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Abstract

New EU member countries are supposed to adopt the Euro as soon as economic convergence is achieved. This paper analyzes the effects of joining a monetary union on output and inflation variability in small acceding countries. An asymmetric macroeconomic two-country model is specified and combined with two different monetary policy regimes: (i) national monetary policy, (ii) monetary union. The performance of the two regimes is analyzed in terms of inflation and output variability for a broad range of structural parameter specifications.

Keywords: European monetary union, open economy macroeconomic models, optimal monetary policy.

JEL classification: E52, F41, F42.

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1 Introduction

Unlike Denmark and the United Kingdom, the new members that have recently joined the European Union have no special status with respect to the European Monetary Union (EMU). They have joined EMU with the status "countries with a derogation" and are supposed to adopt the Euro as soon as economic convergence is achieved. While the Maastricht criteria (inflation rate, long-term interest rate, exchange rate stability, budget deficit and public debt) play a prominent role in the public discussion of the convergence status and are regularly assessed in convergence reports by the European Central Bank, this paper describes the consequences of acceding countries' EMU entrance in terms of the respective country's output and inflation variability. A small two-country model, which can be derived from the optimizing behavior of economic agents, is specified and combined with two different monetary policy regimes: (i) national monetary policy, and (ii) monetary union. The performance of monetary policy is analyzed in terms of inflation rate and output-gap standard deviations, which are the usual components of central banks' loss functions in the literature on optimal monetary policy. A relative loss index is defined as the average of the relative standard deviations of output-gap and inflation rate in the two monetary policy scenarios minus one. If it is smaller than zero, a country can reduce output and/ or inflation variability by joining the monetary union. If it is larger than zero, output and/ or inflation variability increase in case of an accession. Together with other indicators like the Maastricht Criteria or estimates of trade expansion, for example, the indicator can be used in the assessment of advantages and disadvantages of joining a monetary union.

The effects of a monetary union on domestic output and inflation variability within an open economy model have also been studied by Kollmann (2004), Pappa (2004) and Røisland and Torvik (2003), for example. Kollmann (2004) shows that the welfare gain from joining a monetary union is positively linked to the degree of openness. Pappa (2004) analyzes the implications of monetary policy coordination and puts the focus on the question whether the ECB and the Federal Reserve System should cooperate. Røisland and Torvik (2003) derive analytic results in a non-dynamic framework. The contribution of this paper is an analysis of monetary policy performance in a small two-country model, which is based on the open-economy model of McCallum and Nelson (1999, 2001) (MN model, henceforth). While the foreign economy is represented by exogenous univariate stochastic processes in the original MN model, the two-country version in this paper exhibits a fully specified foreign economy with endogenous monetary policy. In this framework, the impact of various structural parameters on the relative performance of a monetary union is analyzed. The MN model is chosen because this model exhibits the empirically supported feature of incomplete exchange-rate pass-through. Additionally, we compare the results of the MN framework to

corresponding results, which are obtained if the real international linkages are modelled like in the framework of Galí and Monacelli (2005).
The paper is organized as follows: In section 2, the macroeconomic model is presented and the performance of national monetary policy is discussed. In section 3, the effects of joining a monetary union are analyzed for broad ranges of the most important structural parameters. Finally, section 4 concludes.

2 A Two-country Model for Monetary Policy Analysis

2.1 General Remarks

In recent years, dynamic stochastic general equilibrium (DSGE) models have become the standard framework for the analysis of monetary policy in the short and medium term. In New-Keynesian DSGE models, monetary policy has real effects because of price rigidities. The main ingredients of usual New-Keynesian models are households that maximize an intertemporal utility function, which depends on consumption and leisure, and firms that maximize profits by setting optimal prices on a monopolistic competitive market. Firms are not able to adjust prices in each period such that price setting is forward-looking in the sense that expectations about future demand and marginal costs are already reflected by today's goods prices. The literature on New-Keynesian models for monetary policy is very extensive and cannot be summarized here, overviews can be found in Clarida et al. (1999), Galí (2002), Walsh (2003) or Woodford (2003), for example. This framework has also been extended to the open economy, see inter alia Clarida et al. (2001, 2002), Galí and Monacelli (2005) as well as McCallum and Nelson (1999, 2001). McCallum and Nelson (MN henceforth) claim that their approach has a "clean and simple theoretical structure" and is "superior empirically" to other approaches. The main difference to alternative models is that imported goods are treated as input factors for domestic production and not as consumption goods. MN compute empirical correlations of the inflation rate and lagged as well as contemporaneous changes in the nominal exchange rate for 11 industrial countries and compare these correlations to the corresponding values obtained from simulations. The contemporaneous correlations for quarterly data vary between -0.1 and 0.3. MN's theoretical baseline scenario implies a contemporaneous correlation of 0.2 while a comparable version of the Galí and Monacelli (2005) model (GM model) yields a contemporaneous correlation of 0.83. Figure 1 shows cross correlations of nominal exchange rate changes and consumer price inflation in selected EU member countries which have not adopted the Euro (Czech Republic, Hungary, Poland, Sweden, Slovak Republic, United Kingdom).

[Figure 1 about here.]

There is no evidence for immediate or complete pass-through of exchange rate changes to consumer price inflation in these countries. However, there is some week evidence for partial pass-through after 2-3 quarters.[1] The transmission of exchange rate changes to domestic variables like the inflation rate is an important factor in the comparison of the two monetary policy scenarios: the extent to which nominal exchange rate changes can help to compensate asymmetric shocks depends on the pass-through to domestic prices, see also de Haan et al. (2005, p. 183 ff.). Here, we focus on the MN framework because it implies a correlation between nominal exchange rate changes and the inflation rate that is closer to the observed correlations for the accession countries. However, we do also report comparative results for the GM framework.

Under a few restrictions, which are broadly accepted for short-run analysis of monetary policy, the dynamics of output-gap and inflation rate can be expressed by a system of linear difference equations, which is called "canonical representation" by Galí and Monacelli (2005) or "optimizing IS-LM model" by McCallum and Nelson (1999, 2001). The system consists at least of a linearized first-order condition for consumption ("New IS-equation"), a price-setting equation ("New-Keynesian Phillips curve"), and a monetary policy rule ("Taylor-rule"). We extend the MN model in the sense that we consider two economies which are both characterized by such a set of equations and which are connected via the exchange rate and international trade in goods and financial assets. In the next section, the model is described in more detail.

2.2 Output and Inflation Dynamics

The basic structure of the MN model is explained in McCallum and Nelson (1999, 2001), and the GM framework is presented in Galí and Monacelli (2005). The following exposition does only report the equilibrium conditions and definitions which are necessary to characterize the dynamic behavior of output (gap) and inflation rate. In both frameworks, the household's log-linearized first order condition relates logarithmic consumption today (c_t) to expected future consumption and the real interest rate:

$$c_t = E_t c_{t+1} - \frac{1}{\sigma}(R_t - E_t \pi_{t+1}) - \frac{1}{\sigma}(x_{d,t+1} - x_{d,t}), \quad \sigma \leq 1, \tag{1}$$

where E_t is the expectation operator, R_t is the one-period nominal interest rate, $\pi_t^c = \ln P_t^c - \ln P_{t-1}^c = p_t^c - p_{t-1}^c$ is the consumer price inflation rate and σ is the inverse elasticity of intertemporal substitution. x_{dt} denotes a demand (preference) shock and follows an exogenous and stationary AR(1) process. The consumption Euler equation (1) has the same structure in both home and foreign country. In the following, home and foreign variables or coefficients are marked by adding a superscript H or F, respectively, and the Euro area

is defined to be the foreign country while the respective accession country is the home or domestic country.

We abstract from government expenditure and investment such that the log-linearized resource constraint of the economy is

$$y_t = g_1 c_t + g_2 ex_t - g_3 im_t, \tag{2}$$

where y_t, ex_t, im_t denote logarithms of output, exports and imports. The weights (g_1, g_2, g_3) are steady state shares in output of the respective component. In the MN framework, imported goods are only used as input factors for domestic production ($g_3 = 0$), while foreign goods are directly consumed by domestic households in the GM framework. The new EU members are relatively small compared to the Euro area as a whole. The sum of 2005 GDP of all acceding countries is about 8% of euro area GDP. Poland, which is the largest acceding country, exhibits a share of about 3% in Euro area GDP.[2] Therefore, the share of imports and exports between the euro area and a single acceding country in Euro area GDP is set equal to zero, that is $g_2^F = g_3^F = 0$.

