 0.3$. The goods market are assumed to be highly forward looking so that $\beta_1 = 0.2$. As it is seen in the Figure 4.6, the value of θ_3 mostly affects to the volatility of output while it is unclear, which policy guarantees the least volatile inflation. Note however, that the best performance again seems to be achieved with fairly moderate policy with θ_3 se equal to 0.75 or 1.

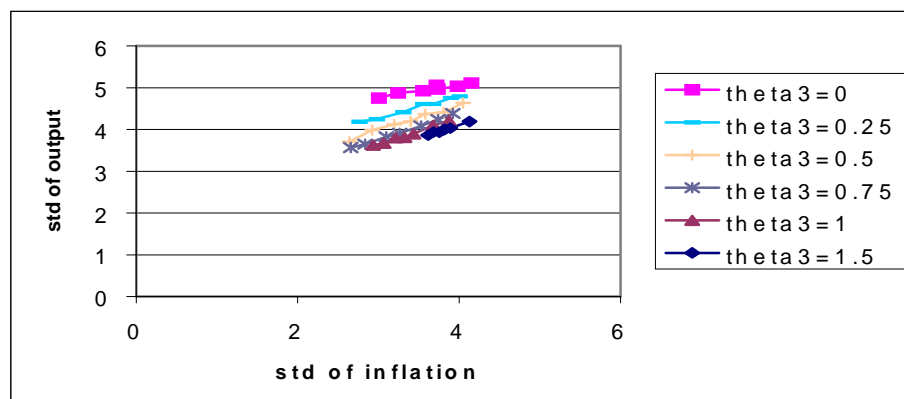


Figure 4.6 The frontiers of the member country when several parameters describing its economy are changed.

The role of the time series properties of the shocks

So far the robustness of the results have been examined only with respect to the parameter values of the model. The sensitivity of the results on the time series properties of the estimated structural shocks used in the simulations are discussed with figures 4.7 to 4.10, which are analogous to Figures 4.2 and 4.5 so that when sliding along a frontier, θ_1 and θ_2 get a set of values while θ_3 remains the same. The structural shocks, however have now different covariance matrices than the shocks in baseline model. In Figures 4.7 and 4.8 the variances of the output and labor market shocks of the member country have been assumed to be smaller than in the baseline model. Figures 4.9 and 4.10 in turn are drawn assuming that all the variances of the shocks are of equal size and strongly contemporaneously positively correlated with each other.

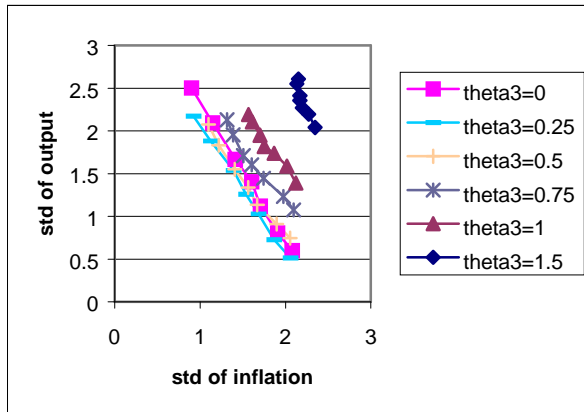


Figure 4.7 The performance frontiers of the union, when the variance of the member country shocks are assumed as smaller than in the baseline cases.

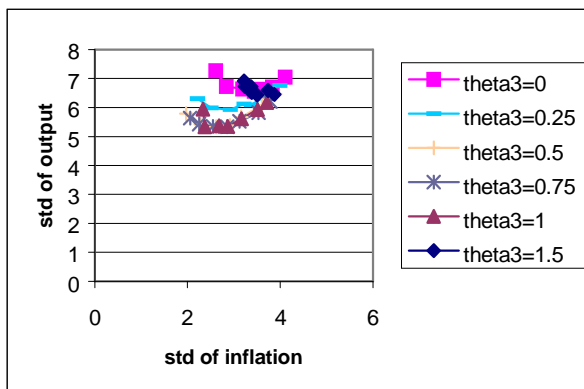


Figure 4.8 The performance frontiers of the member country, when the variance of the member country shocks are assumed as smaller than in the baseline cases.

Comparing the figures 4.7 and 4.8 with the Figures 4.2 and 4.5 shows that the performances the single country is somewhat sensitive to the variance of the structural shocks in the member country. When the variances of the demand and labor market shocks of the member country were reduced to 1.1 and 0.9 percentage points, the standard deviation of member country output reduces to the level of five percentage points, while the standard deviation of its inflation remains at the previous levels around 2-3 percentage points. Also the previous conclusions about the central bank's optimal response to exchange rate changes remain unchanged. From the point of view of the member country the optimal monetary policy still should put a weight ranging from 0.5 –1 to θ_3 , while from the point of view of the union economy the weight should lie somewhere on the level of 0 – 0.5. It is expected that the results for the union remain unchanged is, since the central bank does not react to shocks in the markets of the small member country.

According to the figures 4.9 and 4.10, on the other hand, when the shocks become highly correlated with each other, the value of θ_3 loses its significance. It is seen in the Figure 4.10 that all six performance frontiers of the member economy are of almost equal shape. Also the performance frontiers of the union in the Figure 4.10 look much like each other. This is well understood, since when the exchange rate shocks are highly correlated with the other shocks hitting the economies, the central bank reacts to the exchange rate shocks automatically when it reacts to the shocks to

the goods and labor markets of the union. From Figure 4.10 it is also seen that when the shocks are highly correlated, it is possible to still reduce the volatility of output of the member country. The left ends of the performance frontiers (corresponding to values around 1.5 for the inflation coefficient θ_1 and very low values of the output gap coefficient θ_2) imply that the standard deviation for member country output can be reduced somewhere near the level of 3 %. On the other hand, if the parameters of the reaction function are not near their optimal levels, the model implies rather high volatilities for the output and inflation of the member country.

