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THE ROLE OF THE EXCHANGE RATE IN THE TRANSMISSION MECHANISM IN HUNGARY

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Abstract

We present structural VAR models of the Hungarian economy to investigate the monetary transmission mechanism in Hungary during the nineties, with particular emphasis on the role of the real exchange rate as a shock absorber. As there is no consensus specification in the literature, we used several sets of identification restrictions. We show that real (supply and demand) shocks shaping the Hungarian business cycle were fairly synchronised with Europe-wide disturbances during the last decade compared to other European countries. Asymmetric demand shocks played a limited role in shaping output variability. Premium shocks dominated the developments in the real interest rate and the exchange rate. It implies that renouncing the autonomous monetary policy wouldn't incur considerable costs in terms of stabilisation.

CONTENTS

I. *Introduction*

Ever since the EU entry turned up in the foreseeable future there has been an extended discussion in Hungary about the potential costs and benefits of joining EMU, and adopting the euro as a legal tender in Hungary. As reflected in the Preaccession Economic Program (PEP) the government and the central bank have revealed their preference to adopt the Euro at the earliest feasible date. Since Hungary is committed and obliged to give up the exchange rate, it is important to understand the extent to which changes in the exchange rate has affected macroeconomic developments in the past in order to assess the potential impact of currency union on the main macroeconomic variables.

In a small open economy the exchange rate is supposed to play a crucial role in the transmission of shocks to the economy. Relinquishing the exchange rate means that the country has to give up a potential policy tool, which could be used for macroeconomic stabilization. On the other hand, the exchange rate constitutes an source of idiosyncratic shocks as well. For a small open economy, still classified within the 'emerging' market investment category, volatile capital flows may induce undesirable instability, such as financial contagion effects and speculative attacks on the currency.[1]

Most empirical studies analyzing the effect of monetary policy on the economy have been conducted using the structural VAR (SVAR) methodology. There are two broad lines of research aiming at evaluating the costs of renouncing the exchange rate as a shock absorber. The first one is an indirect approach based on international comparison of cyclical patterns. If the shocks that hit the economy are mainly symmetric with respect to the potential trading partner, the exchange rate can be abandoned without losing an important policy tool. It is only for the asymmetric shocks that the exchange rate needs to take the role of a potential shock absorber. Consequently, one can assess the costs of a currency union by investigating the extent of asymmetries between national shocks. We present an analysis in Section III in this vein.

The second approach has focused on the importance of the various shocks in explaining movements in the real exchange rate and the role of the exchange rate in propagation of disturbances. It tries to disentangle idiosyncratic exchange rate shocks and exchange rate movements due to fundamental, e.g. supply and demand shocks. A high level of exchange rate volatility induced by real shocks makes abandoning the currency more costly. Following this approach, Section IV and V try to determine the factors driving the exchange rate, and investigate the spill-over effects arising from exchange rate volatility.

The SVAR technique disentangles changes in the variables into a part reflecting endogenous responses to the state of the economy and a part reflecting exogenous shifts by identifying the structural shocks hitting the economy. The SVAR

[1] It should be stressed that although surpassing the emerging market status may by itself mitigate higher capital flow volatility, it cannot completely eliminate it, as that can only be achieved by giving up the national currency. Thus, Hungary's entry into the EU and its prospective move away from the emerging market status offers no solution to the problem on its own.

methodology has not yet reached a consensus specification for open economies. We experimented with several sets of identifying restrictions documented in the related literature. All of our exercises rely on the Blanchard-Quah (1989) tradition, separating shocks via long-run identifying restrictions. We also experimented with models based only on contemporaneous restrictions a la Cushman and Zha(1997), but the results were highly unreasonable (results are not presented).

Three exercises are presented below. First, we estimate a two-variable (output, inflation) model following the original Blanchard and Quah (1989) paper, which separates supply and demand shocks in the economy. The estimated series of the supply and demand disturbances are compared to those of the European Union. Then we present our experiments with a three-variable (output, inflation, real exchange rate) VAR model following the identification strategy developed by Clarida and Gali (1994) and Gerlach and Smets (1995). We analyze the forecast error variance decomposition in order to determine the main driving forces causing real exchange rate volatility. Finally, we present results from a four-variable system, adopting a specification similar to Smets (1997). Adding the real interest rate as an endogenous variable to the system, let us separate two types of nominal shocks: the monetary shocks and idiosyncratic shocks on the forex market (= premium shocks), to which monetary policy reacts contemporaneously.

An obvious limitation of our study is the availability and quality of the data sources. SVAR analysis requires rather long data span with fairly high frequency. It poses a serious limitation in the Hungarian context, given that official quarterly GDP data are only available from 1995, and the NBH's own estimates only go back to 1992. Moreover both the economy and the monetary policy framework have undergone significant structural changes, which makes the stability of the estimates an issue.

In order to enhance robustness of our results we present the outcomes from all of the specifications and provide international comparisons when available. Nevertheless, we are fully aware of the limitations of the results presented bellow. It clearly demonstrates the difficulties arising when mechanically adopting techniques that work well on long and consistent time series, but can produce perverse results when applied to countries undergoing structural transformation. But still, we believe that such experimental computations might be more informative than sheer guesswork when assessing the potential consequences of currency union.

We show that real (supply and demand) shocks shaping the Hungarian business cycle were fairly synchronized with Europe-wide disturbances during the last decade compared to other European countries. Asymmetric demand shocks played a limited role in shaping output variability.

Our results confirm that in most of the period under investigation the Hungarian central bank pursued some sort of exchange rate targeting[2]. Changes in the real interest rate were mainly driven by premium shocks, while it also reacted to real shocks. In spite of managing the real exchange rate, a significant part of real exchange rate variability arose from premium shock (according to some specifications up to 50%). On the other hand, the real exchange rate responded to real shocks to a large

[2] Until 1995 it take the form of an adjustable exchange rate peg, then between 1995-2001 a crawling peg regime was operated.

extent. Supply disturbances seem to be the most important driver of the real exchange rate, which can be associated with the Balassa-Samuelson effect.

As we were able to reveal significant similarity between the factors shaping volatility of output, inflation and the real exchange rate, it could be an indication that the real exchange rate operated as an effective stabilization device in the last decade. However, the interpretation of the forecast-error variance decomposition is not straightforward, as the real exchange rate followed an integrated process, partly driven by technological catch-up and not related to stabilization. Moreover, the behavior of the real exchange rate following real shocks suggests that real exchange rate changes were to stabilize the current account and not the output. Joining the EMU the current account constraint will be relaxed.

We also analyzed whether the idiosyncratic exchange rate shocks spill over to affect output and inflation. We couldn't detect significant extra volatility in the variables caused by shocks on the forex market.

What policy conclusion can be drawn from these results? Although the results are ambiguous, the importance of real shocks in real exchange rate variance hints that the costs of EMU entry are not negligible. As the process of technological catch up will last for decades, one might expect a further trend real appreciation of the exchange rate. Fixing the nominal exchange rate, real exchange rate appreciation will be displayed in a higher than average inflation in We couldn't rule out the possibility that the real exchange rate was a shock absorber. It reacted to movements in the current account and, according to some specifications, to asymmetric demand shocks. It implies that joining the monetary union might put extra burden on fiscal policy. Consequently, it is crucial for the Hungarian government to have fiscal policy under control before entering the EMU.

The paper is organized as follows. Section II describes the data. Section III presents the results based on international comparison of business cycles. Then, section IV and V presents the results from the 3 and 4 variables systems respectively. Section VI concludes.

II. Data

The data are quarterly for the sample period 1992:Q1-2001:Q4. Domestic variables are: real GDP, core inflation[3], HUF/DEM real exchange rate and 3-month TB rate. The foreign variables are DEM/USD exchange rate, EU-wide GDP, and GDP and inflation series of the individual EU countries. For the period before 1995 the Hungarian GDP series are the estimates of the NBH. All variables are in logarithms, and seasonally adjusted, except for the interest rate, which is in quarterly terms. Full details on the data including source are available in the data appendix.

[3] Using core CPI as price variable has several alternatives. Since the composition of consumer basket may substantially deviate from that of production, GDP-deflator is often used instead of CPI. We choose the latter, because for the period before 1995 we have estimates of the NBH for the nominal GDP and an estimated GDP deflator series to obtain the real GDP figures. Using the CPI we can avoid spurious co-movements due to estimation bias. The advantage of 'core' CPI relative to CPI is that its movement reflects better economic developments by excluding some volatile items we didn't want to incorporate in our models (e.g. unprocessed food).

Identification of structural shocks in a VAR system requires that all the variables be stationary. This requirement is usually met by taking the first difference of the originally I(1) variables[4]. During the nineties the Hungarian consumer inflation showed remarkable persistency, which questions the assumption that the price level is an I(1) process (see figures 1-2). Indeed, the unit root tests suggest an integration of second order for the price level, i.e. an I(1) inflation process, but trend stationarity can not be rejected either by certain test statistics. The hypothesis of trend stationarity can be justified by a fully credible and announced multiyear disinflation policy, which is an unrealistic assumption in our case. The I(2) price level is consistent with fully adaptive expectations. As the true behavior of inflation expectation lies between these two corner solutions, we experiment with both assumptions. For convenience, they are called as I(1) and detrended models, respectively.

The first difference of real GDP seems to be stationary. According to the unit root tests the real HUF/DEM exchange rate is considered as an I(1) process. Considering the unit root in the Hungarian CPI, it's not surprising that 3-month treasury bill yields also contain a unit root in our sample period. At the same time, Johansen's cointegration-test detects the existence of significant cointegrating relationship between nominal yields and inflation. Based on the LR statistic, we could not reject the null hypothesis that the inflation and nominal interest rates have the same coefficient with opposite sign in the cointegrating equation. Unfortunately, the difference of nominal interest rate and inflation still seems to contain unit root, but this is due to the extremely low real rates during 1992-93. For the period 1993:Q4-2001:Q4 the assumption of having a unit root can be rejected, therefore, following Shapiro and Watson (1988), we used real interest rates (nominal rate minus actual inflation) in VAR estimations instead of nominal rates.

III. Comparison of Hungarian and EU business cycles

Before turning to our results from the SVAR estimation, let us present some descriptive evidence on the cyclical similarities between Hungary and the EU. A comparison of the GDP growth series indicates remarkable synchronization of business cycles within the Hungarian economy and the EU, though co-movements observed in the first half of the 1990s cannot be fully attributed to symmetric economic shocks. The political turnaround in Eastern Europe triggered a transitional recession in Hungary parallel to the slowdown in Europe in 1992–93. Similarities of cyclical movements became more regular in the second half of the decade due to strong trade links that developed across the region in the meantime. Both in the European Union and Hungary, the slump caused by the Russian financial crisis was followed by rapid growth in 1999 and the first half of 2000. Since then economic growth has hampered by global recession.

Insert Figure 3

Next, we compare cyclical fluctuations based on estimation of a two-variable SVAR system in EU countries. Our method, pioneered by *Blanchard and Quah* (1989), was introduced to the literature on optimum currency areas by *Bayoumi and Eichengreen*

[4] Unit root tests are reported in Table 2 (Appendix A.).