The MN production function is of the CES type, and material imports and labor are the two input factors. Accordingly, the demand for imported goods can be characterized as follows:[3]

$$im_t^H = y_t^H - \frac{1}{1-\nu^H} \cdot q_t, \tag{3}$$

where $1/(1-\nu^H)$ is the elasticity of substitution between labor and imported materials. q_t is the logarithmic real exchange rate:

$$q_t = s_t + p_t^{cF} - p_t^{cH}. \tag{4}$$

s_t is the logarithmic nominal exchange rate in terms of domestic currency per unit of foreign currency. Correspondingly, the foreign demand for domestic exports is

$$ex_t^H = im_t^F = y_t^F + \frac{1}{1-\nu^F} \cdot q_t. \tag{5}$$

The flexible price output $\overline{y}$ can be derived from a log-linear approximation to the production function and is given by

$$\overline{y}_t^H = x_{at}^H - \omega^H q_t, \quad \omega^H = \frac{\delta^H}{(1-\nu^H)(1-\delta^H)}, \quad \delta^H = g_3^H \nu^H, \tag{6}$$

where x_{at} represents an exogenous productivity shock.

In the GM framework, both foreign products consumed in the home country and domestic products consumed in the foreign country depend on the terms of trade (tt_t) such that GDP in the home country does also depend on the terms of trade:

$$y_t^H = c_t + \frac{\alpha\omega}{\sigma} tt_t, \quad \omega = \sigma\gamma + (1-\alpha)(\sigma\eta - 1), \tag{7}$$

where

$$tt_t = s_t + p_t^{yF} - p_t^{yH} \tag{8}$$

with p^{yF} and p_t^{yH} denoting the price level of goods produced in the Home and the Foreign country, respectively. α is the share of domestic consumption allocated to imported goods, η represents the substitutability between domestic and foreign goods, and γ the substitutability between goods produced in different foreign countries. The flexible price output depends on domestic productivity and foreign output and is given by

$$\overline{y}_t^H = \Gamma x_{a,t} + \alpha \Psi y_t^F, \qquad \Gamma > 0, \tag{9}$$

Γ and Ψ are functions of the structural parameters.

Firms calculate optimal prices for their products from expected average future inflation and expected future real marginal costs. Assuming that real marginal costs are proportional to the output-gap

$$\tilde{y}_t^H = y_t^H - \overline{y}_t^H, \tag{10}$$

the inflation rate depends on output-gap and expected inflation. We adopt the hybrid Phillips curve (NKPC) specification from Galí et al. (2001) who provide microfoundations and Euro area estimates of the Phillips curve:

$$\pi_t^{yH} = \gamma_b^H \pi_{t-1}^{yH} + (1 - \gamma_b^H) \cdot \beta E_t \pi_{t+1}^{yH} + \kappa^H \tilde{y}_t^H + x_{\pi t}^H, \quad 0 \leq \gamma_f^H < 1, \quad \kappa^H > 0, \tag{11}$$

where π_t^{yH} is the inflation rate of goods that are produced in the home country and x_π^H is a cost push shock. In the MN framework CPI inflation (π_t^{cH}) is equal to this inflation rate ($\pi_t^{cH} = \pi_t^{yH}$), but in the GM framework CPI inflation does also depend on the change in the terms of trade:

$$\pi_t^{cH} = \pi_t^{yH} + \alpha \Delta tt_t.$$

2.3 Monetary Policy and Nominal Exchange Rate

Case (i): Two national monetary policies. In case of two national monetary policies, the acceding country's central bank and the foreign central bank set nominal interest rates following national interest rate rules. The foreign central bank follows a Taylor (1993) rule augmented with interest rate smoothing and a monetary policy shock x_{Rt}^F:

$$R_t^F = \tau_R^F R_{t-1}^F + (1 - \tau_R^F) \cdot \left[\tau_y^F \tilde{y}_t^F + \tau_\pi^F (\pi_t^{yF} - \pi^*) \right] + x_{Rt}^F, \tag{12}$$

$$0 \leq \tau_R < 1, \; \tau_y \geq 0, \; \tau_\pi > 1.$$

The desired inflation rate π^* is assumed to be constant and can therefore be neglected in the dynamic simulations. Taylor (1999) offers a broad overview of different monetary policy

rules and their implications. $\tau_\pi > 1$ guarantees that monetary policy has actually a stabilizing effect on the inflation rate ("Taylor principle"). Since the foreign country is a relatively closed economy in the sense that foreign output and inflation dynamics do not depend on economic shocks in the home country, monetary policy performance cannot be increased by reacting to the exchange rate or foreign variables. However, the monetary policy of the home country, which is open in the sense that output and inflation dynamics depend on foreign economic shocks, may improve its performance by reacting to foreign variables or the exchange rate. Therefore, we specify a very general interest rate rule for the home country:

$$\begin{aligned} R_t^H &= \tau_F^H \left(R_t^F + \tau_s^H x_{st}\right) \\ &\quad +(1-\tau_F^H)\left(\tau_R^H R_{t-1}^H + (1-\tau_R^H)\left(\tau_y^H \tilde{y}^H + \tau_\pi^H \pi_t^{yH} + \tau_q^H \Delta q_t\right)\right) \\ &\quad + x_{Rt}^H. \end{aligned} \tag{13}$$

Special cases of the interest rate rule (13) are a domestic inflation Taylor rule ($\tau_F^H = \tau_s^H = \tau_R^H = \tau_q^H = 0$), a CPI inflation Taylor rule ($\tau_F^H = \tau_s^H = \tau_R^H = 0$, $\tau_q^H > 0$) and an exchange rate peg ($\tau_F^H = \tau_s^H = 1$, $\tau_R^H = \tau_y^H = \tau_\pi^H = \tau_q^H = 0$), for example. In the GM framework, the change in the real exchange rate (Δq_t) has to be replaced by the change in the terms of trade (Δtt_t) in the interest rate rule of the home country. The model is closed with uncovered interest rate parity (UIP). Based on arbitrage considerations UIP states that the interest rate differential between two countries has to be equal to the expected change in the exchange rate:

$$E_t s_{t+1} - s_t = (R_t^H - x_{st}) - R_t^F, \tag{14}$$

where x_{st} denotes a UIP shock.[4]

Case (ii): Monetary union. In the monetary union, the single monetary policy is assumed to be conducted according to the following interest rate rule:

$$\begin{aligned} R_t^F &= \tau_R^F R_{t-1}^F + (1-\tau_R^F)\left(\tau_y^F \left(w\tilde{y}_t^H + (1-w)\tilde{y}_t^F\right)\right. \\ &\quad \left. + \tau_\pi^F \left(w\pi_t^{yH} + (1-w)\pi_t^{yF}\right)\right) + x_{Rt}^F, \end{aligned} \tag{15}$$

where w is the weight (the share in area wide GDP) of the acceding country. In this case, national monetary policy and nominal exchange rate do not exist. However, we allow the home interest rate R_t^H to deviate transitorily from the area wide interest rate R_t^F:

$$R_t^H = R_t^F + x_{st}. \tag{16}$$

This expression follows from equation (14) if the expected change in the exchange rate is zero. However, it is assumed in the following simulations that the variability of the risk

premium shock x_{st} can be reduced substantially in the monetary union. The real exchange rate is now given by:

$$q_t = p_t^{cF} - p_t^{cH}. \tag{17}$$

2.4 Calibration and Solution of the Model

In both cases (i) and (ii), the MN and the GM model can be written as a system of linear difference equations which can be solved numerically for the recursive law of motion of all relevant variables.[5] The baseline model is calibrated as follows, see tables 1 and 2, where also the parameters originally used by MN and GM (MN org, GM org) are reported.

[Table 1 about here.]

[Table 2 about here.]