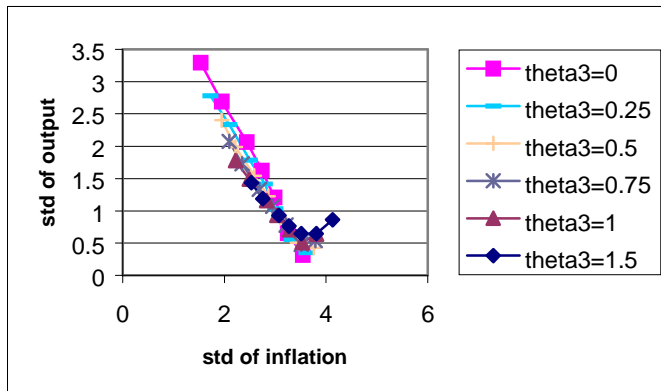


Figure 4.9 The performance frontiers of the union, when the structural shocks between the member country and the union are highly correlated.

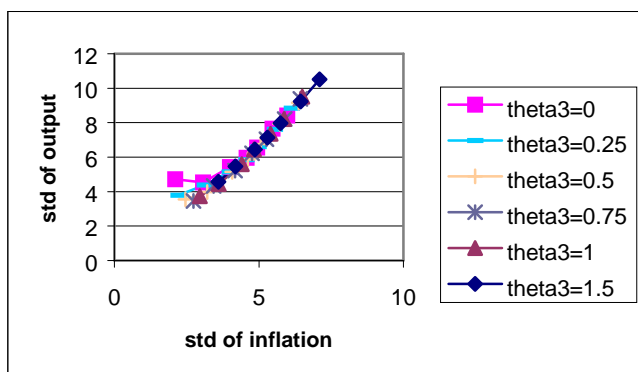


Figure 4.10 The performance frontiers of the member country, when the structural shocks between the member country and the union are highly correlated.

5. CONCLUSIONS

In this paper we have, using a small calibrated macromodel, examined whether it would be optimal for the European Central Bank to adopt an explicit target for the real exchange rate of Euro. From the point of view of a single member country, the problem is a part of the ongoing discussion whether the EMU can be considered as an optimal currency area. Thus, the question has been discussed not only from the viewpoint of the performance of the union economy as a whole, but also from the viewpoint of a small member country. The economy of the single small country differs from the union in two ways. At first, the economy is more open towards the world outside the union, and secondly, the exogenous shocks that hit the economy differ from those that hit the rest of the union.

Our main conclusions are as follows: From the point of view of the whole union economy, the central bank should put at most moderate weight on the direct exchange rate target. The optimal value for the coefficient of the exchange rate in the monetary policy rule lies somewhere between 0.1 and 0.5. For the small member country the optimal response to the exchange rate would however lie between 0.75 and 1. With this policy the standard deviation of the member country output would be reduced by roughly two percentage points and that of inflation about one percentage point. It should be noted however, that even the optimal weight on the direct exchange rate target would not stabilize the volatility of inflation and output of the member country to the same level with the whole union. Moreover, at least when it comes to the volatility of output, the most important reason for the poor performance of the member country seems not to be the structural differences between the member country and the union. Instead it seems to be more a result from the asymmetries in the structural shocks that hit the economies of the member country and the union. When the size and the timing of the structural shocks facing the member country were assumed to be more like those of the rest of the union, the optimal policy implied considerable lower volatility of the member country output.

REFERENCES

- Ball, Laurence (1998)
Policy Rules for Open Economies
NBER Working Paper 6760
- Batini, N. – Haldane, A. G. (1998)
Forward-looking rules for monetary policy
Bank of England Working Paper Series No 91.
- Bayoumi, T. – Eichengreen, B.
Shocking Aspects of European Monetary Unification
NBER Working Paper No. 3949
- Clarida, R. – Gali, J. – Gertler, M. (1999)
The Science of Monetary Policy: A New Keynesian Perspective
Journal of Economic Literature, Vol. XXXVII, PP. 1661 – 1707.
- Coenen, G. – Wieland, V. (2000)
A Small Estimated Euro Area Model with Rational Expectations and Nominal Rigidities
ECB Working Paper n.o. 30.
- Dornbusch, R. – Favero, C. A. – Giavazzi, F. (1998)
The Immediate Challenges for the European Central Bank
NBER Working Paper 6369.

Fuhrer, J. C. - Moore, G. R. (1995)

Inflation Persistence

Quarterly Journal of Economics, Vol 110, pages 127 - 159.

Goldberg, K. P. – Knetter, M. M. (1997)

Goods Prices and Exchange Rates: What have we learned?

Journal of Economic Literature, Sep 1997, Vol. XXXV, Number 3, p. 1243 – 1272.

De Grauwe, P. (2000)

Exchange Rates in Search of Fundamentals. The Case of the Euro-Dollar Rate.

Kamada, K – Muto, I (2000)

Forward-looking Models and Monetary Policy in Japan

Bank of Japan

Mayes, David G. – Viren, M. (1998)

The Exchange Rate and Monetary Conditions in the Euro Area.

Bank of Finland Discussion Papers 27/1998.

McCallum, Bennett, T. – Nelson, Edward (1997)

An Optimizing IS-LM Specification for Monetary Policy and Business Cycle Analysis.

NBER Working Paper 5875

McCallum, Bennet T. (2001)

Should Monetary Policy Respond Strongly to Output Gaps?

NBER Working Paper 8226.

McCallum, B. J. (1999)

Recent Developments in the Analysis of Monetary Policy Rules

Homer Jones Memorial Lecture March 11, 1999. Carnegie Mellon University.

McCarty, J. (1999)

Pass-Through of Exchange Rates and Import Prices to Domestic Inflation in Some Industrialised Economies.

BIS Working Papers 79/1999.

Obstfeld, M. – Rogoff, K. (1996)

The Foundations of International Macroeconomics.

The MIT Press, Cambridge.