(1993). Segregation of demand and supply fundamentally rests on the simple assumption that demand shocks induce a *temporary* rise in output, whereas supply-shocks trigger a *lasting* increase.[5]

Figure 4 shows the results of the estimations both for the detrended and the I(1) inflation models for the Hungarian data. A positive supply shock causes a permanent increase in output and a small negative impact on inflation. In the detrended model the demand shock results in a jump in inflation, which returns slowly to the trend level. The demand shock causes a temporary increase in output, which turns into a slowdown during the period of disinflation. As the I(1) model allows for a permanent increase in inflation, the counterintuitive recessionary phase doesn't appear in that model.

Figure 5 shows the fraction of the forecast error variance at different forecast horizons for each variable, which can be attributed to supply and demand shocks in the model. The variance decomposition of output reveals that supply shocks are far the most important source of variation in output contributing more than 80% to the estimated variance. In contrast, it is the demand side that causes at least two-thirds of the inflation variance in both models.

Insert Figure 4 and 5

We also calculated demand and supply shocks for each European country and three other accession countries in order to compare cyclical movements. We defined the time series of the European shocks as the first principal component of the series of the EU countries. The advantage of using the principal component analysis to derive European demand and supply series[6] is that larger countries will only carry a higher weight to the extent that exhibit actual correlation with the cycles of several other countries. Thus, this approach provides a numerical representation of genuine shocks common to several countries simultaneously.

Figure 6 shows the correlation coefficients of demand and supply shocks with the principal component of the European supply and demand shocks. For Hungary we considered the results of the I(1) inflation model, since it produced interpretable impulse responses. In the period of 1992-2000, France, Germany and Belgium showed higher-than-average correlation with the European component in respect of both demand and supply shocks, while Switzerland, Spain and Finland also exhibited significant correlation in terms of both constituents. Despite the differences in methodology, these results are comparable to those of Bayoumi and Eichengreen (1993), who found that business cycles of France, Belgium and Denmark exhibited the highest degree of harmonization as compared to Germany. Great Britain seems to have displayed less co-movement in the 1990's than in the previous decades.

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[5] These shocks don't correspond entirely to those of next sections. The two main differences are that here we don't treat export demand separately, and that demand here incorporates other sources of fluctuations that don't cause the output to shift permanently, i. e. nominal shocks.

[6] The inclusion of other principal components in addition to the first principal component, which accounts for 10-50% of the demand shocks and 0-45% of the supply shocks to non-peripheric EU member nations, will not significant increase explanatory power. This justifies the proposition to view the first principal components as common European components, with their values interpreted as pan-European demand and supply shocks.

Of the accession countries under review, the Czech Republic can be viewed as the country least exposed to asymmetric shocks in the 1990s. Demand shocks affecting Hungary showed broadly the same degree of correlation (0.36) with Europe as those in Italy, the Czech Republic and Great Britain. Hungary's correlation coefficient of 0.3 for supply fluctuations, corresponding to the level for Switzerland, represents a slightly greater degree of symmetry than that of Spain and Luxembourg.

Demand shocks exhibit slightly stronger co-movement with European shocks than with supply shocks. The lower correlation of supply shocks can be attributed to the fact, that the post-communist countries experienced an economic restructuring in the 1990s, which can be interpreted as a series of country-specific supply shocks. In contrast with technological innovation in the developed regions of Europe, technology imports appear to have played a dominant role in supply shocks in the accession countries. However, the catching-up process will likely entail a reduction in supply-side asymmetries.

Insert Figure 6

Recent research using a similar approach has found that, out of the former CMEA countries, Hungary can be viewed as a country with an economy showing the highest degree of symmetry with the euro area. Based on SVAR estimates of quarterly GDP and GDP deflator series made by Fidrmuc and Korhonen (2001) the Hungarian supply correlation coefficient equals 0.46 relative to the euro area, while the demand correlation coefficient is 0.25. This puts Hungary directly after the four largest euro-area member nations in respect of symmetry. Estimates by Frenkel, Nickel and Schmidt (1999) based also on GDP and its deflator suggest that of the accession countries only Hungarian demand and supply shocks are positively correlated with those of both Germany and France. It should be remembered, however, that although based on an essentially identical SVAR model, the results of the two papers cited and our calculations differ significantly. This is partly because estimation is sensitive to specifications (such as the selection of lags in the VAR model), the length of the sample period and data selection, and partly because the standards for comparing the correlations are different (the euro area, Germany and France, European principal component).

IV. The role of the nominal shocks in macroeconomic fluctuations

In the second exercise, we would like to determine the extent to which movements in the real exchange rate have been driven by real (supply and demand) as opposed to nominal shocks, and the spill-over of nominal shocks to output and inflation developments.

Introducing a new endogenous variable (the real exchange rate) allows for identification of an additional shock relative to the output-inflation system. Identification aims at disentangling demand shocks caused by real developments (e.g. shifts in preferences, fiscal policy) and nominal shocks (due to changes in monetary policy or asset prices etc.). For an (exact) identification of the three variable system one needs to impose (at least) two more restrictions. One of them is rather straightforward, the nominal shock has only temporary impact on the level of output. Regarding the last restriction, there doesn't exist a theoretically justified 'consensus' specification. First we apply the Clarida-Gali (1994) specification, then we combine long- and short-term restrictions similarly to Gerlach and Smets (1995).

Clarida and Gali distinguish between demand and nominal shocks by assuming that the latter has no permanent effect on the real exchange rate. The identifying restrictions are based on the Obsfeld-Rogoff (1985) model. It assumes imperfect competition on the international goods market, where prices are sticky and output adjustment is sluggish. The model exhibits short-term dynamics characterizing the Mundell-Flemming model. A positive supply shock creates an excess supply of home goods and leads to a permanent depreciation of the currency. A positive demand shock increases the demand for home output, which temporarily increases, and the exchange rate appreciates permanently. A nominal shock leads to a short-run depreciation of the real exchange rate and a temporary increase in output.

Most studies following the Clarida-Gali approach specify the variables in relative terms in order to filter out the effect of symmetric shocks. This approach relies on the assumption that the transmission mechanism of the shocks is similar in the countries under investigation. As the amplitude of the business cycle fluctuations tends to be larger in the accession countries, we have taken another approach. To avoid estimation bias arising from important omitted variables we model explicitly the foreign economy. At this stage of the research, we have incorporated EU output as an additional explanatory variable into the three-domestic-variable model.

Since there is an asymmetry in size and openness we can rule out any interdependence and treat the EU as a closed economy. Consequently, we can apply a block diagonal recursive structure to identify the shocks. First, we estimated an AR(2) model[7] for the log difference of EU-15 GDP, and interpreted the estimation residuals as a proxy for export demand shocks.

In the benchmark model we estimated the following equations:

$$\Delta y_t = \sum_{i=1}^{2} \alpha_i^y \Delta y_{t-i} + \sum_{i=1}^{2} \beta_i^y \Delta \pi_{t-i} + \sum_{i=1}^{2} \gamma_i^y \Delta q_{t-i} + \sum_{i=1}^{2} \delta_i^y \Delta y_{t-i}^{EU} + \phi^y e_t^{EU} + \varepsilon_t^y \qquad (1)$$

$$\Delta \pi_t = \sum_{i=1}^{2} \alpha_i^\pi \Delta y_{t-i} + \sum_{i=1}^{2} \beta_i^\pi \Delta \pi_{t-i} + \sum_{i=1}^{2} \gamma_i^\pi \Delta q_{t-i} + \sum_{i=1}^{2} \delta_i^y \Delta y_{t-i}^{EU} + \phi^\pi e_t^{EU} + \varepsilon_t^\pi \qquad (2)$$

$$\Delta q_t = \sum_{i=1}^{2} \alpha_i^q \Delta y_{t-i} + \sum_{i=1}^{2} \beta_i^q \Delta \pi_{t-i} + \sum_{i=1}^{2} \gamma_i^q \Delta q_{t-i} + \sum_{i=1}^{2} \delta_i^y \Delta y_{t-i}^{EU} + \phi^q e_t^{EU} + \varepsilon_t^q \qquad (3)$$

where y, q, y^{EU} are GDP, real exchange rate and EU GDP, respectively), e^{EU} is the proxy for shocks in export demand. π stands for the inflation. In the linearly detrended case inflation was used instead of its first difference. The ε disturbances are linear combinations of the structural shocks. The choice of appropriate number of lags is based on several lag-selection criteria. The two recommended lag lengths were 2 and 6. Because of the shortness of our series, the former is chosen.

After extracting orthogonal structural shocks from estimation residuals, we can disentangle their contribution to the variance of each endogenous variables. Figure 9

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[7] Two lags proved to be enough to produce white-noise type residuals and it is consistent with our later lag length selections.

presents the impulse response functions. The reactions to the supply and external shocks are rather similar in the I(1) and in the detrended model, while the characteristics of the identified demand and nominal shocks are different.

Insert Figure 9

The dynamics of output and inflation responses to supply shocks is similar to the two-variable case[8], a positive shock implies a permanent increase in output and decreasing inflation. The real exchange rate responds to supply shocks quickly, but – opposite to the suggestion of the Mundell-Flemming model – it appreciates. The Balassa-Samuelson effect may account for this phenomenon: faster productivity growth in the traded than in the nontraded sector relative to main trading partners induces an appreciation of the equilibrium real exchange rate[9]. Another explanation can be derived from the fact that the exchange rate was a policy variable assigned to altering policy goals during the period under investigation. There were episodes when the exchange rate was used as an anti-inflationary device, while in other periods maintaining competitiveness got priority in exchange rate management. A supply shock improves the current account position, which facilitates a shift towards a more anti-inflationary policy stance.

Reactions to the external shocks exhibits strange real exchange rate dynamics. Higher growth in the EU boosts domestic output, increases domestic inflation and surprisingly depreciates the real exchange rate permanently. This is due to the positive correlation between real depreciation and (lagged) EU-growth during our sample period. There were several episodes, when monetary tightening in Hungary coincided with slowdown in Europe, or expansion with European boom. Although this relationship lacks any causality, because of the empirical non-orthogonality of monetary and external shocks, our identification procedure will incorporate the former into the latter.

Domestic demand disturbance increases output and depreciates the real exchange rate in both models. The Mundell-Flemming model suggests real exchange rate appreciation following a positive demand shock. Explaining the perverse movements in the real exchange rate we can refer to the goal of current account management assigned to exchange rate policy: improving competitiveness should have counterweighted the deterioration of the current account. We also have to note that demand shocks due to changes in fiscal policy have an ambiguous impact on the real exchange rate. As a direct effect, a fiscal expansion should lead to real appreciation. When sustainability considerations are also taken into account, the reaction of the real exchange rate might well be the opposite.

The reaction of inflation to domestic demand disturbances is opposite in the two models. In the I(1) model inflation accelerates, while it decelerates in the detrended model. The different identification of the shocks has a counterpart in the impulse-response functions related to nominal shocks, which also differ in the sign of the inflation reaction.

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[8] We also reestimated the Blanchard-Quah specification with EU-block. Results can be seen on figures 7-8.

[9] Astley and Garratt (1998) point out that when supply shock affect different sectors unequally, the prediction of the model changes.