The discount factor is $\beta = 0.99$, which corresponds to a steady state real annual return of about 4%. The coefficient of relative risk aversion, that is, the inverse elasticity of substitution, is $\sigma = 5$, which corresponds to an interest rate elasticity of consumption of -0.2. This is compatible with the corresponding value that has been estimated by Smets and Wouters (2003) (SW) for the Euro area. While labor supply is inelastic in the MN model, we use a labor supply elasticity of $1/\varphi = 1/3$ for the GM model. Following MN, the elasticity of substitution between labor and material is calibrated such that no excess variability in the flexible price output is generated: $\nu^H = -6$ and $\nu^F = -2$. Export and import shares are set to 0.3, respectively. The elasticity of substitution between varieties of domestic goods is $\epsilon = 6$ which implies a steady state markup of $\mu = 1.2$. In the GM framework, the elasticity of substitution between domestic and foreign goods (η) and the elasticity of substitution between goods that are produced in different foreign countries (γ) are both equal to one. Following Galí et al. (2001) (GGL), the fraction of backward looking firms is $\gamma_b = 0.3$; and κ is equal to 0.1 in the MN framework, while κ is a function of other structural parameters in the GM model. The Euro area monetary policy rule is specified such that it corresponds approximately to the estimated interest rate rule in Smets and Wouters (2003): $\tau_R^F = 0.96$, $\tau_y^F = 0.25$, $\tau_\pi^F = 1.82$. The baseline specification for the home country interest rate rule uses $\tau_y = 0.5$, $\tau_\pi = 1.5$ and $\tau_q = 0.1$ (other coefficients equal zero). This specification is discussed in section 2.5. All nine exogenous shocks are stationary autoregressive processes or order one. The AR coefficients and innovation standard deviations are given in table 2. Foreign productivity, demand and interest rate shocks are specified like in Smets and Wouters (2003), the cost-push shock and UIP shock parameterizations are more or less arbitrary but not unrealistic. Home shocks have the same AR coefficients like foreign shocks

but higher standard deviations given that the Euro area shocks are averages of the national shocks in current member countries.

The solution of the model has the form of a recursive law of motion that describes the time path of the variables. From the recursive law of motion, the impulse responses to exogenous shocks and standard deviations of the endogenous variables can be computed. The model has standard properties in the sense that demand shocks temporarily increase inflation and output-gap, cost push shocks increase inflation and decrease output-gap, and restrictive monetary policy shocks are followed by temporary decreases in output-gap and inflation rate. However, the exact shape of the impulse responses depends on the domestic monetary policy rule, which we discuss in the next section.

2.5 Performance of National Monetary Policy in the Home Country

We now solve and simulate the calibrated model for different national monetary policy rules in the home country. The considered interest rate rules are summarized in table 3.[6]

[Table 3 about here.]

The first rule, which is called strict inflation targeting (SIT) is an interest rate rule with only inflation as argument. The next four rules are flexible inflation targeting rules (FIT I to IV), which include also other arguments. FIT I and II include inflation rate and output-gap; FIT I is the standard Taylor rule, and FIT II has a larger output-gap coefficient. FIT III implies an interest rate response to changes in the real exchange rate; and FIT IV assumes that the home central bank follows partially foreign interest rate policy. Both, FIT III and IV aim at smoothing the exchange rate. PEG is a fixed exchange rate regime, in which the home interest rate is set such that it corresponds to foreign interest rate plus UIP shock, which can be interpreted as time-varying risk premium. Finally, MU is the monetary union scenario, in which the home central bank follows the case (ii) monetary policy rule that has been defined in equation (15). For the current exercise, we assume, that the UIP shock is completely eliminated in the MU scenario. The performance of monetary policy is measured in terms of output-gap and inflation variability. This is the standard measure in the related literature, see for example Taylor (1999).[7] The standard deviations of output-gap, CPI inflation, nominal interest rate, change in log nominal exchange rate and change in log real exchange rate that follow from the simulation of the baseline model using the six described monetary policy rules are reported in table 4.

[Table 4 about here.]

The largest differences in the standard deviations occur for the exchange rate. Both real and nominal exchange rate changes exhibit large variability in case of SIT, FIT I and FIT II,

medium variability in case of FIT III and FIT IV, and no variability in case of PEG and MU. The output-gap standard deviation is minimized by the aggressive Taylor rule FIT II. The variability of the CPI inflation rate is minimal in case of the PEG and MU regimes. Overall, there is no monetary policy rule in any of the two frameworks that dominates all others in the sense of smaller standard deviations of output-gap and inflation rate than all other rules, see also figure 2.

[Figure 2 about here.]

In the following section, we use the interest rate rule FIT III as the national benchmark for the analysis of the effects of joining a monetary union. FIT III is the best reference rule because it reflects the fact that small open economies like the possible accession countries do often react to a certain extent to foreign economic shocks.[8] This is also the case for FIT IV, but table 4 and figure 2 show that FIT III clearly dominates FIT IV with respect to output-gap and inflation rate variability. We have also analyzed whether output-gap and inflation rate variability can be further reduced by varying the reaction coefficients (τ_y, τ_π, τ_q) in FIT III. While a more aggressive reaction to the output-gap leads to a further reduction in the variability of the output-gap (MN and GM) and also of the inflation rate (GM), a variation of the reaction to the real exchange rate does not reduce output-gap and inflation variability.

3 Effects of Joining the Monetary Union

3.1 Impulse Response Analysis

It can already be seen in table 4 and figure 2 that the standard deviation of the home CPI inflation rate can be substantially reduced by joining a monetary union with the large foreign country, while the variability of the output-gap increases at the same time. In order to investigate the rationale for this finding, we now discuss impulse responses of selected variables to foreign and domestic economic shocks. Due to the relative smallness of the home country, foreign output-gap and inflation rate react only to foreign shocks. Foreign demand shocks increase foreign output-gap and inflation rate, foreign cost-push shocks decrease the foreign output-gap and increase the foreign inflation rate, and transitory foreign productivity shocks have the same implications like foreign demand shocks with opposite sign.

The response of home macroeconomic variables to economic shocks depends on the monetary policy rule of the home country. We first look at the responses to a UIP shock, which can be interpreted as a country-specific risk premium shock that depreciates the domestic currency. Figure 3 shows that output-gap and inflation rate increase in response to the depreciation in the MN framework.

[Figure 3 about here.]

The depreciation reduces domestic potential output and increases the demand for domestic exports such that the output-gap increases. This leads in turn to higher inflation. In the GM framework, output-gap and CPI inflation do also increase. The depreciation increases the demand for domestic exports and makes consumption goods that are produced in the foreign country more expensive, see figure 4.

[Figure 4 about here.]

The UIP shock in a narrow sense disappears in a monetary union. However, there still may be an interest rate differential, which is represented by x_{st}, but now with lower variability than in the national monetary policy scenario. This is one reason, why the monetary union regime might yield lower inflation rate and output-gap standard deviations than the national monetary policy rules. The baseline scenario finding of table 4 that the standard deviation of the output-gap is larger and that the standard deviation of the inflation rate is lower in a monetary union than for the benchmark rule FIT III can be illustrated quite well for foreign demand shocks. A foreign demand shock increases the demand for domestic export goods and depreciates the domestic currency, which leads to domestic inflation. However, in case of a monetary union the real depreciation is not as strong as in case of FIT III, such that the increase in inflation is smaller. On the other hand, the output-gap is substantially larger, partially also because the single monetary policy rule is not as aggressive with respect to the output-gap as the domestic monetary policy rule FIT III. Since these results are quite similar for both MN and GM framework, we do only show the corresponding impulse responses for the MN framework in figure 5.

[Figure 5 about here.]

The MN and GM frameworks do also have the common implication that the national monetary policy leads to lower standard deviations of output-gap and inflation rate than the monetary union if only foreign cost push shocks are present.

3.2 The Relative Loss-Index and its Determinants

The relative standard deviations of domestic output-gap and inflation rate,

$$L_y = \frac{L_y^{(ii)}}{L_y^{(i)}} - 1 = \frac{\sigma_{\tilde{y}}^{(ii)}}{\sigma_{\tilde{y}}^{(i)}} - 1, \qquad L_\pi = \frac{L_\pi^{(ii)}}{L_\pi^{(i)}} - 1 = \frac{\sigma_\pi^{(ii)}}{\sigma_\pi^{(i)}} - 1, \tag{18}$$

are interpreted as measures of the relative performance of monetary policy. $\sigma_{\tilde{y}}^{(i)}$ and $\sigma_\pi^{(i)}$ denote standard deviations of domestic output-gap and consumer price inflation rate in case

of two national monetary policies. $\sigma_{\tilde{y}}^{(ii)}$ and $\sigma_{\pi}^{(ii)}$ denote standard deviations of domestic output-gap and consumer price inflation rate in case of a monetary union. The relative loss in the monetary union can be summarized in a weighted average of L_y and L_π:

$$RLI = \zeta L_y + (1 - \zeta) L_\pi. \tag{19}$$

The relative loss index (RLI) reveals whether it is advantageous for an acceding country to join the monetary union ($RLI < 0$) or not ($RLI > 0$). We will now discuss the impact of selected structural parameters on the relative standard deviations of output-gap and inflation rate and on the relative loss index for $\zeta = 0.5$.