Peersman, Gert – Smets, Frank (1998)

Uncertainty and the Taylor rule in a simple model of the euro-area economy

Ranki, Sinimaaria (2000)

Does the Euro Exchange Rate Matter?

ETLA Discussion Papers no. 729

Schelkle, Waltraud (2001)
The Optimum Currency Area Approach to European Monetary Integration: Framework of Debate or Dead End?
South Bank European Papers 2/2001. South Bank University. London.

Svensson, Lars E. O. (1998)
Open-Economy Inflation Targeting
NBER Working Paper 6545

Taylor, John B. (2000)
Alternative Views of the Monetary Transmission Mechanism: What Difference Do They Make for Monetary Policy?
Stanford University.

Taylor, John (2001)
The Role of the Exchange Rate in Monetary-Policy Rules
American Economic Review, Vol. 91, No 2.

Uhlig, Harald (1999)
A toolkit for analysing nonlinear dynamic stochastic models easily
In ‘Computational Methods for the Study of Dynamic Economies’, edited by Marimon, R. and Scott, A.
Oxford University Press 1999.

Wallius, S. (2001)
Euro ja uskomukset
Kansantaloudellinen aikakauskirja 2/2001, s.208-223.

Walsh, Carl E. (1998)
Monetary Theory and Policy
The MIT Press, Cambridge, Massachusetts.

Woodford, M. (1999)
Inflation Stabilization and Welfare.
Working Paper, Princeton University, June.
(Available at <http://www.princeton.edu/~woodford/>)

Woodford, M. (2000)
Interest and Prices
Princeton University. (Available at <http://www.princeton.edu/~woodford/>)

Woodford, M. (2001)
The Taylor Rule and Optimal Monetary Policy
American Economic Review Vol. 91 No. 2. P. 232 – 237.

APPENDIX A

The calculation of the unconditional variances of inflation and output

The conditional moments were calculated from simulated series. The simulation horizon of each series was 100 periods and the simulation was repeated x times, so that totally $100x$ sets of solution values was available for the calculation of the unconditional moments.

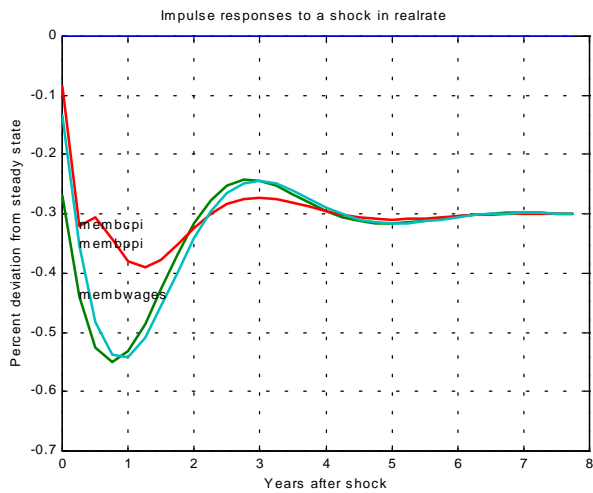
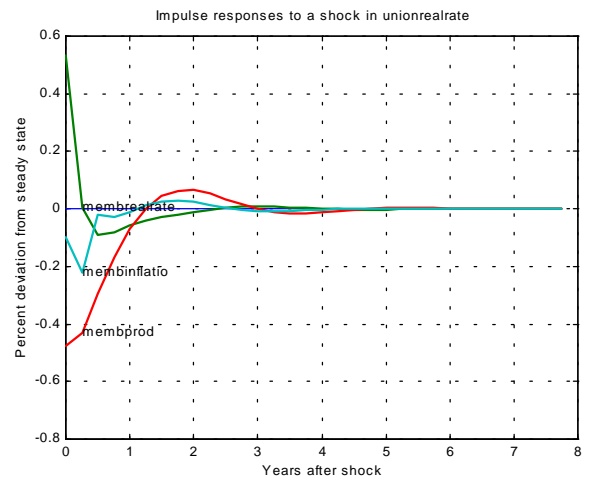
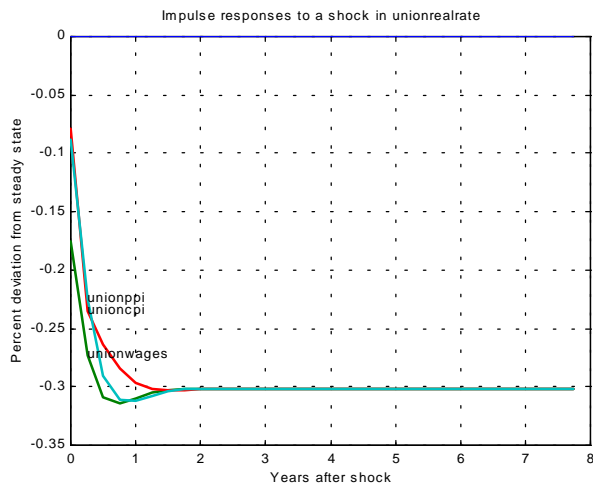
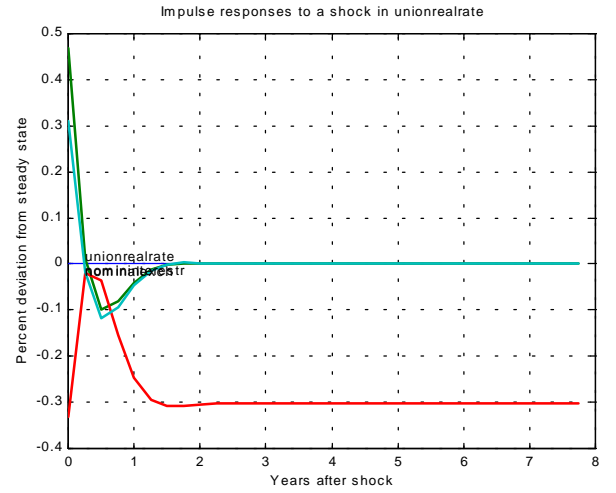
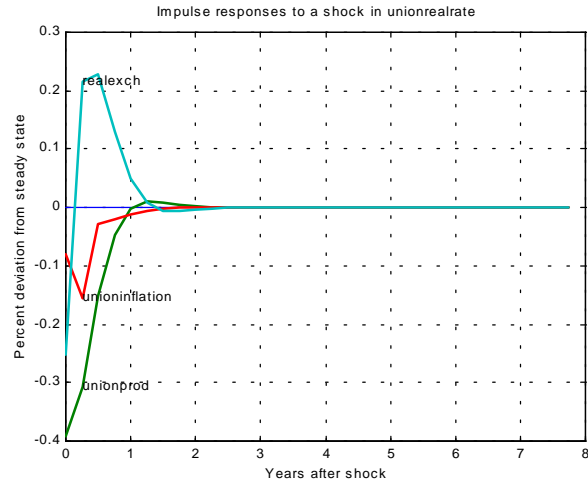
Denote the estimated covariance matrix of the structural shocks by $m \times m$ matrix $\hat{\Sigma}$, computed as $(1/T)\hat{\mathbf{Z}}\hat{\mathbf{Z}}'$, where $\hat{\mathbf{Z}}$ is the $m \times T$ matrix of the estimated values of the exogenous structural shocks. If the z shocks are IID distributed, the set of shocks used in the stochastic simulation can be obtained from a simple transformation of $\hat{\Sigma}$. To generate the shocks, the matrix $\hat{\Sigma}$ is decomposed into two triangular matrices that, when calculated together, yield the original matrix $\hat{\Sigma}$. If the rank condition holds ($T > m$), there exists a unique such decomposition, $\hat{\Sigma} = \mathbf{P}\mathbf{P}'$ such that \mathbf{P} is lower triangular and \mathbf{P}' is upper triangular.