Acceleration of inflation seems to be a more reasonable reaction to a positive demand shock (as in th I(1) model), especially in the light of the depreciating real exchange rate. In the case of nominal shocks, there may be an interpretation to both results. If the nominal shock is mainly driven by idiosyncratic monetary policy shocks, then lax policy may result in a depreciating real exchange rate and accelerating inflation, which is accompanied with a slight and short output expansion, as indicated by the detrended model. On the other hand, if forex premium shocks drive the nominal shocks, a depreciation of the currency is usually coupled with higher interest rates, so inflation and output may decrease, in line with the prediction of the I(1) model[10]. In order to check the robustness of the results, in the next section we decompose nominal shocks into monetary policy shocks and premium shocks.

As the I(1) model gives impulse responses that are easier to interpret, we emphasize results from forecast error variance decomposition based on the I(1) model. But even in the better performing model we found depreciation during export expansion, a strange result that may indicate poor identification of the shocks. As the identification of the supply shocks seems to be quite robust, the variance decomposition attributes a similar role to the supply shocks in both models, while we have different decompositions with respect to the other three shocks.

Insert Figure 10

Supply shocks explain most of the variance in output. External shocks are another important driving force, while demand and nominal shocks have a negligible effect on output fluctuations. At longer horizons supply and nominal shocks are responsible for most of the variation in inflation. Volatility of the real exchange rate is mainly driven by real shocks.

Results from similar estimations of other authors vary in a wide range. In the original Clarida and Gali (1994) article the authors found that the main source of real USD exchange rate fluctuation were shifts in (relative) demand, and the role of nominal shocks was considerable (30-40%), too. Using the same estimation strategy, Astley and Garratt (1998) found nominal shocks to have virtually no role in shaping the real sterling exchange rate vis-à-vis the US, German, Japanese and French currency, with demand shocks being the main determinant. Thomas (1997) estimates the contribution of nominal disturbances to exchange rate fluctuation being 30-40% in case of Sweden, Austria, Belgium, France and 70-80% in case of the Netherlands at almost every horizons. Funke (2000) comes to similar conclusion regarding the ECU/GBP real exchange rate as Astley and Garrett (1998). Canzoneri, Valles and Vinals (1996) find the nominal shocks to be the main source of real exchange rate changes against DEM in Austria, Netherlands, France, Italy, Spain and the UK (50-90% weight in variance decomposition for all countries for all horizons).

Although there are differences in weights, all of the studies listed above considers nominal and demand shocks as the main driving force of real exchange rate volatility. Importance of the supply shocks in the Hungarian case can be partly attributed to the process of technological catching up. As we mentioned above, the Balassa-Samuelson effect implies real exchange rate appreciation following a supply shock. Low share of nominal shocks in explaining real exchange rate variability is an obvious consequence

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[10] In emerging markets depreciation of the currency is often followed by contraction as documented by Calvo and Reinhardt (2000).

of the identification restrictions we imposed. Both supply and demand shocks result in a permanent change in the real exchange rate, while the effect of the nominal shocks is only temporary.

We relax the assumption as the risk premium required on domestic assets by foreign investors is not necessarily a stationary process, and a random walk premium implies permanent real exchange rate effects[11]. Another widely used identification restriction for distinguishing between demand and nominal shocks is that the latter does not affect output contemporaneously. This restriction is based on the observation that transmission of nominal shocks works through the economy with a significant time lag, and short run effects can be neglected. This restriction can substitute the one imposed in the previous exercise, according to which nominal shocks have no long-run effect on the real exchange rate.

A combination of both long and short-run restrictions was first applied by Gali (1992). Gerlach and Smets (1995) built upon the estimation strategy of Shapiro and Watson (1988), in addition to imposing short run restrictions. We follow their approach with some modifications. First, we use the real exchange rate instead of the real interest rate, which allows for a direct comparison to the results from the Clarida-Gali specification. We have expanded the model with the EU block and have changed the price level variable as in the previous case. A detailed description of the estimation process can be found in Gerlach and Smets (1995).

This identification strategy does not give a qualitatively different decomposition of the shocks. The shape of the response functions to supply and demand disturbances (Figure11) are similar to the shape of the functions in Clarida-Gali specification, although the magnitudes of the reactions are different. The reaction of the real exchange rate to nominal shocks – the only significant difference - seems to be persistent. It reveals that the data do not support the long-run neutrality assumption we imposed in the Clarida-Gali specification.

Insert Figure 11

Allowing for persistent reactions of the real exchange rate to nominal shocks alters the forecast error variance decomposition. In the I(1) model, the influence of the supply and external shocks on each variable is more or less the same as in the Clarida-Gali model, while the shares of variance due to demand and nominal disturbances are interchanged. Demand shocks play a more important role in inflation fluctuations, while a larger part of the unforeseeable real exchange rate fluctuation can be attributed to nominal shocks.

Insert Figure 12

V. Monetary or forex market shocks?

In the last exercise we extend the model to incorporate four variables. The four-variable system allows for disentangling the shocks that originate in the forex market from those due to monetary policy. If the CB reacts to developments in the forex market contemporaneously, then separation of the two disturbances is not

[11] For a formal derivation of this statement see Appendix E.

straightforward. Variation in the interest rate can be either due to the autonomous monetary policy setting or due to monetary policy reaction to forex market developments. Similarly, exchange rate variation might arise from forex developments directly or stem from the reaction to interest rate changes. For short, idiosyncratic shocks on the forex market are called premium shocks[12].

There are several approaches to disentangling monetary and premium shocks. Bagliano and Favero (1998) try to solve the simultaneity problem by using information extracted from financial markets independently from the VAR. Smets (1997) determines the extent to which monetary policy takes into account exchange rate developments. Then he uses this information when segregating the two types of shocks.

We follow a similar identification strategy to Smets (1997), but we use a different method to sort out the two nominal shocks. Smets (1997) uses additional estimation in order to obtain the relative contemporaneous weight of the exchange rate shock in the interest rate movements, assuming some kind of MCI-targeting monetary policy rule. Our identification procedure is based on the assumption that when there is a monetary disturbance (positive interest rate shock) the exchange rate appreciates, whereas a positive premium shock is accompanied by declining interest rates and an appreciating exchange rate. Therefore, we maximized the difference between the reaction of the exchange rate in the case of monetary and premium shocks both causing the same contemporaneous change in the interest rate[13]. This procedure implicitly assumes that among all types of nominal shocks producing unit immediate interest rate increase, the monetary shock is accompanied by the highest exchange rate appreciation, while the premium shock is accompanied by the highest depreciation.

Insert Figure 13

Adding a new endogenous variable to the previous three-variable system does not change the basic pattern of the responses to supply, demand and external shocks. Nevertheless, the interest rate responses can help to understand the underlying developments described by the three-variable system. The reaction function of the real interest rate to supply shocks supports our previous interpretation, which is that a positive supply shock brings about a shift towards tighter monetary policy. In the case of demand shocks, monetary policy reacts sluggishly to accelerating inflation. The slow reaction of the bank helps to understand the real depreciation of the currency following the demand expansion. As we mentioned above, the outcome can be justified by a current account targeting policy, under which increasing competitiveness should counterweight the impact of the domestic demand expansion on the external position of the economy. An investigation of the reactions to external shocks can reveal that the strange depreciation of the currency is accompanied by increasing real interest rates. It looks as if external shocks were associated with premium shocks, but we cannot give any reasonable explanation.

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[12] We have to note, however, that the shock reflects only the contagious part of the variation in the risk premium, which is orthogonal to the endogenous domestic variables.

[13] The difference typically has no global maximum, since – for example - choosing the interest rate effect of the premium shock small enough, the maximum can be arbitrarily large. We found, however, that it always had a unique local maximum, so we considered this local maximum as the solution to our problem. The resulting monetary and premium shocks seem to be interpretable.

We defined monetary shock in terms of monetary tightening leading to an immediate exchange rate appreciation. We can identify the well-known price puzzle in the I(1) model. In the detrended model, inflation changes in the expected direction, but monetary tightening leads to expansion in output.

Both models give the same impulse-response pattern for the premium shock. All variables respond in the expected way. A negative premium shock results in increasing real interest rates, depreciating real exchange rates and higher inflation. Output declines, which can be attributed to the shift in capital flows usually accompanying the premium shocks.

Insert Figure 14

Forecast error variance decomposition reveals that introduction of new variables into the model does not affect the determinants of output and inflation variability. Idiosyncratic monetary shocks play a minor role in explaining deviations of the real interest rate from its foreseeable path. Premium shocks appear to be the most important source of fluctuations, but it also reacted to real developments. This finding is consistent with the central bank policy seeking to smooth the exchange rate, and allowing the interest rate to absorb the volatility in the risk premium. This smoothing behaviour seems to have been only partial, because premium shocks were responsible for half of the real exchange rate variations.

We can compare our results with Smets(1997). Using an identification scheme similar to ours, Smets estimates a considerable role (75-85%) of nominal shocks in shaping the German, French and Italian nominal exchange rate against the ECU.

VI. Conclusions

Before drawing policy conclusions, we try to test the robustness of the outcomes and rank the specifications on the basis of a common sense understanding of the developments in the variables under investigation. We did it by comparing the obtained structural shocks to each other and to some natural indicators. We constructed proxies for structural shocks by estimating simple univariate AR models of the trade balance, government budget deficit, and the DEM-denominated government bond spread over the German benchmark yield. We considered the residuals of the first two regressions as approximation of demand and the third one as proxy for nominal (risk premium) shocks.[14]

Correlation coefficients are reported in tables 3-5 for the period 1995:Q1-2001:Q4, where our proxies are reliable. High correlation between supply shocks estimated by assuming I(1) inflation indicate greater robustness, while in the case of detrended inflation the estimation is more sensitive to the specification. A similar argument applies to demand shocks, although with a much weaker contrast. The demand disturbances drawn from the detrended 4-variable Gerlach-Smets framework seem to have nothing in common with those of other specifications.

While government spending does not correlate with estimated demand shocks, disturbances in the trade balance exhibit significant co-movement with the estimated

[14] We also considered proxies for supply shocks but without any significant results.

shock series. The high negative correlation (from -0.4 to -0.5) between trade balance improvement and the demand shocks of I(1) inflation models underpins our interpretation of the estimated real exchange rate depreciation following a positive demand shock. Accordingly, the real exchange rate moves to mitigate the deterioration in the current account.

Comparison with DEM-bond spreads sheds more light on the difference between the Clarida-Gali and the other approaches. One would expect positive correlation with nominal (risk premium in the 4-variable case) shocks and no correlation with demand shocks. Tables 4-5 reveal that the results from the Gerlach-Smets type models meet this condition, while imposing a long-run restriction on nominal shocks leads to mixed demand and nominal shocks.

The correlation coefficients between estimated disturbances and corresponding proxies suggest the superiority of models treating inflation as I(1) process, and moreover, the superiority of the Gerlach-Smets approach over the Clarida-Gali identification scheme. Based on these results, we tend to favor, and draw our conclusions from, the 4-variable Gerlach-Smets specification with I(1) inflation. Nevertheless, one has to keep in mind that even that specification falls short of being satisfactory, therefore we interpret only the most robust results.