Relative risk aversion (elasticity of intertemporal substitution). If all other parameters are fixed at their baseline values, the relative loss index decreases in the relative risk aversion (σ, the inverse of the elasticity of intertemporal substitution), see figure 6 (c). That is, the less consumption reacts to interest rate changes, the lower are the costs of joining the monetary union in terms of output and inflation variability. This effect is driven by the corresponding effect on the standard deviation of the output-gap, see figure 6 (a), while the relative variability of the inflation rate is more or less invariant to variations in the coefficient of relative risk aversion if all other parameters are fixed at their baseline values, see figure 6 (b). The effect on RLI is not invariant to changes in the baseline parameters. If the degree of price flexibility (κ) increases, the relationship becomes unstable.

[Figure 6 about here.]

Compatible to the findings of Pappa (2004, p. 769 f.), in the GM framework the relative loss is strictly decreasing in the coefficient of relative risk aversion.[9]

Degree of price flexibility. The relative loss index RLI is increasing in the degree of price flexibility (κ) if all other parameters are fixed at their baseline values, see figures 6 (a)-(c). In particular the relative standard deviation of the inflation rate increases in κ.

Openness. In the MN framework, the degree of openness is reflected by the export share. Keeping all other parameters at their baseline values, the relative standard deviation of the output-gap and the RLI are decreasing in the degree of openness, see figure 7. The relative standard deviation of the inflation rate is only slightly affected by variations in the degree of openness (notice the scaling in figure 7 (b)). That is, a single monetary policy becomes more attractive when a larger share of domestically produced goods is exported to the foreign country. This is also found in the GM framework, where the degree of openness is reflected by the import share (α).

[Figure 7 about here.]

Export demand elasticity. The export demand elasticity describes the percentage change in domestic exports in response to a one percent change in the real exchange rate. In the MN framework, this elasticity depends on the substitutability of labor and imported materials in the foreign production function and is given by $1/(1-\nu^F)$, see equation 5. The larger ν^F (the smaller in absolute value), the larger is the export demand elasticity. While the relative standard deviation of the output-gap is decreasing in the export demand elasticity, the relative standard deviation of the inflation rate is only affected to a small extend by it, see figure 7. In the GM framework, the parameter η governs the export demand elasticity. The larger the export demand elasticity, the lower are the costs of joining the monetary union in terms of output and inflation variability, which is again compatible to the findings of Pappa (2004, p. 769 f.).

Shocks. The RLI is also determined by the properties of the stochastic shocks that drive the dynamics. We consider productivity shocks first. If foreign and home productivity shocks are uncorrelated and if their standard deviations correspond to the baseline values, then the standard deviation of the output-gap increases ($L_y > 0$) and that of the inflation rate decreases ($L_\pi < 0$) by joining the monetary union. This has already been discussed in section 3. If the standard deviations of uncorrelated home and foreign productivity shocks become larger, then the relative standard deviations increase and the monetary union becomes even less attractive. While the relative standard deviation of the output gap is more or less invariant to changes in the correlation of home and foreign productivity shocks, the relative standard deviation of the inflation rate decreases in the correlation, see figure 8. (In the figure, the respective baseline values of the two standard deviations are scaled by the factor represented by the 'xa S.D.' axis.)

[Figure 8 about here.]

In the GM framework, the relative standard deviation of the output-gap behaves more or less like in the MN framework, but the relative standard deviation of the inflation rate is increasing in the correlation of foreign and home productivity shocks. The effects of cost-push shock properties on the RLI are depicted in figure 9. The RLI is strictly decreasing in the correlation of foreign and home cost-push shocks.

[Figure 9 about here.]

In the GM framework, standard deviation and correlation of cost-push shocks exhibit positive impact on the relative standard deviation of the inflation rate, and negative impact on

the relative standard deviation of the output gap. The standard deviation and the correlation of demand shocks have only a very small impact on RLI in both frameworks.

3.3 Comparison of MN and GM and Discussion

The effects of parameter variations on the relative standard deviations in both frameworks are summarized in table 5.

[Table 5 about here.]

In most cases, the effects have the same sign or the effect is rather small in one of the frameworks. So one can state that the corresponding effects are not contrary in the two frameworks. However, this statement does not hold true for the effect of the properties of the cost-push shock on inflation. While the relative standard deviation of the inflation rate decreases in standard deviation and correlation of the cost-push shock in the MN framework, the opposite effect occurs in the GM framework.

There exist parameter constellations in both frameworks, for which the relative standard deviation of the inflation rate can be decreased by joining the monetary union ($L_\pi < 0$). The standard deviation of the output-gap, however, does increase for all realistic specifications of the considered structural parameters ($L_y > 0$), but the increase is smaller if the relative risk aversion is large, if the respective country is relatively open in terms of the export share, or if cost-push shocks are positively correlated. The assessment of the overall effect on output-gap and inflation variability does therefore depend on the corresponding preferences (ζ). Additionally, joining the monetary union will reduce the standard deviation of risk premium (UIP) shocks substantially since no exchange rate changes are expected to occur in the future. Taking this effect into account would move all the surfaces that we have considered downwards and would eventually lead to an RLI that is smaller than 0. Furthermore, it should be kept in mind that our analysis puts its focus on the costs of joining the monetary union in terms of output and inflation variability. In the decision process if or when to join EMU, the various benefits of a monetary union, for instance lower transaction costs or imported credibility, have to be considered, too.

4 Conclusions

We have used two different frameworks (MN and GM) for small open economies to investigate the effect of joining a monetary union on output and inflation variability in a small accession country. The models are calibrated such that they roughly reflect the situation of the new EU member countries which are expected to join the European Monetary Union within the next years. In the McCallum-Nelson (MN) framework, imported goods are not directly

consumed like in the Galí-Monacelli (GM) framework such that consumer price inflation is not as strongly influenced by nominal exchange rate changes as in the GM framework. This is motivated by the empirical finding that pass-through from nominal exchange-rates to consumer prices is rather low – at least in the short run. Two main results can be reported. The first main result is related to the traditional argument in the literature on the costs and benefits of a monetary union that the renunciation of national monetary policy may lead to larger variability in output-gap and inflation rate. In a monetary union, monetary policy is not tailor-made for any of the member countries, especially not for small member countries. Therefore, monetary policy in a monetary union does not explicitly stabilize output-gap and inflation rate in case of national economic shocks. We have shown how the effect of joining the monetary union on domestic output-gap and inflation rate variability depends on structural parameters like relative risk aversion, price flexibility, export demand elasticity, openness and shock correlations. For this task, standard deviations of output-gap and inflation rate in a monetary union are compared to the corresponding standard deviations in a reference scenario with a flexible open-economy interest rate rule. In our baseline scenario and for a broad range of parameter specifications, joining the monetary union increases the variability of the output-gap, but decreases the variability of the inflation rate. However, if there are quite volatile country-specific UIP shocks (risk premium shocks), which increase the standard deviation of the nominal exchange rate and which can be reduced or even be eliminated by joining the monetary union, then the variability of output-gap *and* inflation rate can be reduced by joining the monetary union. The second main result is related to the usage of particular models like the MN or GM framework for the derivation of policy implications in practice. It turns out that both frameworks yield quite similar results, but that the effects of variations of the cost-push shock properties on the relative variability of the inflation rate are contrary in both frameworks.

Notes

[1]The graphical analysis of these correlations is, of course, not sufficient to support this statement. A more detailed analysis is provided by Hoffmann and Holtemöller (2007).

[2]Own calculations from Eurostat data. Euro area GDP is the sum of the GDP in Euro in 2005 of all thirteen current members of the EMU. Accession countries are all non-EMU EU members with exception of United Kingdom and Denmark.

[3]In all behavioral equations we neglect constant terms because they have no influence on the dynamic simulations.

[4]Kollmann (2004, p. 294) argues that shocks in the UIP equation reflect a bias in the date t forecast for the exchange rate in $t + 1$. Alternatively, the UIP shock can be interpreted as a country-specific risk premium.

[5]The MatLab toolkit provided by Uhlig (1999) has been used for this task.