The initial ($t=0$) values for the exogenous shocks z were calculated by first drawing m values from a standard normal distribution. Let's denote the vector of these values by \mathbf{e}_1 . These white noise disturbances were then turned into structural shocks by $\mathbf{z}_1^* = \mathbf{P}\mathbf{e}_1$. Using the values \mathbf{z}_1^* and the equations of the recursive law of motion, it is then possible to calculate values of \mathbf{x}_1 and \mathbf{y}_1 . Another draw from a normal distribution is then made for calculating values for \mathbf{z}_2^* , \mathbf{x}_2 and \mathbf{y}_2 . The process is then repeated until N values are obtained.

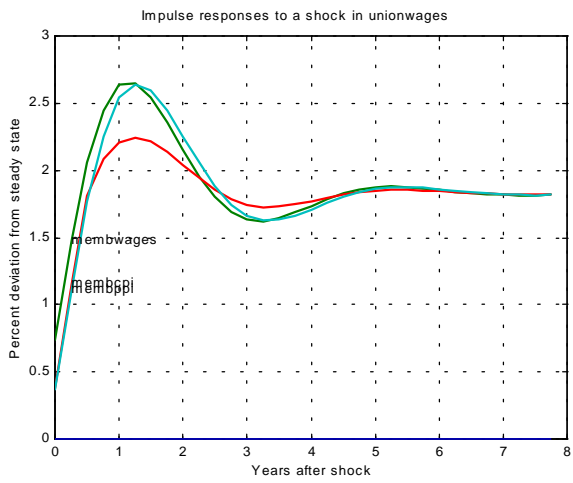
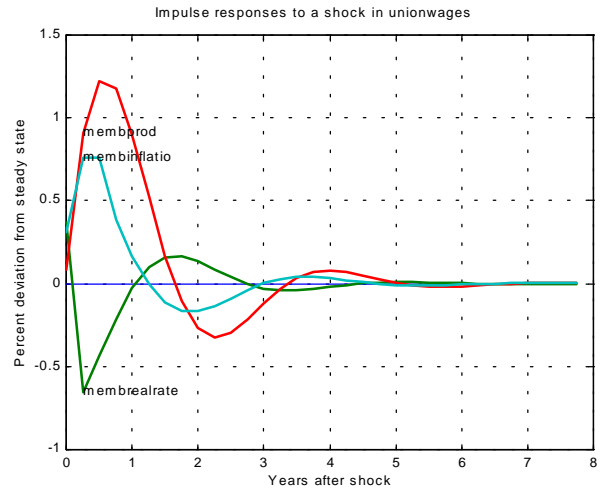
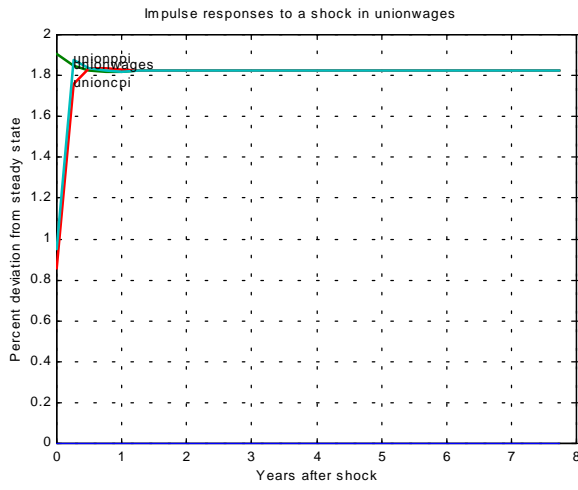
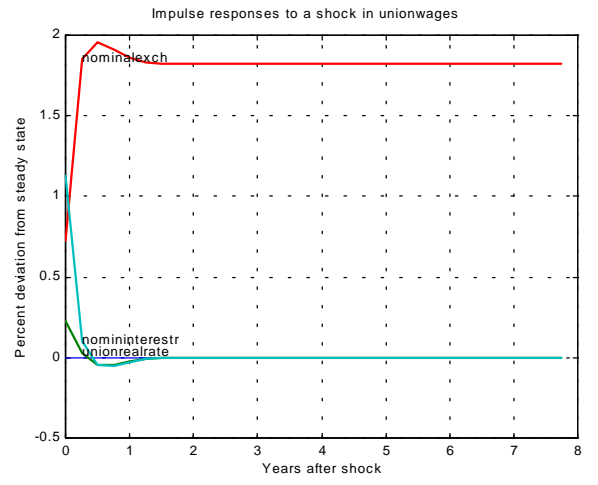
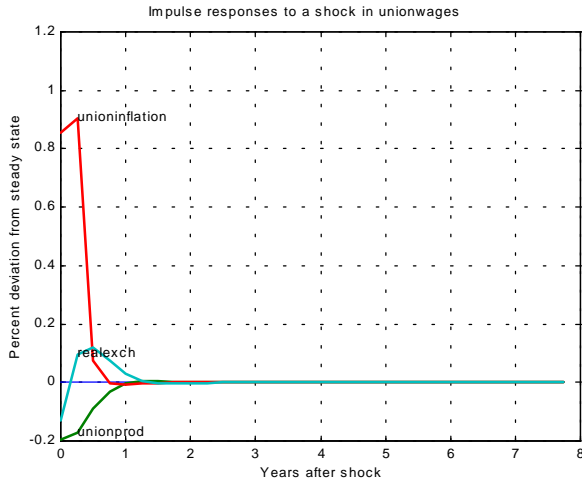
Assuming that the historical residuals are independently and identically distributed implies that in the equation all elements in the matrix \mathbf{N} equal to zero. In case that the historical residuals are autocorrelated, the residuals have to be "whiten" before calculating the covariance matrix. Suppose, for example, the first order autocorrelation $\mathbf{z}_t = \mathbf{N}\mathbf{z}_{t-1} + \mathbf{v}_t$, $\mathbf{v}_t \approx \mathbf{N}(\mathbf{0}, \Sigma_v)$. $\hat{\Sigma}_v = \mathbf{P}^*\mathbf{P}^{*}$ Now the value for \mathbf{z}_1^* is obtained from $\mathbf{z}_1^* = \mathbf{P}^*\mathbf{e}_1$, where \mathbf{P}^* is obtained from the Choleski factorization $\hat{\Sigma}_v = \mathbf{P}^*\mathbf{P}^{*}$. The value for \mathbf{z}_2^* is then calculated from $\mathbf{z}_2^* = \mathbf{N}\mathbf{z}_1^* + \mathbf{P}^*\mathbf{e}_2$.