The identification of supply shocks seems to be robust taking the difficulties related to the Hungarian data into account. Asymmetric (or country-specific) supply shocks are responsible for more than half of the output variance. The significant effect of EU-shocks on Hungarian GDP indicates cyclical co-movements, while asymmetric domestic demand shocks play a limited role in shaping output fluctuation. It means that direct costs of denouncing the exchange rate as an absorber are moderate in terms of output variability. On the other hand, getting rid of real exchange rate volatility will not moderate output fluctuation.

The other exogenous shock we consider as well-identified is the risk premium or exchange rate shock. Due to monetary policy managing the exchange rate, these shocks account for 35% of the real interest rate, and 50% of the real exchange rate fluctuations, and contribute virtually nothing to output or inflation movements.

The remaining half of real exchange rate variance is explained almost entirely by EU- and supply shocks. This might imply that the exchange rate has played an important role in alleviating asymmetric disturbances. However, an analysis of the impulse-response functions reveals that the reaction of the real exchange rate was opposite to that which would smooth output fluctuations. The direction of the real exchange rate adjustment can be justified by the Balassa-Samuelson effect or by a policy that smoothed current account fluctuations.

Based on this result we do not think that currency union would amplify the volatility of output fluctuations. Nevertheless, the observed interactions of the variables might have other consequences. First, the real exchange rate appreciation due to the Balassa-Samuelson effect will manifest in higher inflation than in trading partner countries. On the other hand, it should be fiscal policy that cares about the sustainability of the current account, although the salient role of the current account will diminish in the currency union.

Although we believe that the Gerlach-Smets specification gives a better representation of the economy, we cannot neglect the more pessimistic results from the Clarida-Gali specification. The Clarida-Gali specification attributes a larger role to asymmetric demand shocks in explaining real exchange rate variability. This would impose a higher burden on fiscal policy in smoothing asymmetric cyclical movements in the economy.

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Appendix

A) Data description

Table 1

Description of data series used in estimations

	Source	***Special treatment***	***Period***
Hungarian 3-month treasury bill yields	IFS		1992:Q1-2001:Q4
Yields of DEM-denominated Hungarian government bonds	NBH		1995:Q1-2001:Q4
HUF/DEM exchange rate	NBH		1992:Q1-2001:Q4
USD/DEM exchange rate	NBH		1992:Q1-2001:Q4
Hungarian GDP	CSO	Seasonal adjustment; for 1992:Q1-1994:Q4 NBH calculation	(1992:Q1-)1995:Q1-2001:Q4
Hungarian core-CPI	CSO	Seasonal adjustment	1992:Q1-2001:Q4
GDP and CPI of Western European countries	OECD	Seasonal adjustment	1980:Q1-2000:Q4
German CPI	OECD	Seasonal adjustment	1980:Q1-2001:Q4
GDP and CPI of Eastern European countries	OECD	Seasonal adjustment	1992:Q1-2000:Q4

IFS: International Financial Statistics, IMF
NBH: National Bank of Hungary
CSO: Hungarian Central Statistics Office
For seasonal adjustment we used the model-based method of Tramo/Seats built in Demetra.

Table 2

Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests

	With intercept		*With intercept and trend*	
	ADF	**PP**	**ADF**	**PP**
GDP	-0.355	1.812	-1.959	-2.952
1st difference	-2.658*	-3.295**	-1.997	-3.566**
EU-15 GDP	-0.177	0.895	-3.532*	-4.277***
1st difference	-2.259	-3.405***	-1.972	-2.834
Core inflation	0.177	-1.256	-4.731***	-2.325
1st difference	-2.987**	-6.203***	-3.078	-6.109***
Nominal interest rate	0.278	-1.675	-3.626**	-2.062
1st difference	-4.5***	-3.754***	-4.436***	-3.669**
Real interest rate	-2.921*	-1.937	-1.705	-1.891
Real exchange rate	-2.324	-1.580	-0.885	-1.298
1st difference	-5.3***	-5.347***	-3.693**	-5.478***

ADF: lag selection based on Akaike information criterion
PP: Bartlett kernel, Newey-West bandwith
,,*** denote significance at 10, 5, 1% level respectively*

Figure 1

Hungarian quarterly core inflation in the sample period (first difference of the logarithm of seasonally adjusted core price level)

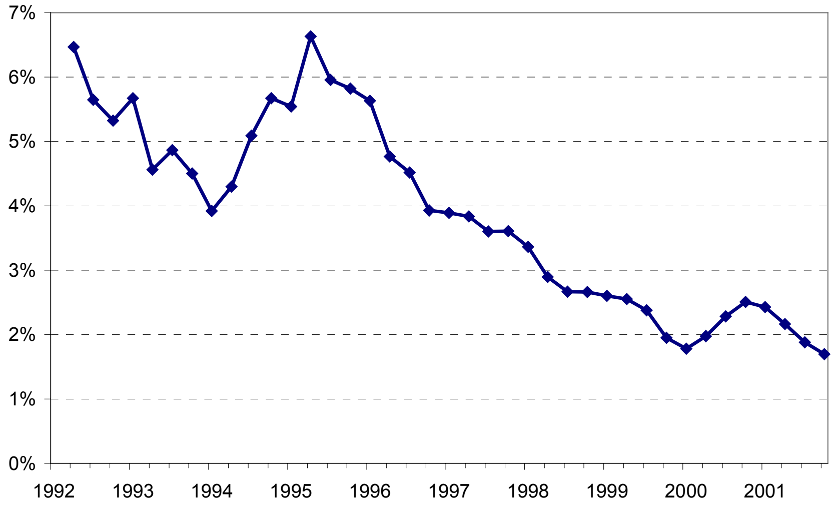
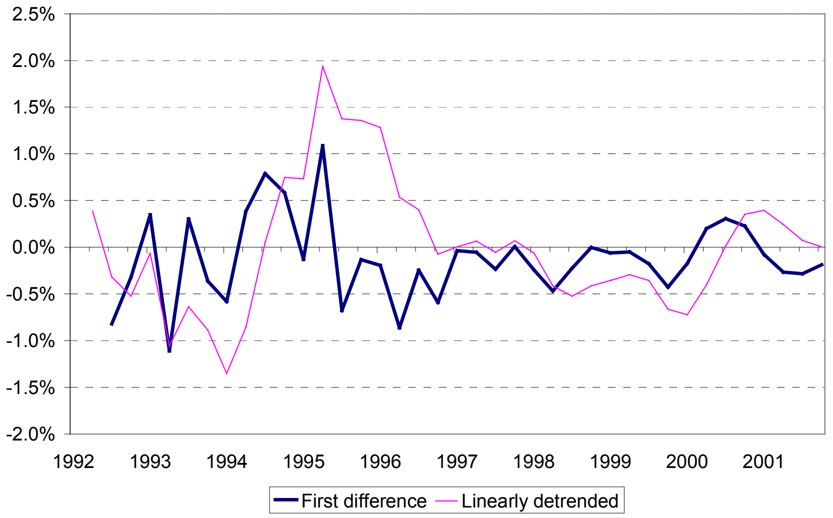


Figure 2

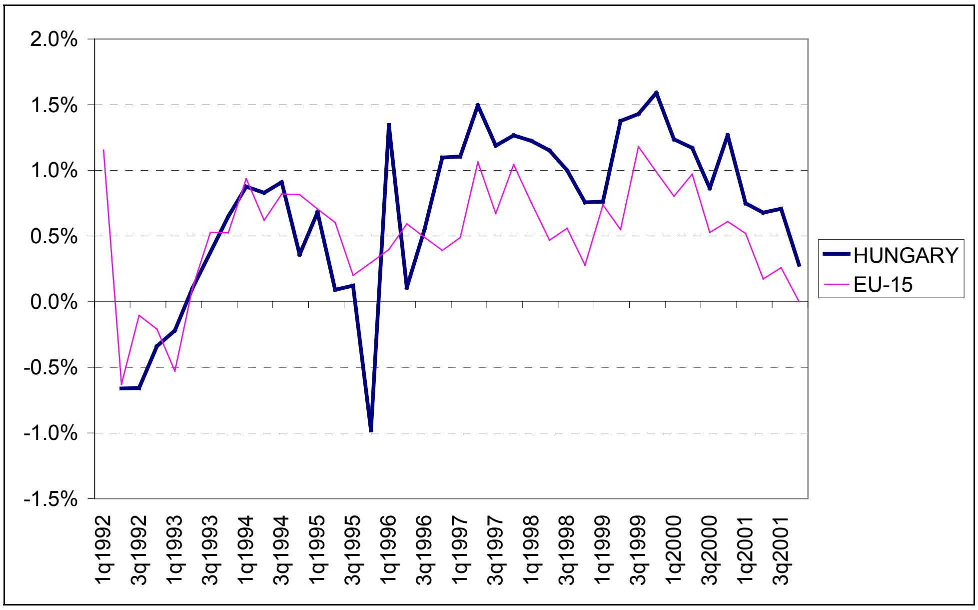
Detrended inflation series used in estimations



B) Figures of Section III

Figure 3

Quarterly real GDP growth in the 15 EU members and Hungary*



**Quarter-on-quarter growth rates, derived from the seasonally adjusted data. Data for Hungary for the period prior to 1995 Q1 are NBH estimates.*

Figure 4

Impulse responses – Blanchard-Quah model (left column: difference-stationary inflation, right column: trend-stationary inflation)

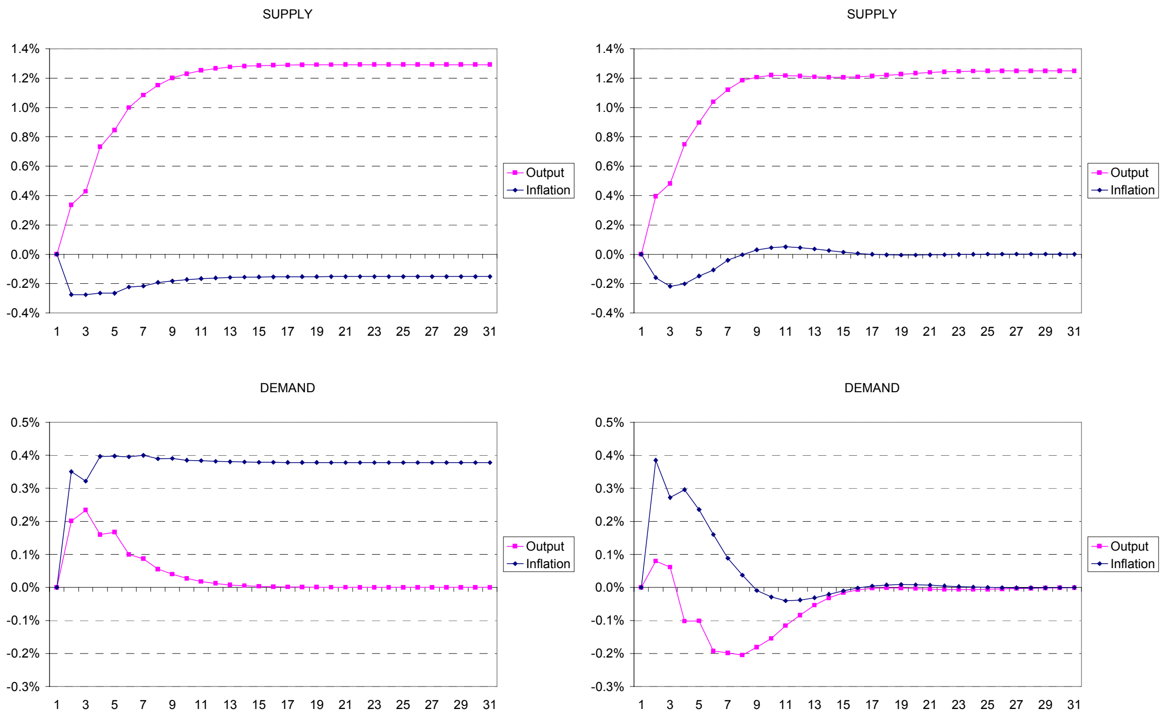


Figure 5

Forecast error variance decomposition – Blanchard-Quah model (left column: difference-stationary inflation, right column: trend-stationary inflation)