[6]Interest rate smoothing in the home country is not considered here because the effect on output-gap and inflation rate variability is very small in the current MN and GM frameworks. However, interest rate smoothing can increase welfare in models with habit persistence in consumption, see Choi and Jung (2003).

[7]Using a fully specified optimizing model would allow to assess performance in terms of the utility function of the representative household. This approach is proposed by Woodford (2003), for example.

[8]Moreover, Wollmershäuser (2006) shows that a monetary policy rule that reacts to the real exchange rate dominates closed economy interest rate rules if exchange rate uncertainty occurs.

[9]We do not report detailed figures for the GM framework in order to save space. An appendix that contains these figures is available upon request.

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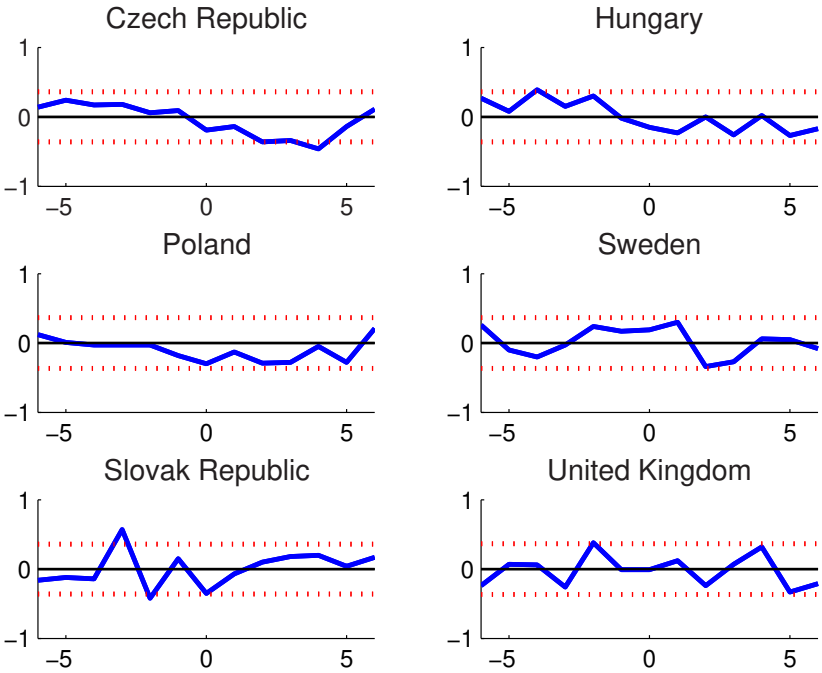
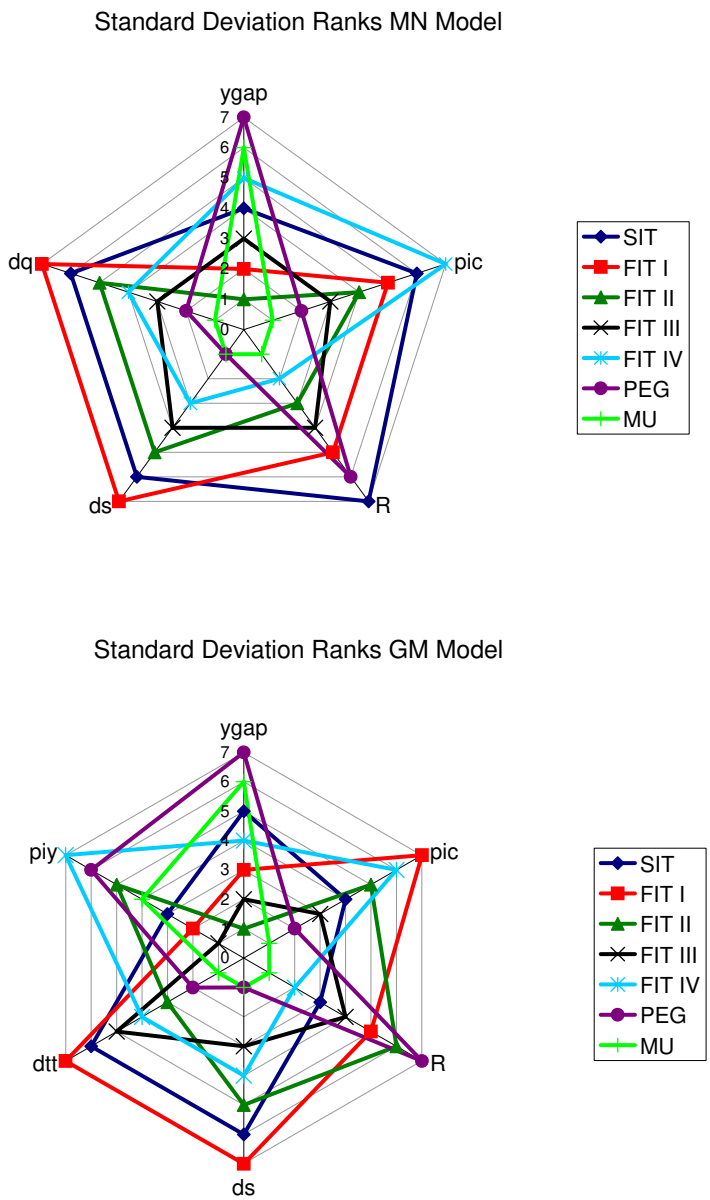
List of Figures

Figure 1: Cross Correlations of Nominal Exchange Rate Changes and Consumer Price Inflation Rates in Selected Countries



Notes: The graphs show correlations of the CPI inflation rate at time t and the change in the log nominal exchange rate at time $t + j$. The horizontal axis represents the index j. Quarterly data from 1999:1 to 2006:2 has been used. The CPI inflation rate has been seasonally adjusted by regressing it on seasonal dummies and AR-terms and subtracting the deterministic seasonal pattern. Dotted lines are ± 2 standard errors.

Figure 2: Monetary Policy Rules Ranked by Standard Deviations in MN and GM Frameworks



Notes: For all seven monetary policy scenarios, the respective variables have been ordered with respect to their standard deviations. The figures show the corresponding ranks, where 1 denotes the smallest standard deviation and 7 the largest one. ygap denotes the output-gap, pic consumer price inflation, R nominal interest rate, ds nominal exchange rate growth rate, dq real exchange rate growth rate, dtt growth rate of terms of trade, and piy inflation rate of domestic goods. The monetary policy scenarios are specified in table 3.

Figure 3: Impulse Responses of Domestic Variables to UIP Shock (MN)