APPENDIX B
The impulse responses of deterministic analysis

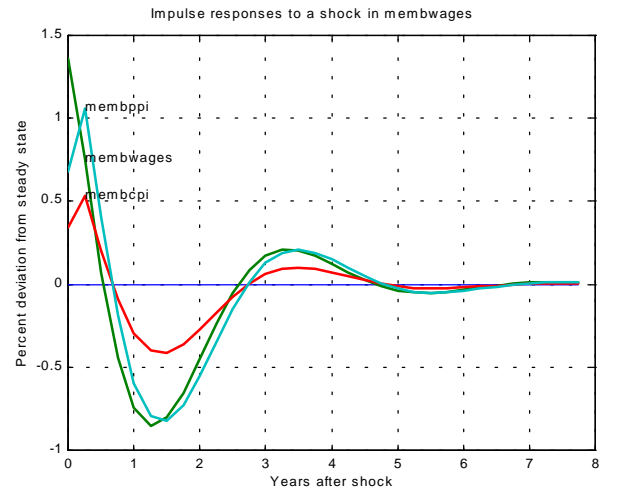
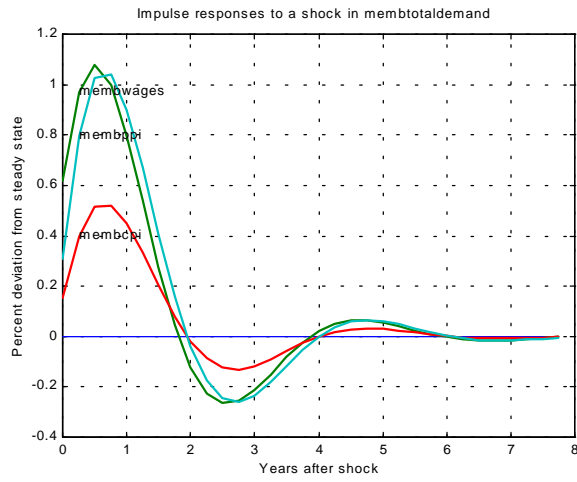
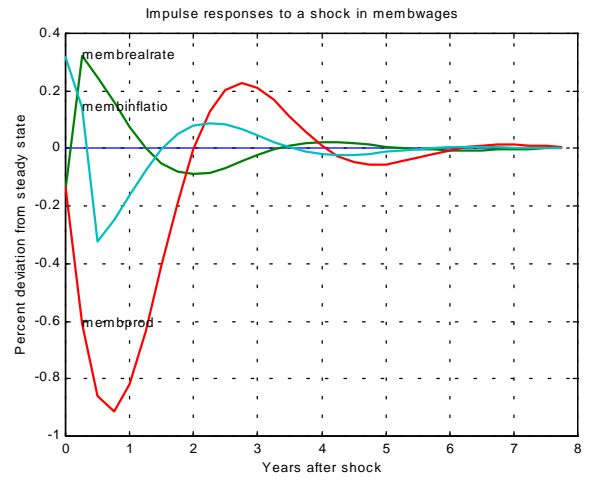
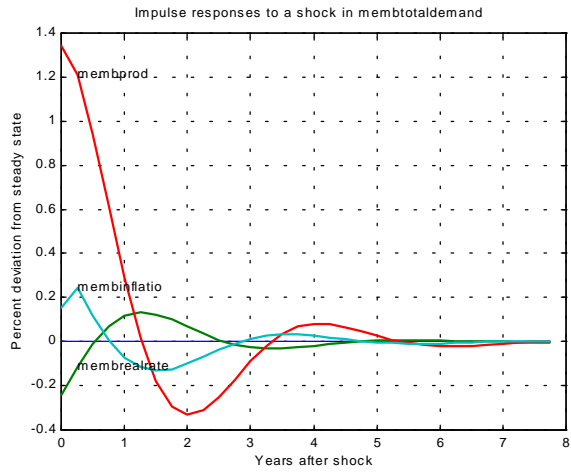
Interest rate shock