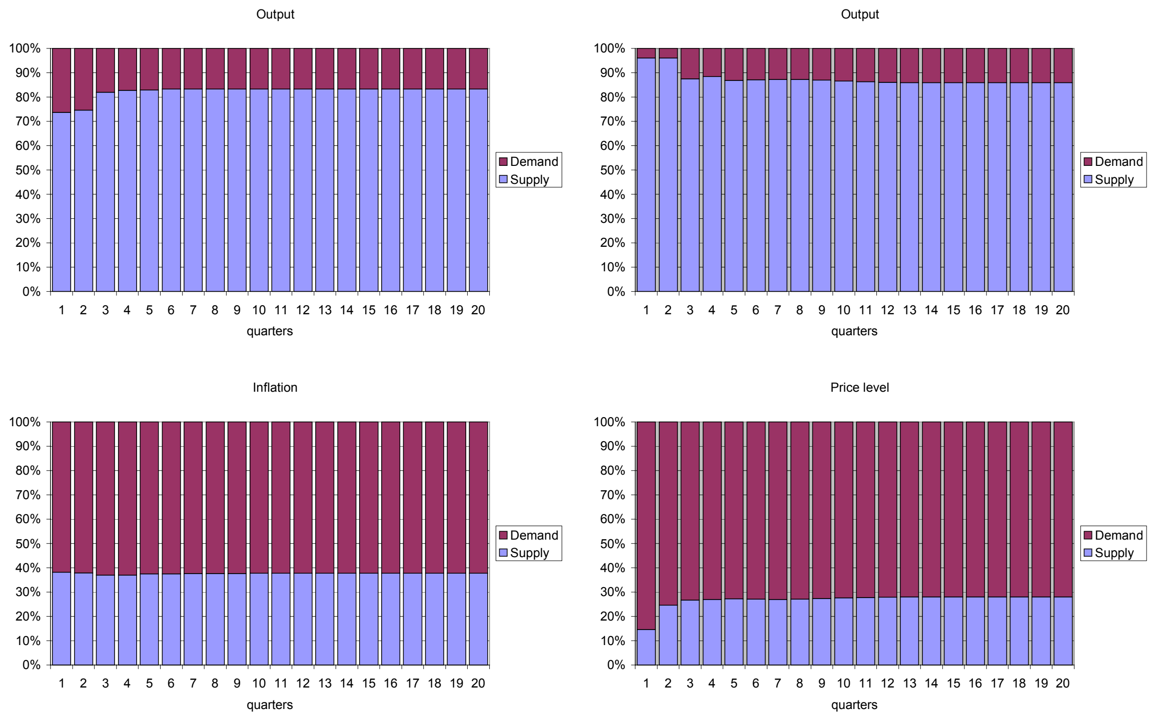
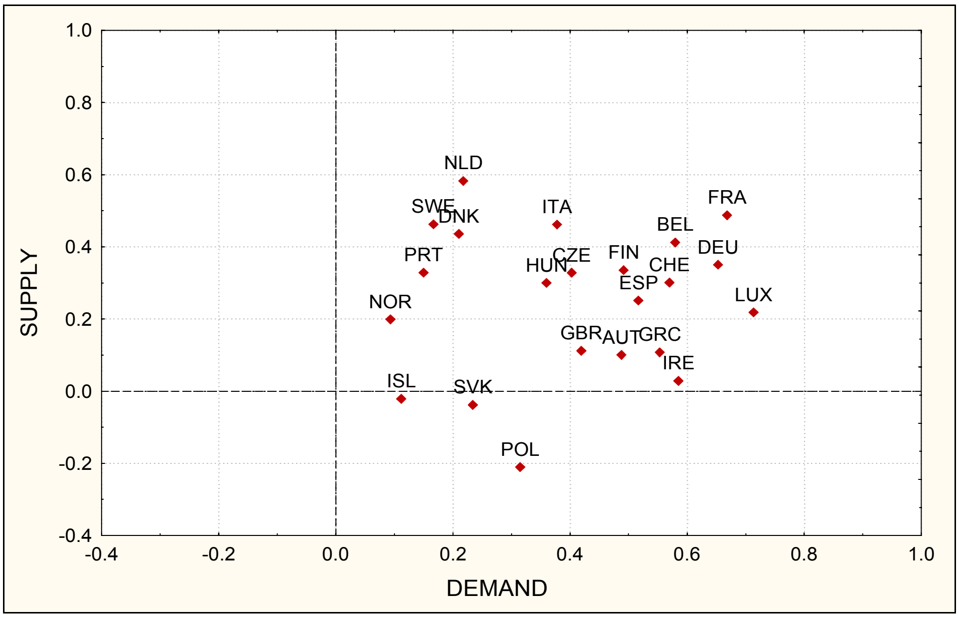


Figure 6

Correlations of demand and supply shocks with the European principal component, (1993 Q1 – 2000 Q4)



C) Estimation results of models with EU-output block

Figure 7

Impulse responses – Blanchard-Quah model (left column: difference-stationary inflation, right column: trend-stationary inflation)

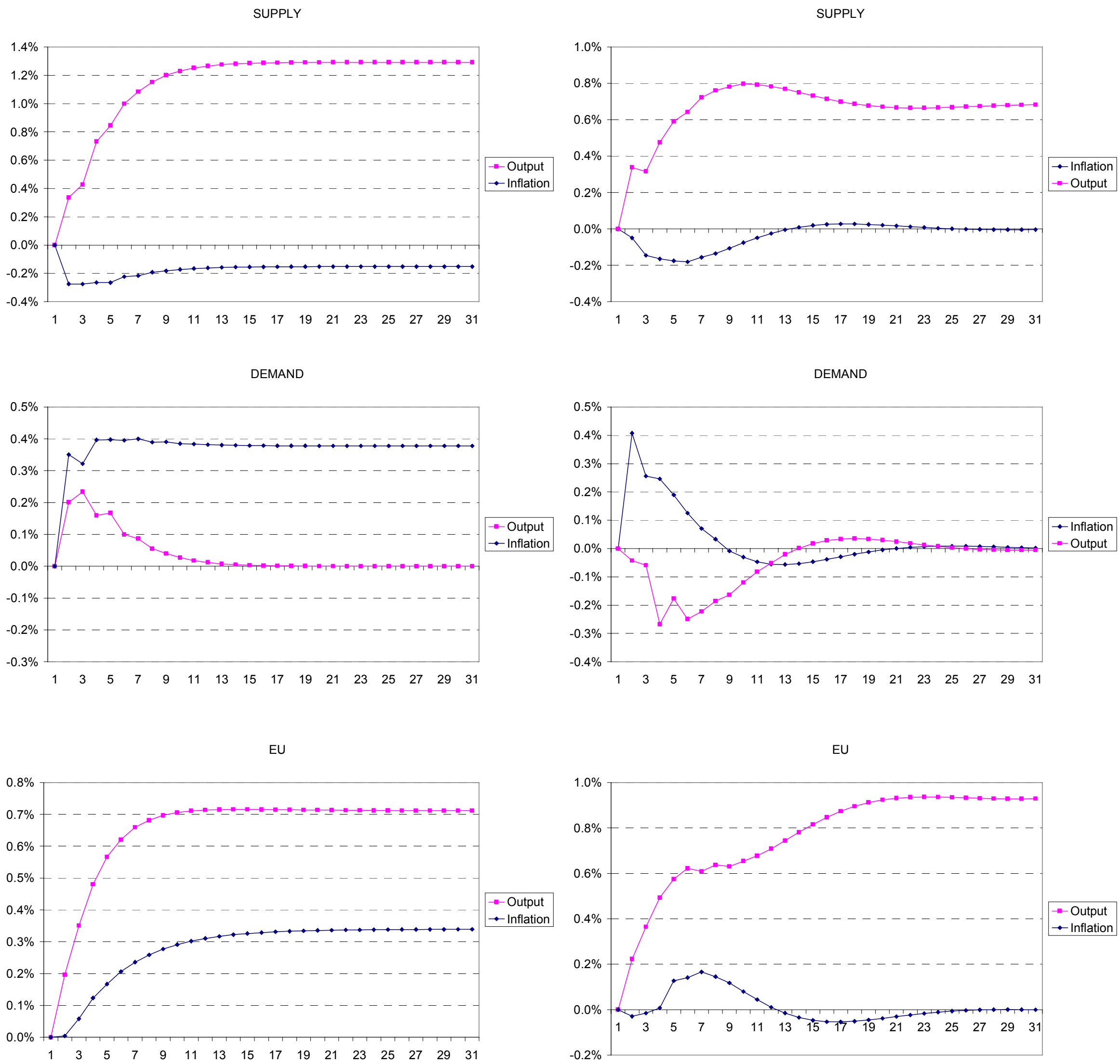


Figure 8

Forecast error variance decomposition – Blanchard-Quah model (left column: difference-stationary inflation, right column: trend-stationary inflation)

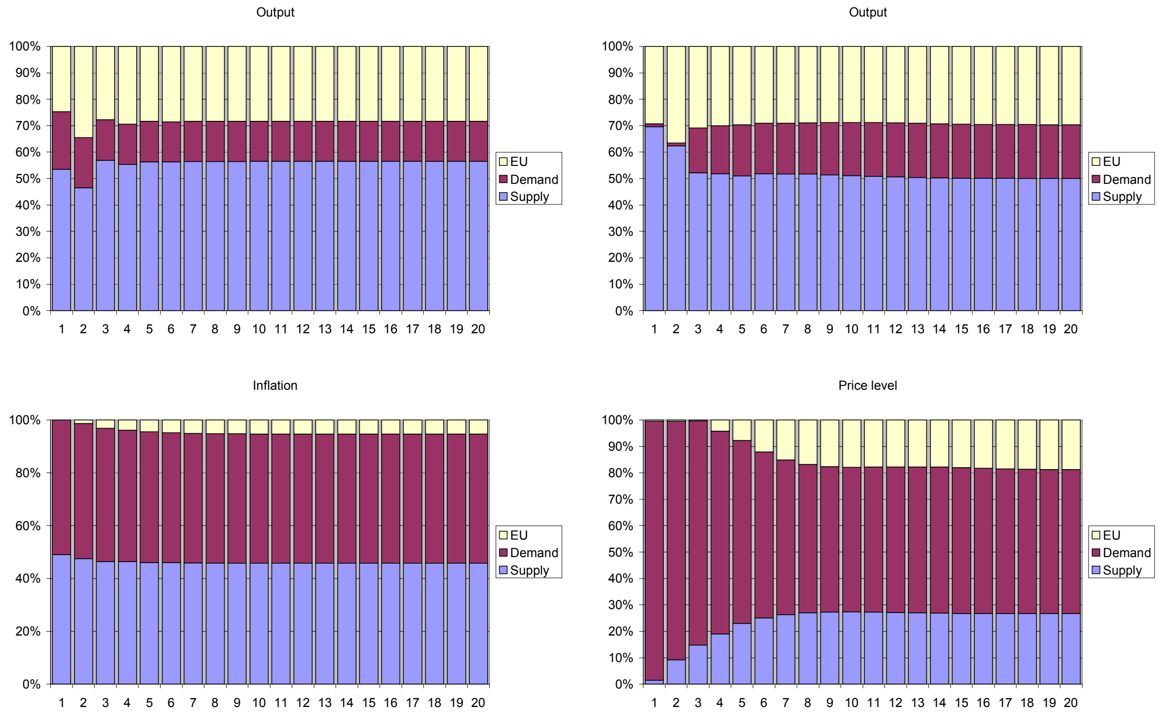


Figure 9

Impulse responses – Clarida-Gali model (left column: difference-stationary inflation, right column: trend-stationary inflation)