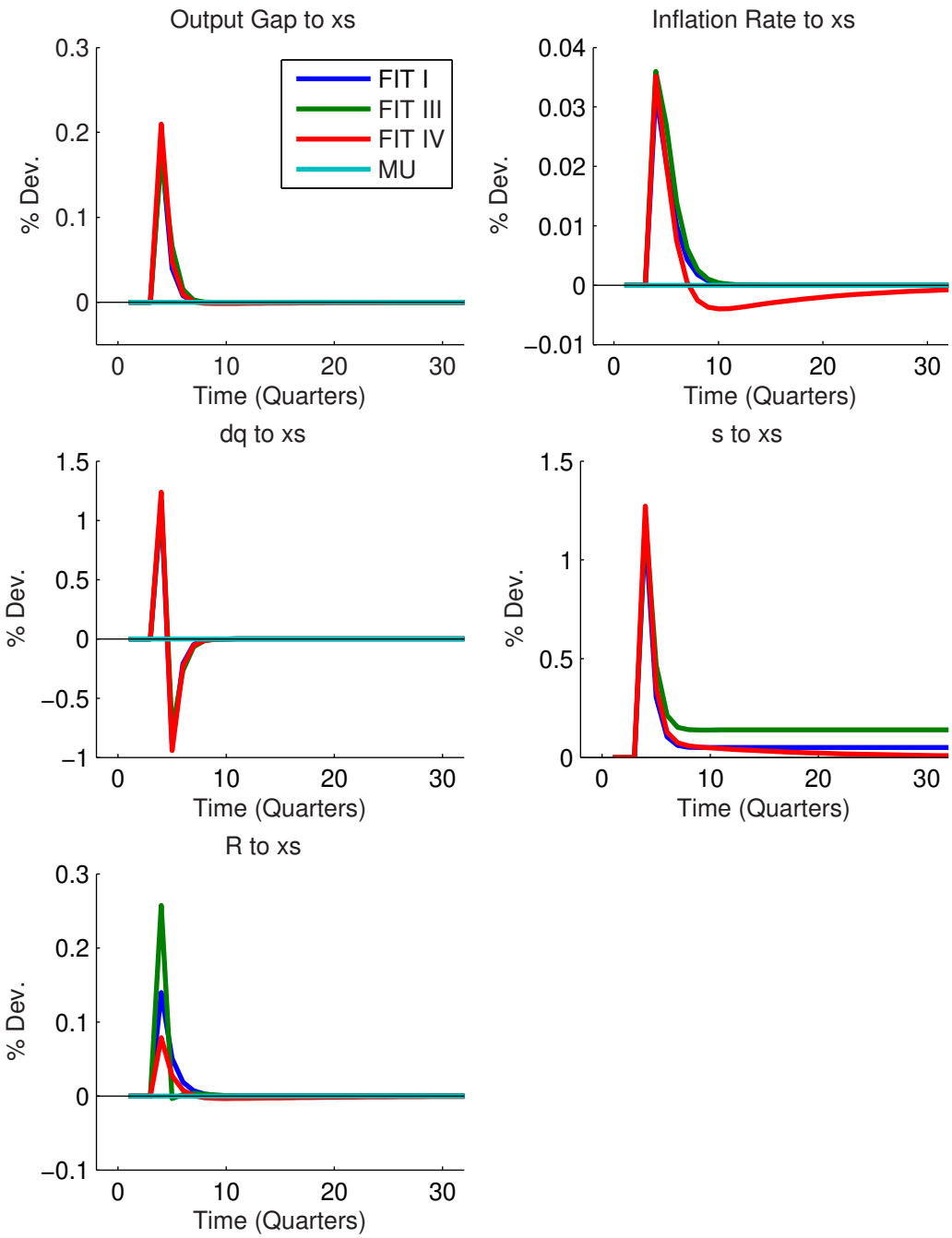


Figure 4: Impulse Responses of Domestic Variables to UIP Shock (GM)

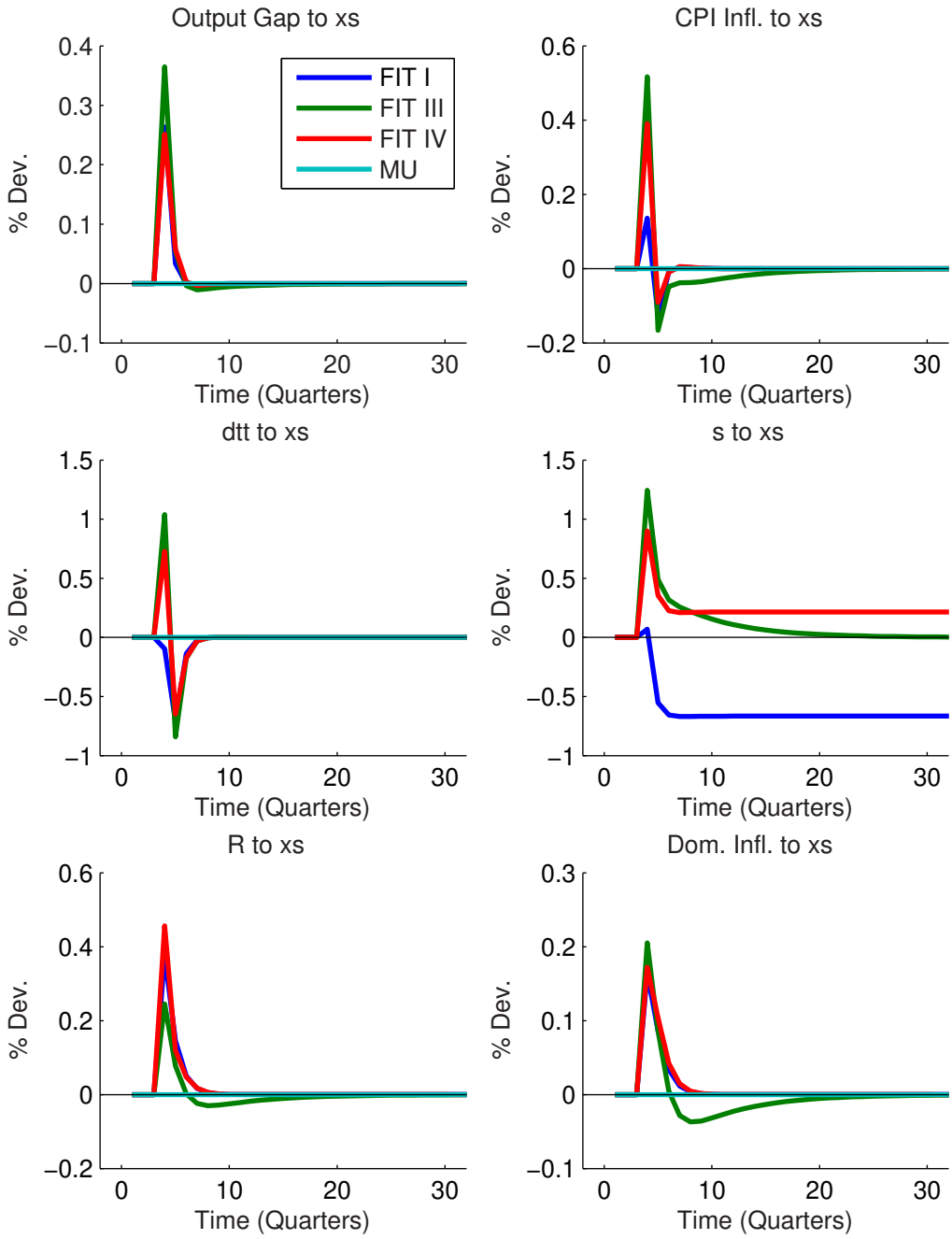


Figure 5: Impulse Responses of Domestic Variables to Foreign Demand Shock (MN)

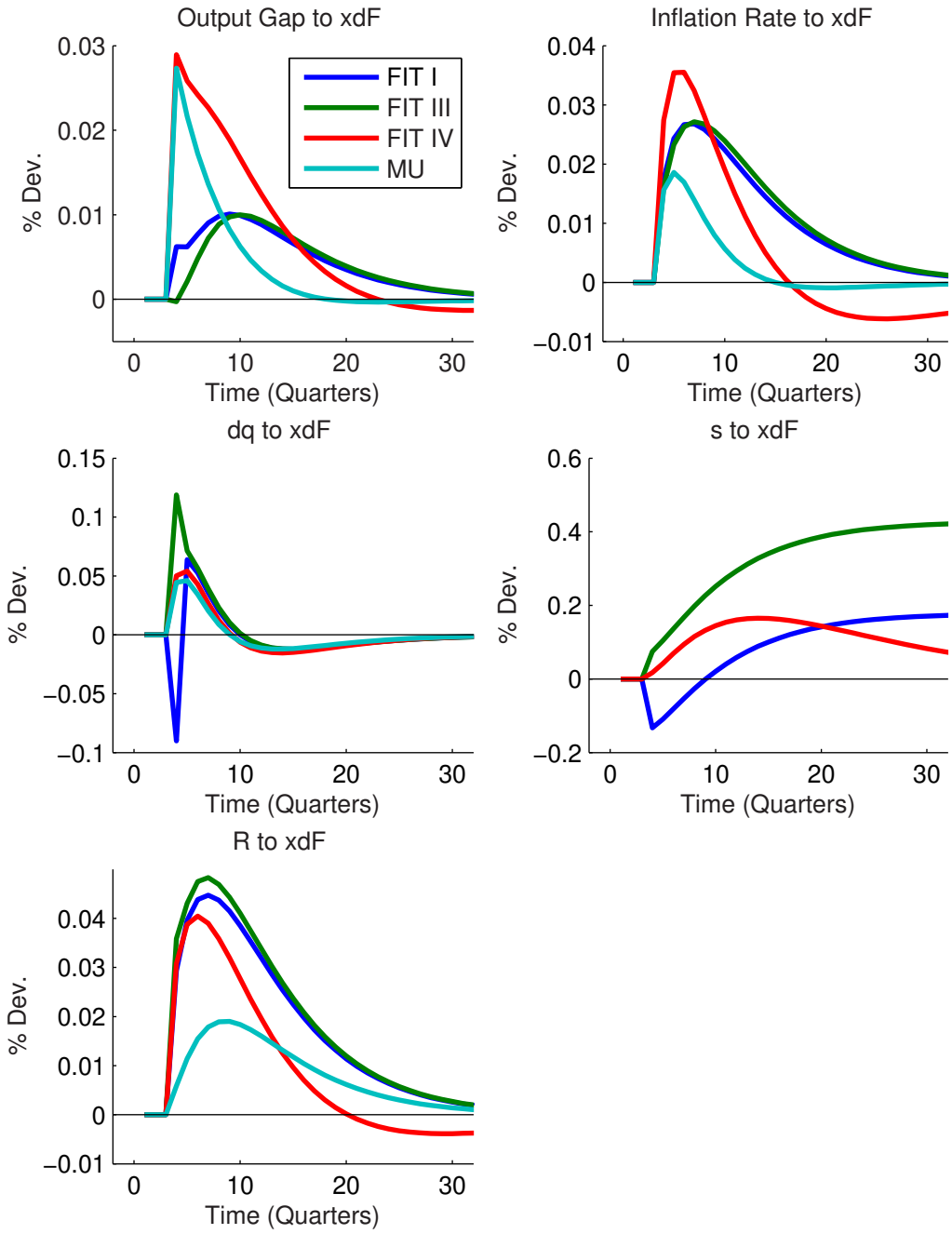
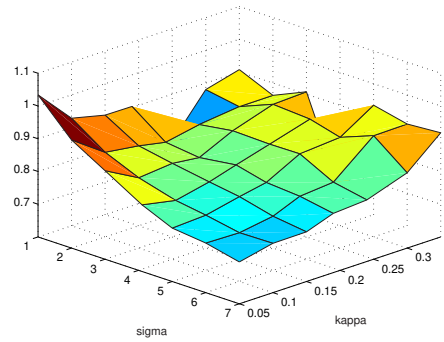
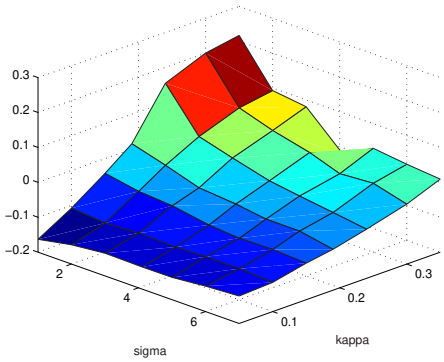