Wage shock



Demand and wage shock in the member country



APPENDIX C The performance frontiers

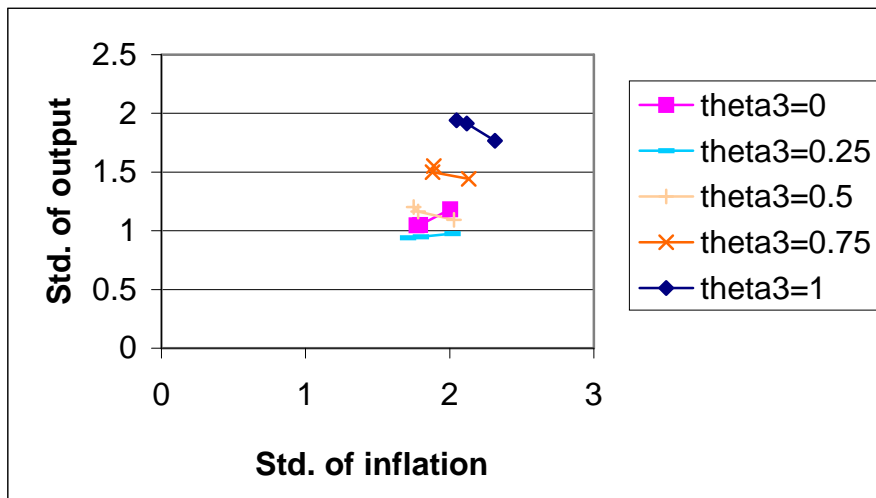


Figure C.1. The effects of changing the speed of pass-through in the union area.

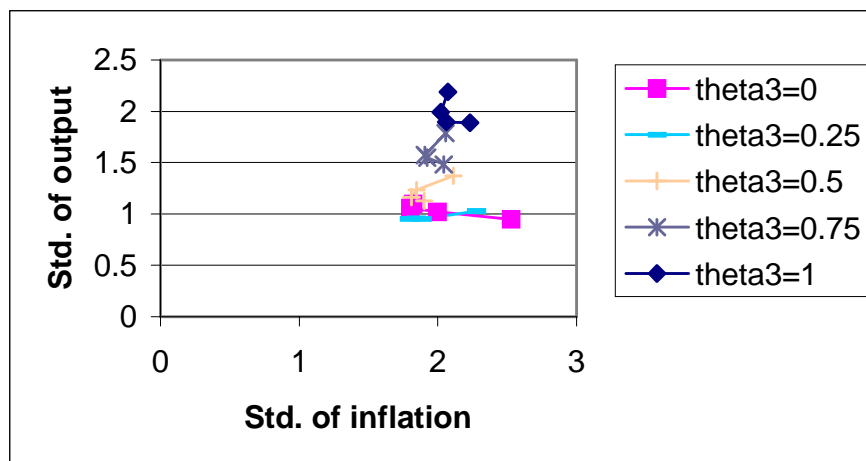


Figure C.2. The effects of changing the weight of import prices (ϕ) in the union consumption basket.

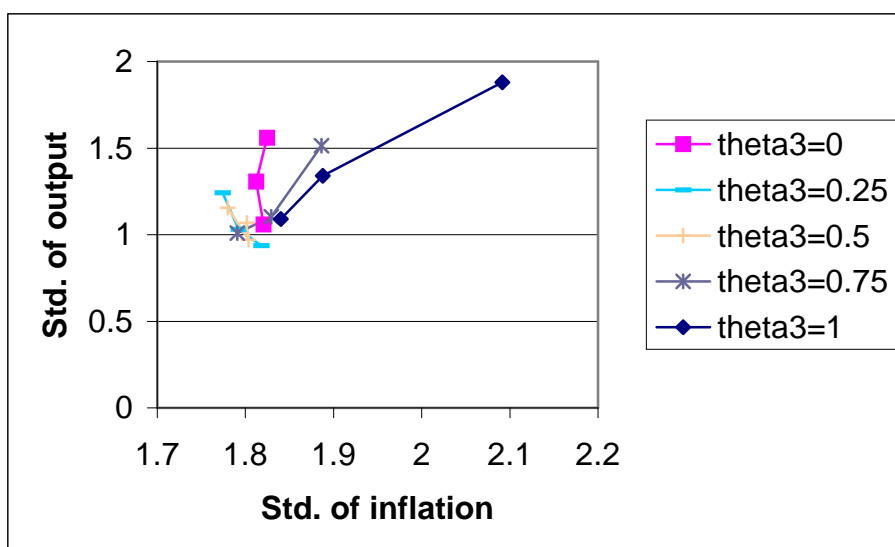


Figure C.3. The effects of changing the value of α_4 .