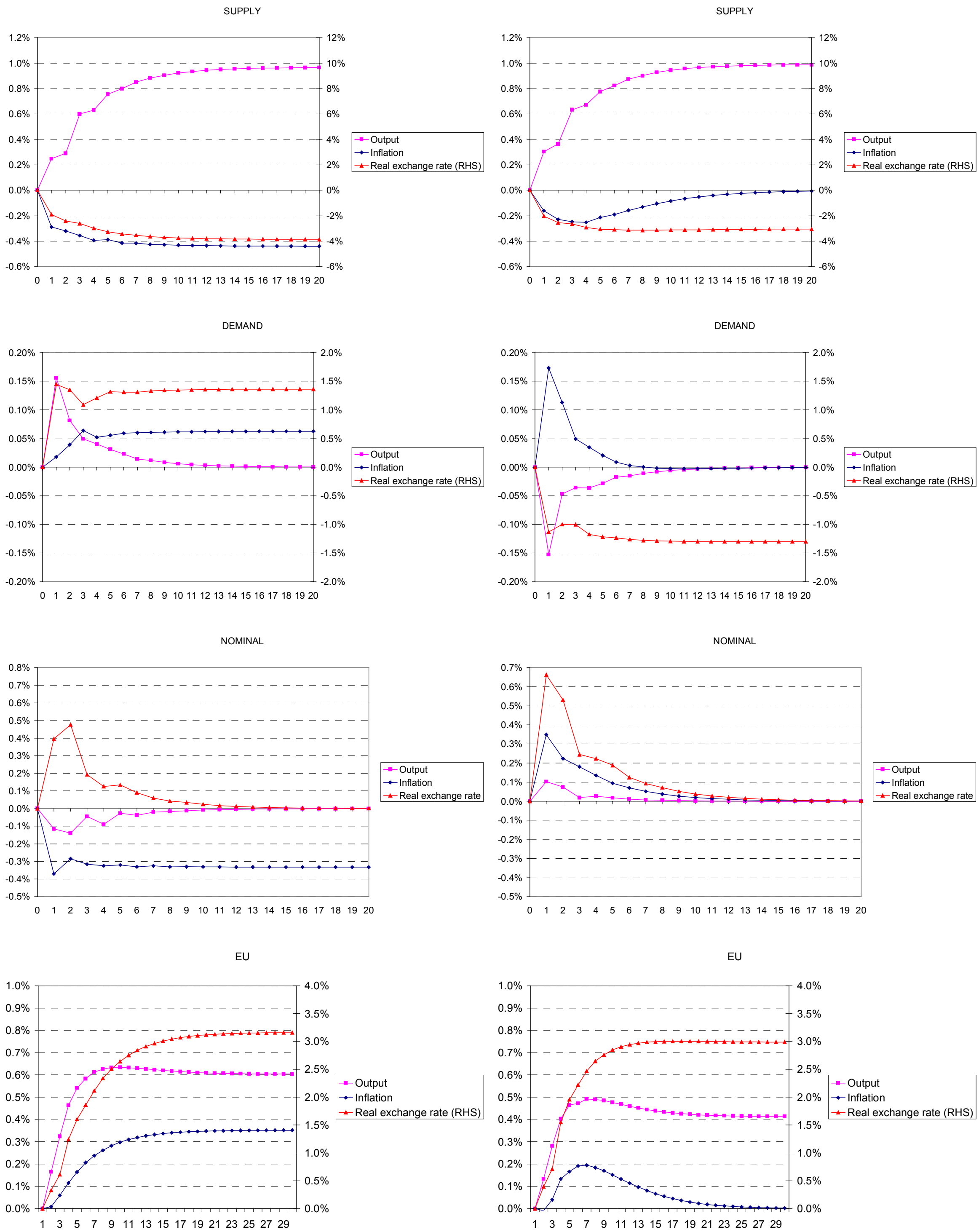


Figure 10

Forecast error variance decomposition – Clarida-Gali model (left column: difference-stationary inflation, right column: trend-stationary inflation)

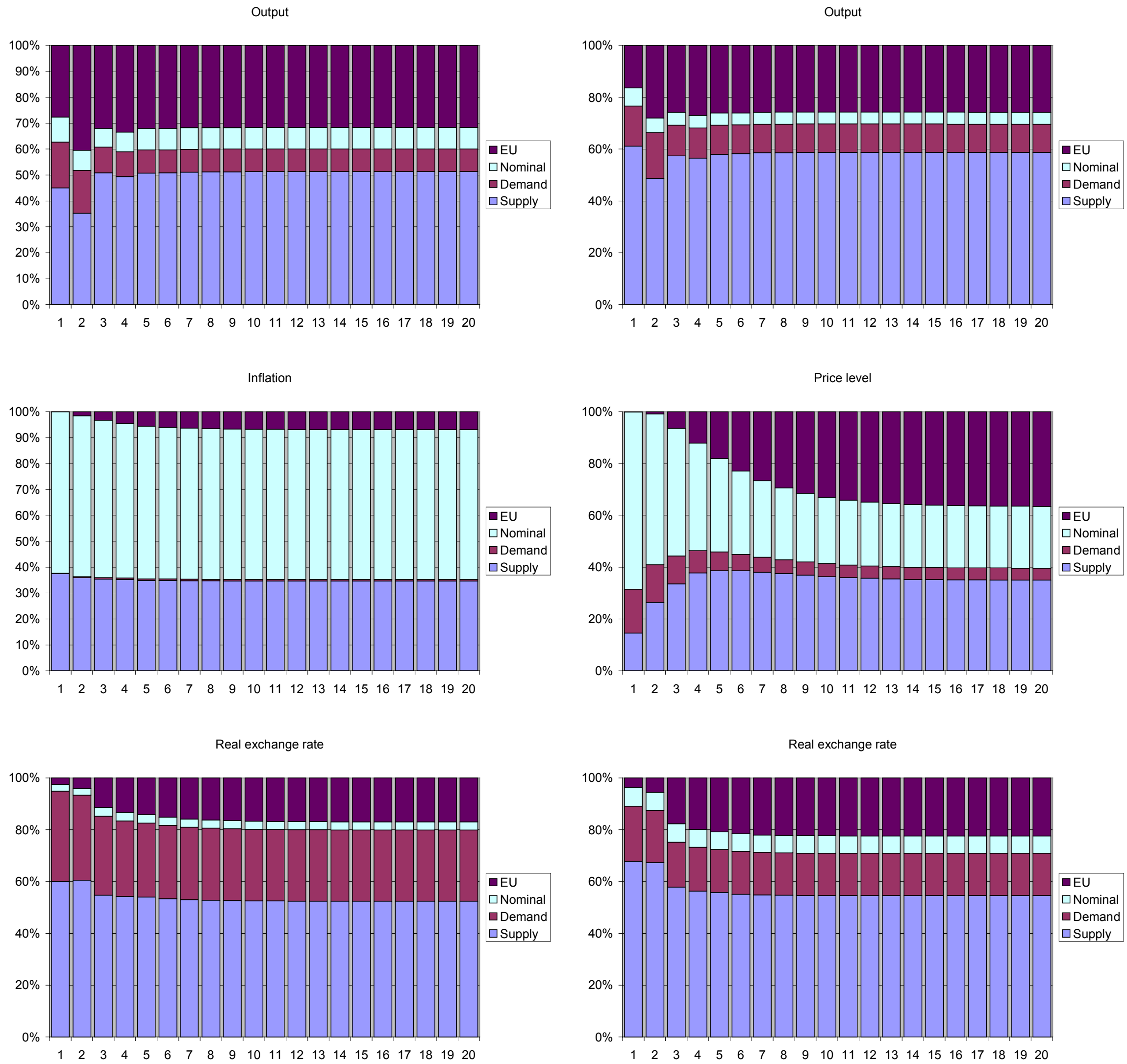


Figure 11

Impulse responses – Gerlach-Smets 3-variable model (left column: difference-stationary inflation, right column: trend-stationary inflation)