Figure 6: Relative Risk Aversion, Price Flexibility and RLI (MN Framework)

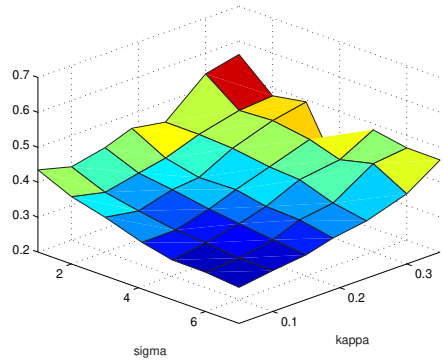
(a) L_y



(b) L_π



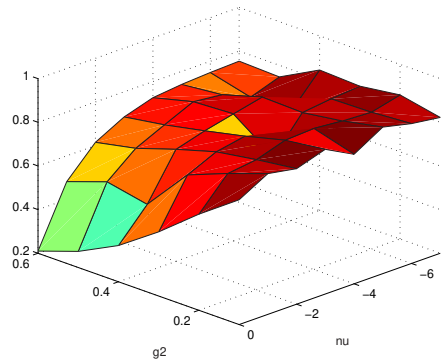
(c) RLI ($\zeta = 0.5$)



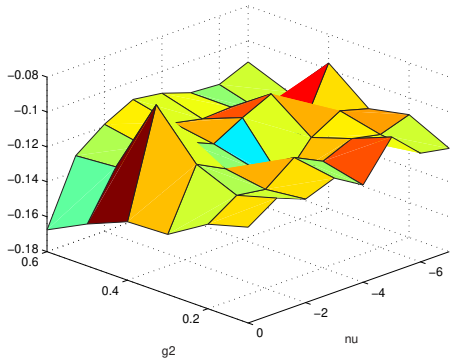
Notes: The figures show (a) the relative standard deviation of the output gap minus one, L_y, (b) the relative standard deviation of the inflation rate minus one, L_π, and (c) the relative loss index, RLI, for different values of the coefficient of relative risk aversion (inverse elasticity of intertemporal substitution), σ, and the degree of price flexibility, κ.

Figure 7: Openness, Export Demand Elasticity and RLI (MN Framework)

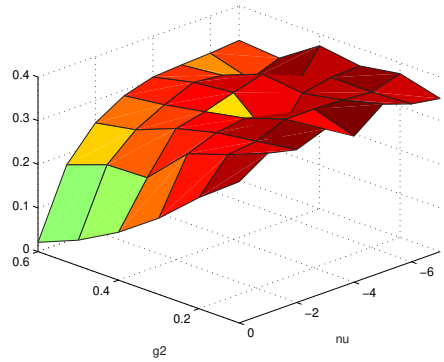
(a) L_y



(b) L_π



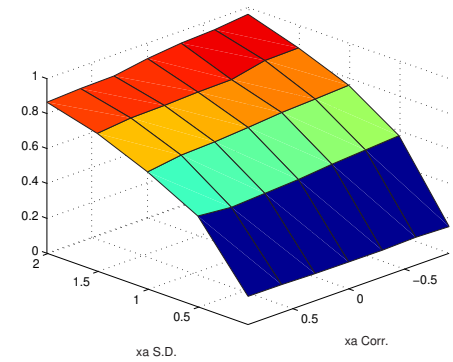
(c) RLI ($\zeta = 0.5$)



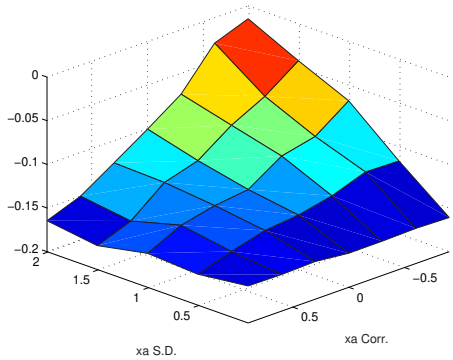
Notes: The figures show (a) the relative standard deviation of the output gap minus one, L_y, (b) the relative standard deviation of the inflation rate minus one, L_π, and (c) the relative loss index, RLI, for different values of the export share (the degree of openness), g_2, and the export demand elasticity, which is a monotone transformation of ν.

Figure 8: Productivity Shocks and RLI (MN Framework)

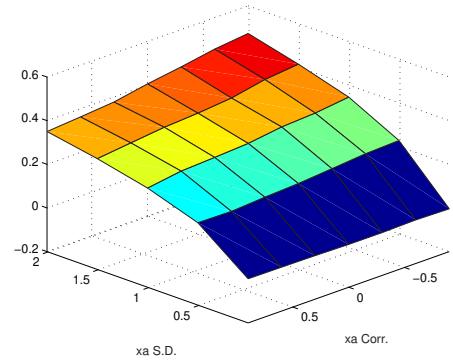
(a) L_y



(b) L_π



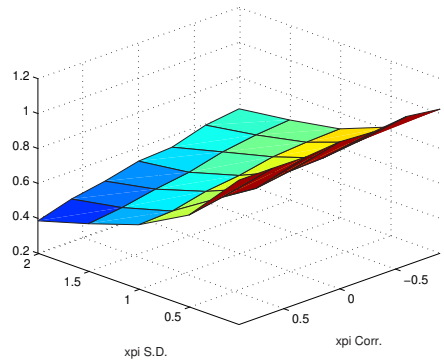
(c) RLI ($\zeta = 0.5$)



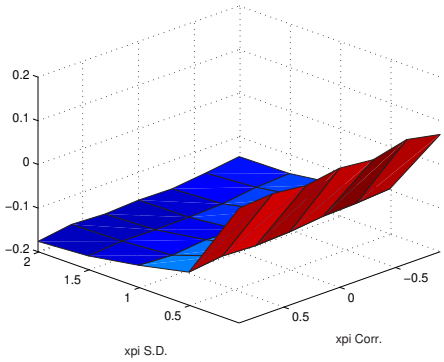
Notes: The figures show (a) the relative standard deviation of the output gap minus one, L_y, (b) the relative standard deviation of the inflation rate minus one, L_π, and (c) the relative loss index, RLI, for different values of the standard deviation of home and foreign productivity shocks, xa S.D., and the correlation of home and foreign productivity shocks, xa Corr.