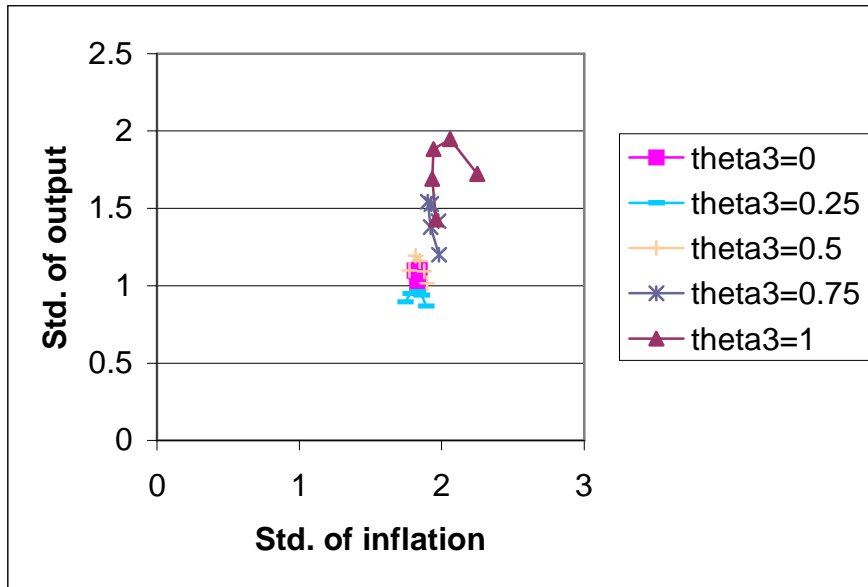


Figure C.4. The significance of the rate of forward lookingness of the goods market of the union (the value of α_1).

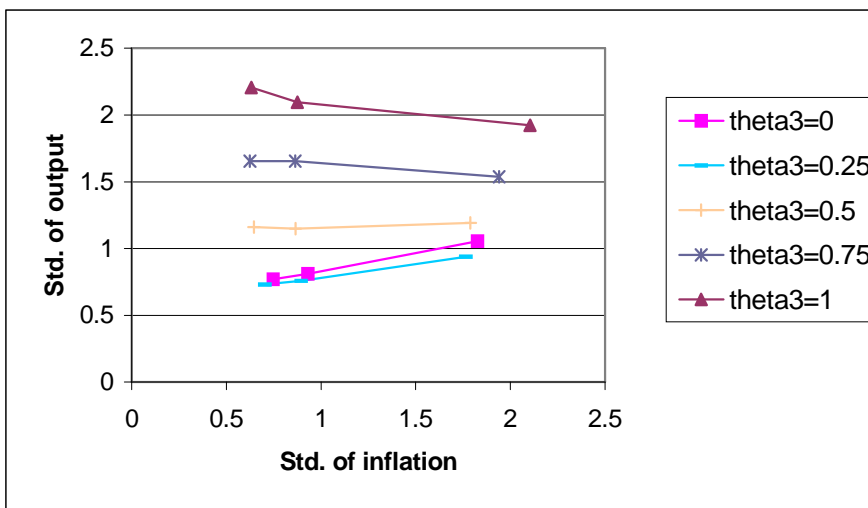


Figure C.5. The effects of the rate of forward lookingness of the labor markets of the union (the value of χ_0).

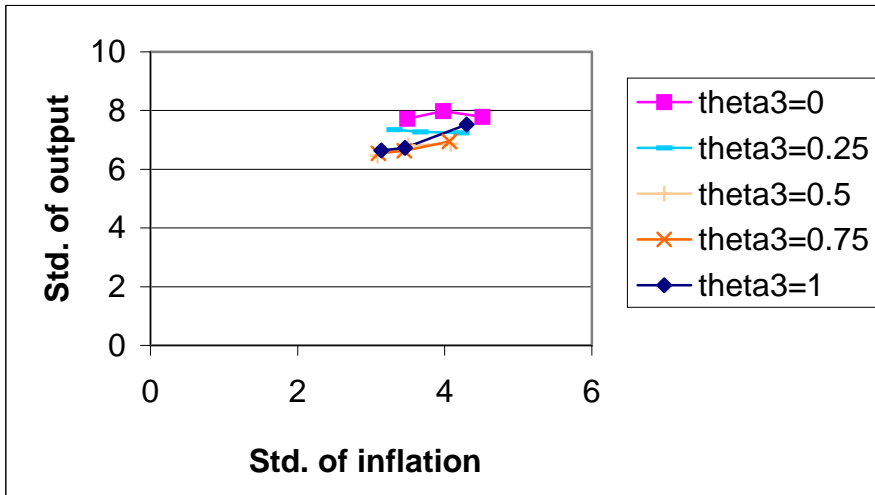


Figure C.6. The effects of changing the speed of pass-through in the member country.

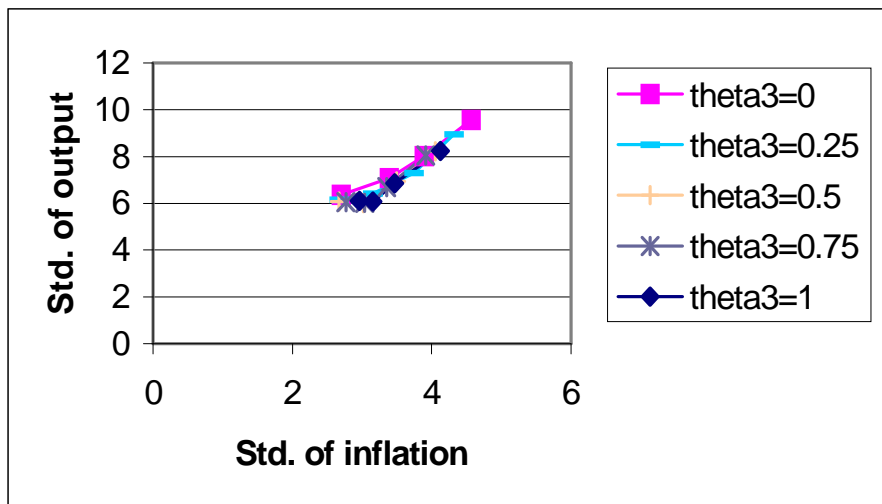


Figure C.7. The effects of changing the weight of import prices (ϕ) in the consumption basket of the member country.