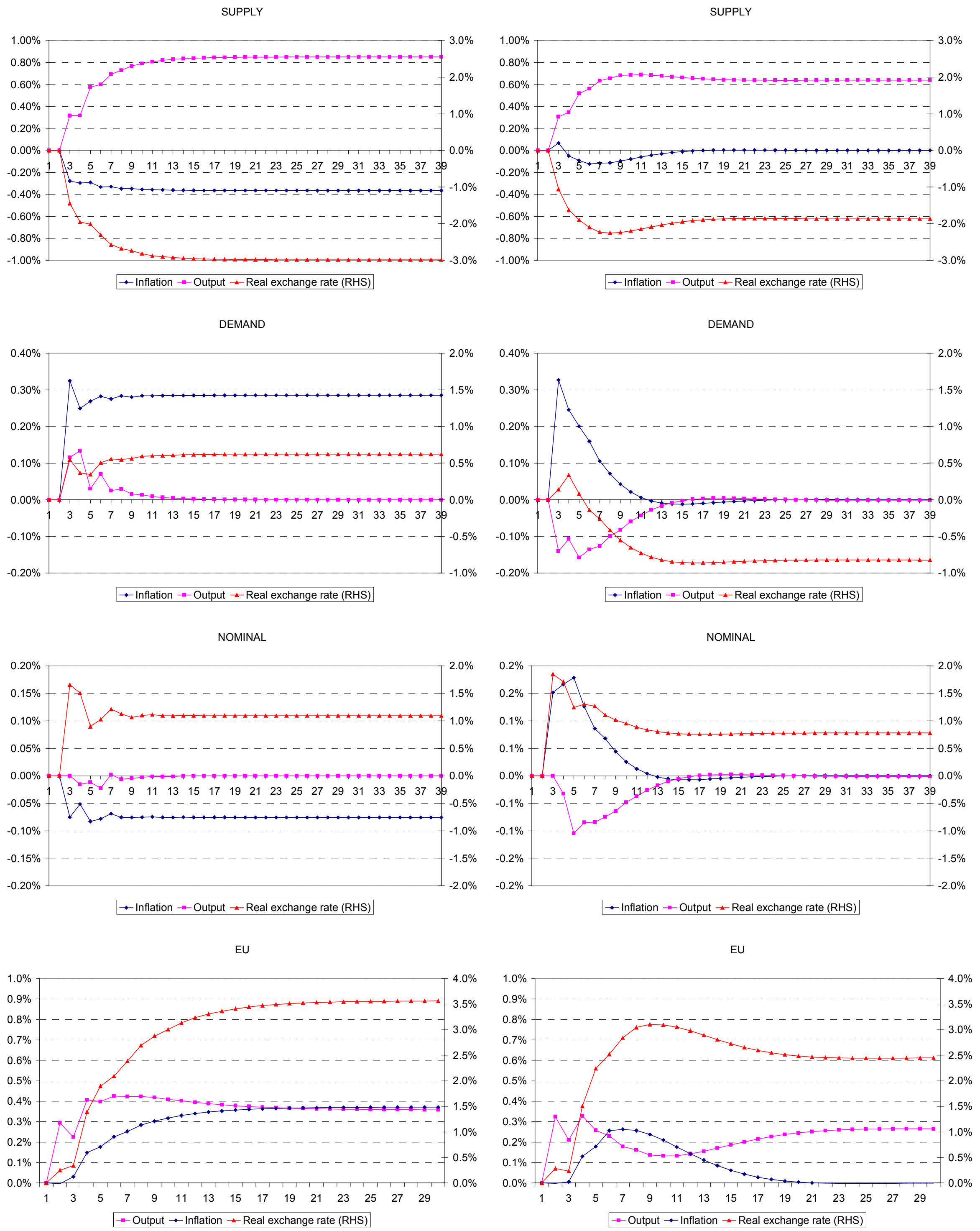


Figure 12

Forecast error variance decomposition – Gerlach-Smets 3-variable model (left column: difference-stationary inflation, right column: trend-stationary inflation)

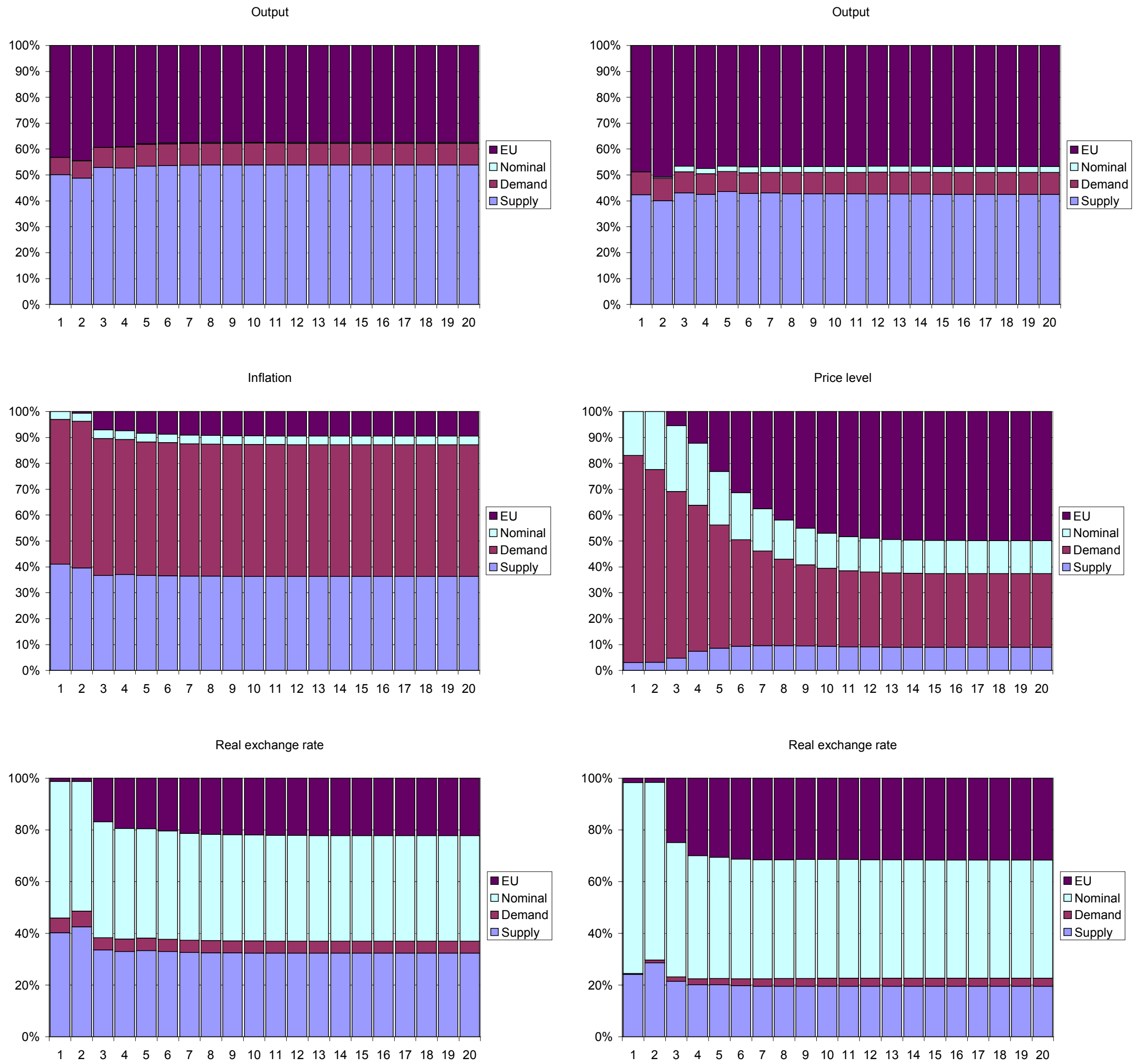
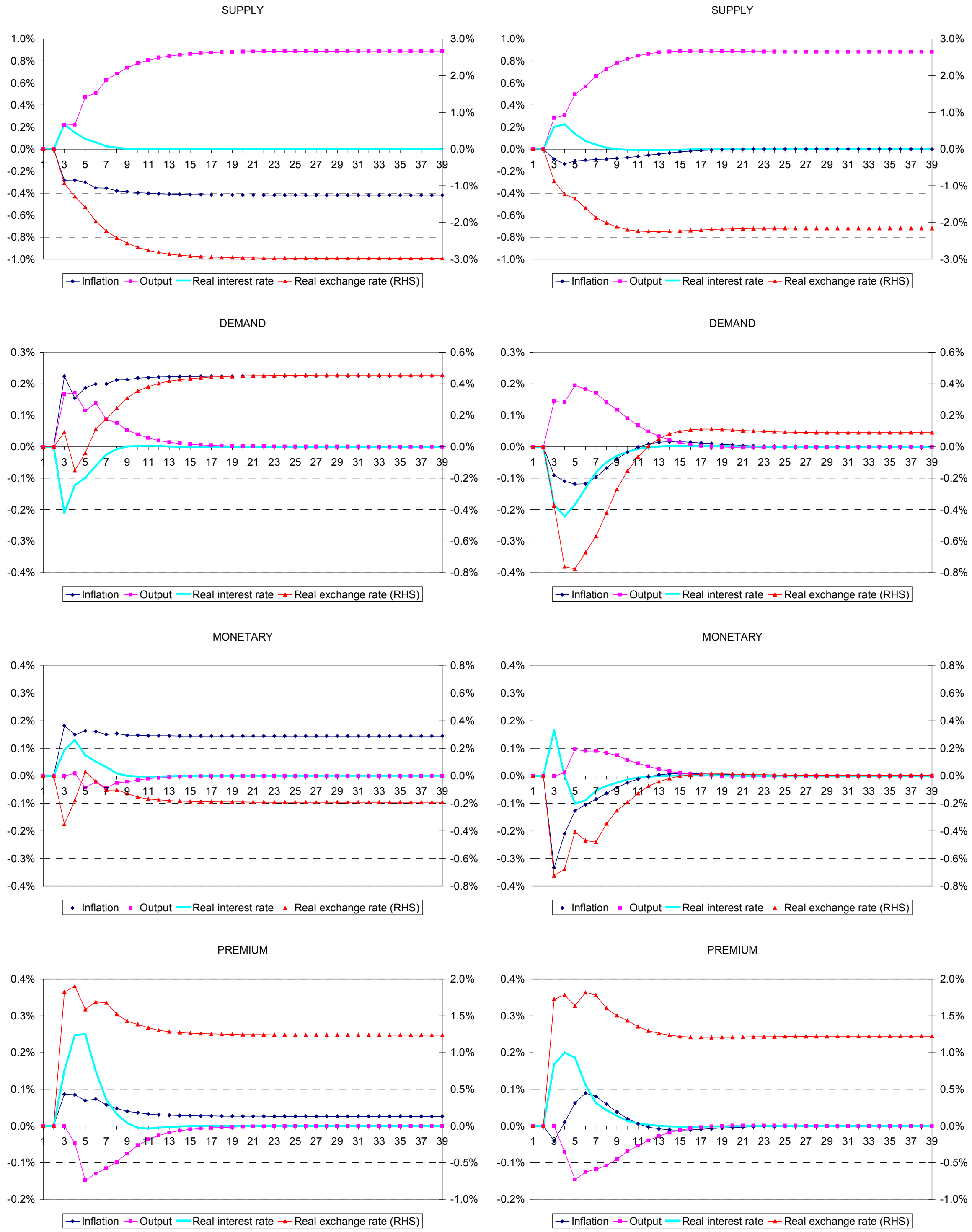
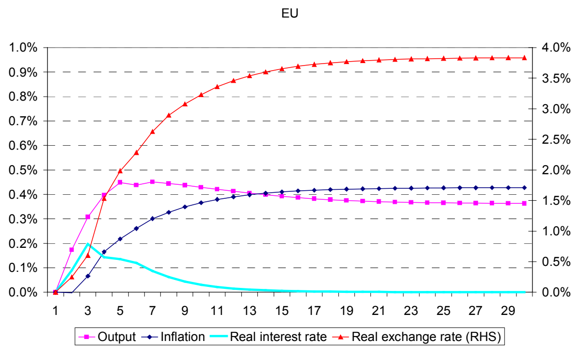


Figure 13

Impulse responses – Gerlach-Smets 4-variable model (left column: difference-stationary inflation, right column: trend-stationary inflation)




EU
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0.8%
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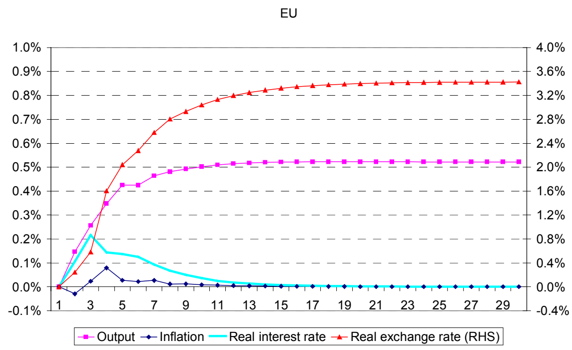
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
Output
Inflation
Real interest rate
Real exchange rate (RHS)