Figure 9: Cost-push Shocks and RLI (MN Framework)

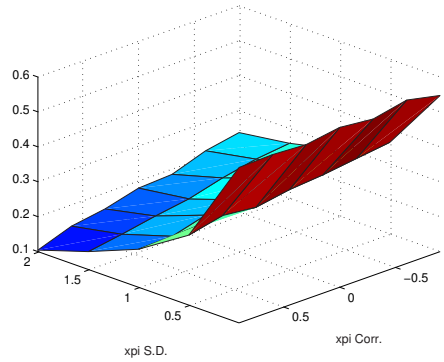
(a) L_y



(b) L_π



(c) RLI ($\zeta = 0.5$)



Notes: The figures show (a) the relative standard deviation of the output gap minus one, L_y, (b) the relative standard deviation of the inflation rate minus one, L_π, and (c) the relative loss index, RLI, for different values of the standard deviation of home and foreign cost-push shocks, xpi S.D., and the correlation of home and foreign productivity shocks, xpi Corr.

List of Tables

Table 1: Baseline Calibration (Part 1)

Coefficient	Description	MN	MN org	GM	GM org	Remarks
β	Discount factor	0.99	0.99	0.99	0.99	Corresponds to MN/GM
σ	Reciprocal elasticity of intertemporal substitution	5	5	5	1	$\sigma = 5$ corresponds to interest rate elasticity of consumption of -0.2
φ	Reciprocal real wage elasticity of labor supply	0	0	3	3	MN do also compare their model to GM model with elastic labor supply
ν^H	CES production function parameter	-6	-2	–	–	Following MN, ν is set such that no excess variability of potential output is generated.
ν^F	CES production function parameter	-2	–	–	–	$1/(1-\nu)$ is elasticity of substitution between labor and material
g_2^H	Export share	0.3	0.11	0.3	0.4	Sophisticated guess
g_3^H, α	Import share	0.3	0.12	0.3	0.4	Sophisticated guess
$g_2^F = g_3^F$	Export / Import share	0	0	0	0	Foreign country is quasi-closed
ϵ	Elasticity of substitution between varieties of domestic products	6	6	6	6	Markup: $\mu = \epsilon/(\epsilon - 1) = 1.2$
η	Substitutability between foreign and domestic goods	–	–	1	1	Original GM setting.
γ	Substitutability between goods produced in different foreign countries	–	–	1	1	Original GM setting.
κ^H	Output-gap coefficient in NKPC	0.1	0.086			Original MN/GM settings.
κ^F	Output-gap coefficient in NKPC	0.1	–			Original MN/GM settings.
γ_f	Lagged inflation in NKPC	0.3	0	0.3	0	GGL estimate
τ_R^H	Interest rate smoothing	0	–	0	0	Corresponds to standard Taylor rule
τ_y^H	MP reaction to output-gap	0.5	–	0.5	0	Corresponds to standard Taylor rule
τ_π^H	MP reaction to inflation rate	1.5	–	1.5	1.5	Corresponds to standard Taylor rule
τ_q^H	MP reaction to real exchange rate	0.1	–	0.1	0	See section on national monetary policy performance
τ_F^H	MP reaction to foreign interest rate	0	–	0	0	Corresponds to standard Taylor rule
τ_s^H	MP reaction to UIP shock	0	–	0	0	Corresponds to standard Taylor rule
τ_R^F	Interest rate smoothing	0.96	–	0.96	–	SW estimate
τ_y^F	MP reaction to output-gap	0.25	–	0.25	–	SW estimate
τ_π^F	MP reaction to inflation rate	1.82	–	1.82	–	SW estimate

Table 2: Baseline Calibration (Part 2)

Coefficient	Description	MN	MN org	GM	GM org	Remark
w	Weight of accession country in MU interest rate rule	0.01	–	0.01	–	Accession countries are small
ρ_a^H	ACR of productivity shock	0.823	0.95	0.823	0.66	Equal to corresponding foreign shock
ρ_d^H	ACR of demand shock	0.855	0.3	0.855	0	Equal to corresponding foreign shock
ρ_π^H	ACR of cost-push shock	0.293	–	0.293		Equal to corresponding foreign shock
ρ_R^H	ACR of MP shock	0	–	0	–	Equal to corresponding foreign shock
ρ_s	ACR of UIP shock	0.25	0.5	0.25	–	Sophisticated guess
ρ_a^F	ACR of prod. shock	0.823	1	0.823	0.86	SW estimate
ρ_d^f	ACR of demand shock	0.855	–	0.855		SW estimate
ρ_π^F	ACR of cost-push shock	0.293	0	0.293		Sophisticated guess
ρ_R^F	ACR of MP shock	0	–	0	–	SW estimate
σ_a^H	S.D. of prod. shock	1.196	0.7	1.196	0.71	2 times S.D. of corresponding foreign shock
σ_d^H	S.D. of demand shock	0.672	0.1	0.672	–	2 times S.D. of corresponding foreign shock
$\sigma_p i^H$	S.D. of cost-push shock	0.51	–	0.51	–	2 times S.D. of corresponding foreign shock
σ_R^H	S.D. of MP shock	0.08	–	0.08	–	Equal to corresponding foreign shock
σ_s	S.D. of UIP shock	2	4	2	–	Sophisticated guess
σ_a^F	S.D. of prod. shock	0.598	2	0.598	0.78	SW estimate
σ_d^F	S.D. of demand shock	0.336	–	0.336	–	SW estimate
$\sigma_p i^F$	S.D. of cost-push shock	0.255	–	0.255	–	Sophisticated guess
σ_R^F	S.D. of MP shock	0.08	–	0.08	–	SW estimate

Table 3: Home Country Interest Rate Rules

		τ_y	τ_π	τ_F	τ_q	τ_R	τ_s
SIT	Strict Inflation Targeting	0	1.5	0	0	0	0
FIT I	Flexible Inflation Targeting I	0.5	1.5	0	0	0	0
FIT II	Flexible Inflation Targeting II	1	1.5	0	0	0	0
FIT III	Flexible Inflation Targeting III	0.5	1.5	0	1	0	0
FIT IV	Flexible Inflation Targeting IV	0.5	1.5	0.5	0	0	0
PEG	Peg	0	0	1	0	0	1
MU	Monetary Union						

Table 4: Monetary Policy Rule and Standard Deviations of Macroeconomic Variables

	Standard Deviations MN Model					Standard Deviations GM Model					
MP Rule	$\tilde{y}$	π^c	R	Δs	Δq	$\tilde{y}$	π^c	R	Δs	Δtt	π^y
SIT	1.217	1.416	2.128	4.502	4.588	0.933	1.367	1.470	3.360	3.178	0.978
FIT I	0.935	1.316	1.972	4.668	4.824	0.757	2.506	1.487	8.960	9.432	0.972
FIT II	0.761	1.281	1.894	3.989	3.616	0.635	1.413	1.517	3.139	2.698	0.985
FIT III	0.941	1.280	1.963	3.830	3.492	0.752	1.182	1.482	3.042	3.079	0.969
FIT IV	1.406	1.474	1.315	3.589	3.512	0.897	1.644	1.363	3.125	2.849	1.438
PEG	1.709	1.127	2.075	0.000	1.225	1.064	0.797	2.072	0.000	1.007	1.008
MU	1.664	1.125	0.197	0.000	1.223	0.971	0.781	0.135	0.000	0.983	0.983

Notes: The table shows standard deviations of selected variables for different monetary policy scenarios. The monetary policy scenarios are explained in table 3. The standard deviations are computed using 1000 replications of simulated time series of length 1000.

Table 5: Effects of Parameter Variations on Relative Standard Deviations

Parameter	Effect on L_y		Effect on L_π		Effect on RLI	
MN, GM	MN	GM	MN	GM	MN	GM
σ	–	–	–	0	–	–
κ, φ	+	0	+	0	+	0
g_2, α	(–)	–	$\sim$	–	(–)	–
ν, η	–	–	$\sim$	$\sim$	–	–
xa S.D.	+	+	(+)	+	+	+
xa Corr.	0	0	(–)	$\sim$	0	0
xpi S.D.	–	–	–	+	–	–
xpi Corr.	–	–	–	+	–	(–)

Notes: – indicates a negative partial effect, + a positive partial effect, 0 no effect. Parentheses indicate that the strongness of the effect depends on the value(s) of other parameter(s). $\sim$ symbolizes that there is no clear and unambiguous effect of the parameter on the respective relative standard deviation.