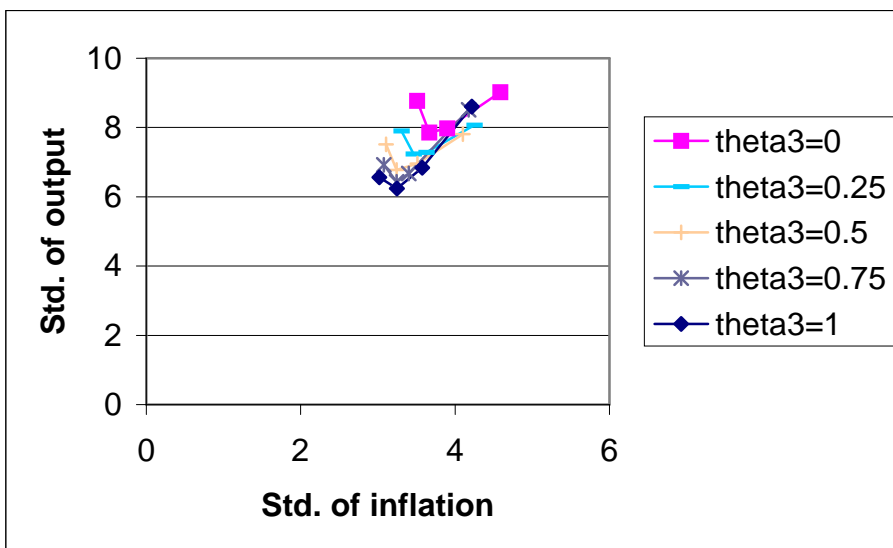


Figure C.8. The effects of changing the value of β_4 .

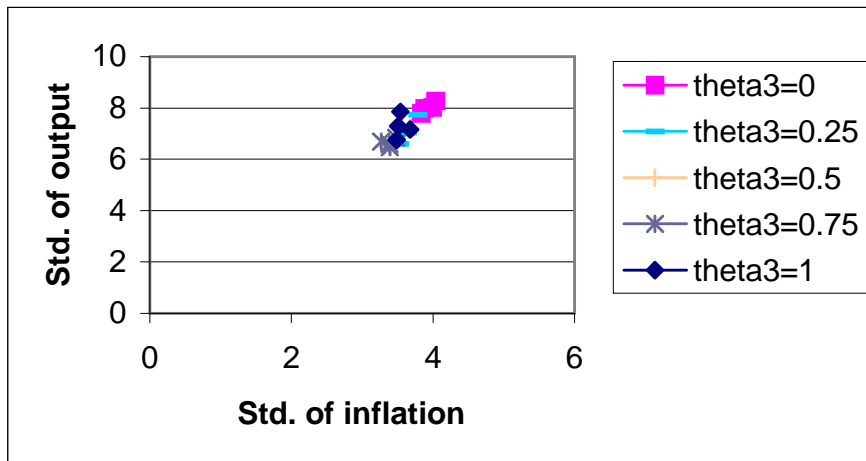


Figure C.9. The effects of changing the value of β_5 .

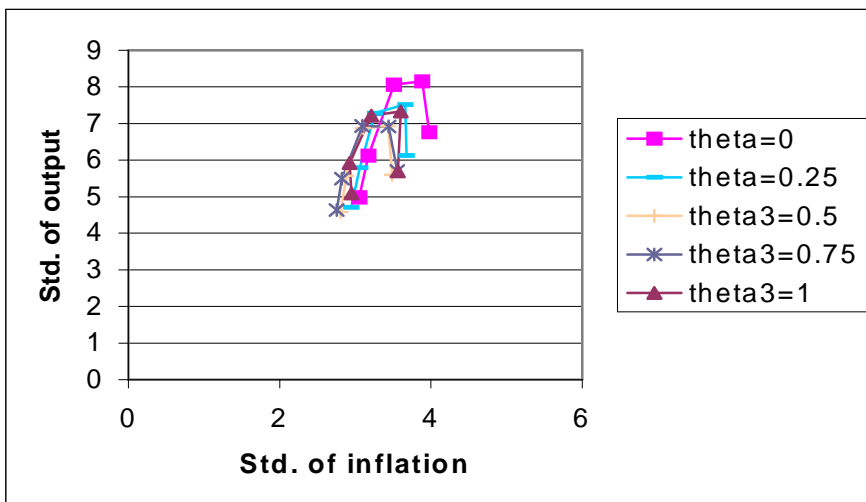


Figure C.10. The significance of the rate of forward lookingness of the goods market of the member country (the value of β_1).

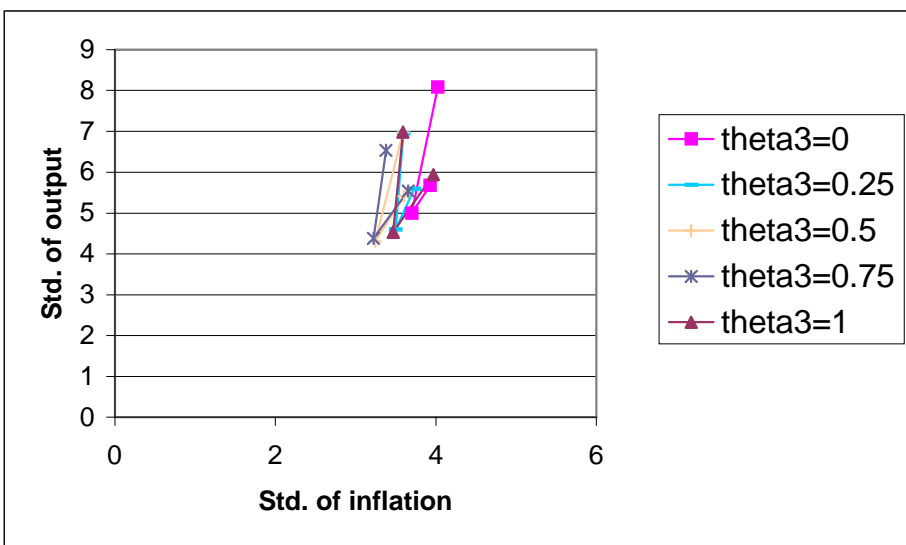


Figure C.11. The effects of the rate of forward lookingness of the labor markets of the member country (the value of ψ_0).