EU
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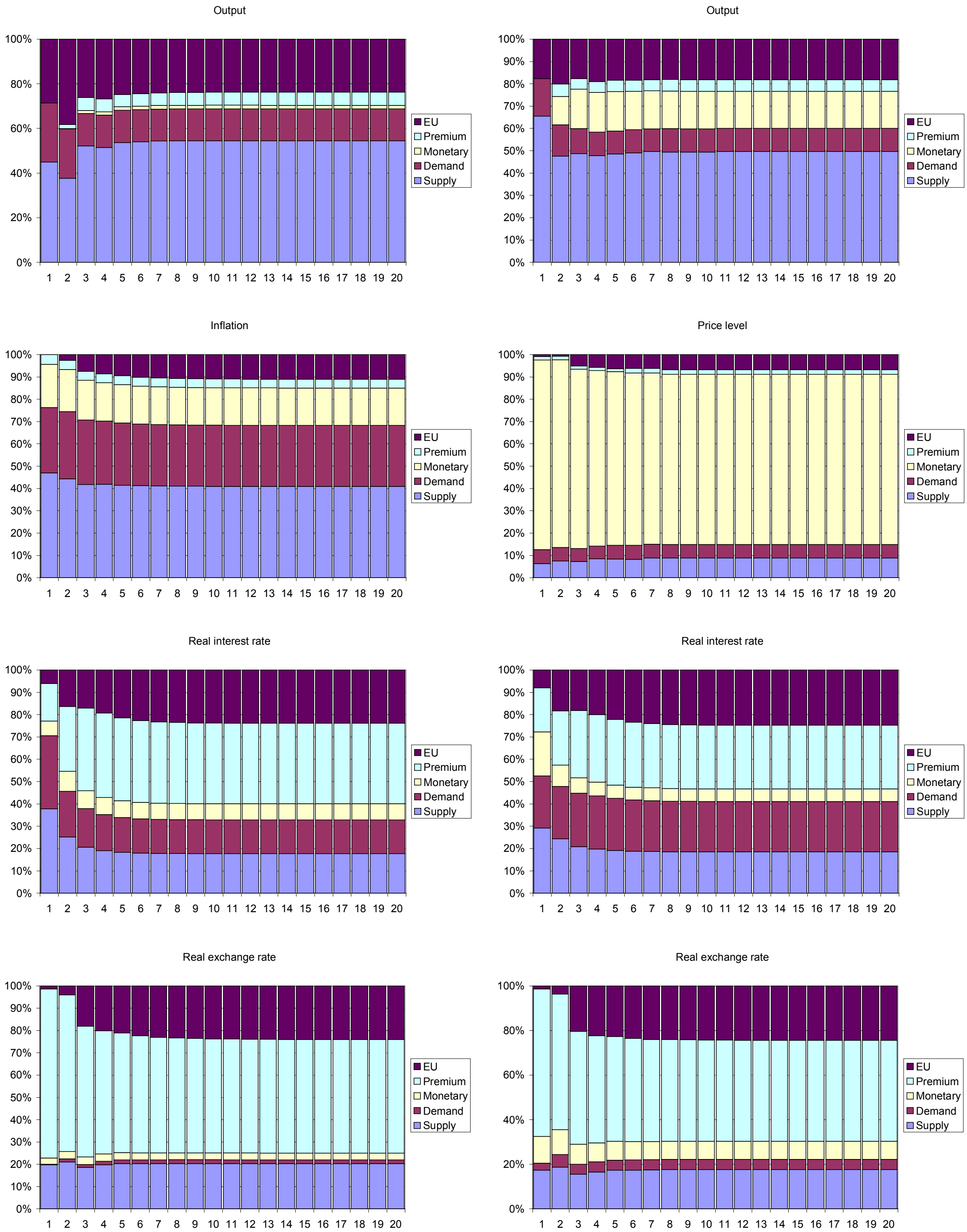
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
Output
Inflation
Real interest rate
Real exchange rate (RHS)

Figure 14

Forecast error variance decomposition – Gerlach-Smets 4-variable model (left column: difference-stationary inflation, right column: trend-stationary inflation)



D*) Correlation between estimated shocks and proxy variables*

Table 3

Supply shocks

Inflation		Difference-stationary				Trend-stationary			
		BQ	CG	GS3	GS4	BQ	CG	GS3	GS4
Difference-	Blanchard-Quah	**1.00**	**0.89**	**0.91**	**0.91**	**0.77**	**0.72**	0.50	0.59
stationary	Clarida-Gali	**0.89**	**1.00**	**0.81**	**0.81**	0.62	**0.90**	0.46	0.54
	Gerlach-Smets (3-var.)	**0.91**	**0.81**	**1.00**	**1.00**	**0.66**	**0.68**	0.46	**0.77**
	Gerlach-Smets (4-var.)	**0.91**	**0.81**	**1.00**	**1.00**	**0.66**	**0.68**	0.46	**0.77**
Trend-	Blanchard-Quah	**0.77**	0.62	**0.66**	**0.66**	**1.00**	0.55	**0.73**	0.60
stationary	Clarida-Gali	**0.72**	**0.90**	**0.68**	**0.68**	0.55	**1.00**	**0.69**	**0.67**
	Gerlach-Smets (3-var.)	0.50	0.46	0.46	0.46	**0.73**	**0.69**	**1.00**	**0.77**
	Gerlach-Smets (4-var.)	0.59	0.54	**0.77**	**0.77**	0.60	**0.67**	**0.77**	**1.00**

Table 4

Demand shocks

Inflation		Difference-stationary				Trend-stationary			
		BQ	CG	GS3	GS4	BQ	CG	GS3	GS4
Difference-	Blanchard-Quah	**1.00**	0.35	**0.96**	**0.87**	0.64	0.11	0.48	0.10
stationary	Clarida-Gali	0.35	**1.00**	0.47	0.37	-0.02	**-0.86**	-0.43	0.28
	Gerlach-Smets (3-var.)	**0.96**	0.47	**1.00**	**0.85**	**0.68**	-0.01	0.44	0.09
	Gerlach-Smets (4-var.)	**0.87**	0.37	**0.85**	**1.00**	0.45	0.02	0.27	0.54
Trend-	Blanchard-Quah	0.64	-0.02	**0.68**	0.45	**1.00**	0.37	**0.81**	-0.19
stationary	Clarida-Gali	0.11	**-0.86**	-0.01	0.02	0.37	**1.00**	**0.77**	-0.29
	Gerlach-Smets (3-var.)	0.48	-0.43	0.44	0.27	**0.81**	**0.77**	**1.00**	-0.34
	Gerlach-Smets (4-var.)	0.10	0.28	0.09	0.54	-0.19	-0.29	-0.34	**1.00**
	Budget deficit	0.03	0.13	0.09	0.04	0.30	-0.10	0.10	0.08
	(-1*) Trade Balance	0.40	0.28	0.40	0.47	0.04	-0.18	-0.11	0.35
	DEM-bond spread	0.13	0.42	0.29	0.08	0.10	-0.27	0.05	-0.17

Table 5

Nominal shocks

Inflation		Difference-stationary				Trend-stationary			
		CG	GS3	GS4 mon.	GS4 prem.	CG	GS3	GS4 mon.	GS4 prem.
Difference-	Clarida-Gali	**1.00**	-0.31	-0.36	0.06	**-0.75**	-0.10	**0.69**	0.31
stationary	Gerlach-Smets (3-var.)	-0.31	**1.00**	0.53	**-0.94**	-0.22	**-0.86**	0.13	**-0.99**
	Gerlach-Smets (4-var. monetary)	-0.36	0.53	**1.00**	-0.26	0.00	-0.40	0.02	-0.49
	Gerlach-Smets (4-var. premium)	0.06	**-0.94**	-0.26	**1.00**	0.42	**0.91**	-0.32	**0.94**
Trend-	Clarida-Gali	**-0.75**	-0.22	0.00	0.42	**1.00**	**0.66**	**-0.89**	0.24
stationary	Gerlach-Smets (3-var.)	-0.10	**-0.86**	-0.40	**0.91**	**0.66**	**1.00**	-0.60	**0.86**
	Gerlach-Smets (4-var. monetary)	**0.69**	0.13	0.02	-0.32	**-0.89**	-0.60	**1.00**	-0.13
	Gerlach-Smets (4-var. premium)	0.31	**-0.99**	-0.49	**0.94**	0.24	**0.86**	-0.13	**1.00**
	DEM-bond spread	-0.01	-0.50	0.01	0.60	0.17	0.50	-0.21	0.50
	Budget deficit	0.01	-0.16	-0.43	0.09	0.21	0.25	-0.31	0.15

Bold numbers denote significantly non-zero values at 99%-level. Critical values for significance at 90, 95, 99% are (±) 0.44, 0.51 and 0.64 respectively. (two-sided tests; sample size: 28)

E) Some reasonable modifications of the Obstfeld open economy model

Here we demonstrate the consequences of changing the assumptions incorporated in the model Clarida and Gali (1994) used. The modifications we make are reasonable considering the features of Hungarian economy during the '90s.

The original model consisted of IS, LM, UIP and price setting equations. Since here we restrict our interest to the long run properties, we assume flexible prices and ignore the price setting behaviour, which influences only the short run dynamics. All variables except interest rates are in logs and represent home relative to foreign levels.

$$y_t = d_t + \eta q_t - \sigma\left(i_t - E_t \pi_{t+1}\right) \tag{A1}$$

$$i_t = E_t\left(s_{t+1} - s_t\right) \tag{A2}$$

$$m_t - p_t = y_t - \lambda i_t \tag{A3}$$

Equation (A1) is the IS equation where *y, q, i, π* denote the (relative) output, the real exchange rate, the (relative) nominal interest rate and the (relative) consumer inflation ($\pi = \Delta p$), respectively. *d* is the exogenous component of demand. Equation (A2) describes the uncovered interest parity (UIP), and *s* is the nominal exchange rate ($s = q + p$). The last equation is the standard LM equation, where *m* denotes the money supply.

All the three exogenous variables (*y, d, m*) contain unit root and are governed by the structural supply, demand and nominal shocks:

$$y_t = y_{t-1} + \varepsilon_t \tag{A4}$$

$$d_t = d_{t-1} + \delta_t - \gamma \delta_{t-1} \tag{A5}$$

$$m_t = m_{t-1} + \nu_t \tag{A6}$$

It is easy to show that the rational expectations solution of this system is the following:

$$y_t = y_t \tag{A7}$$

$$p_t = m_t - y_t + \left(\frac{\lambda\gamma}{(1+\lambda)(\eta+\sigma)}\right)\delta_t \tag{A8}$$

$$q_t = \frac{1}{\eta}\left(y_t - d_t\right) + \left(\frac{\sigma\gamma}{\eta(\eta+\sigma)}\right)\delta_t \tag{A9}$$

In the long run only the price level is affected by all three shocks, while demand shocks have only temporary impact on output, and nominal socks have only temporary impact on both output and real exchange rate. These properties serve as a base to the Clarida-Gali identification scheme.

There are reasons to believe that this model doesn't capture some important features of Hungarian economic development during the '90s. In addition to the high persistence in inflation, the historical evidence of the prominent role of risk premium drives us to alter the framework.

The first modification concerns the uncovered interest parity equation. We supplemented it with a premium term (ρ), which represents the excess yield investors require from HUF denominated assets as a compensation for the excess exchange rate, default etc. risk:

$$i_t = E_t\left(s_{t+1} - s_t\right) + \rho_t \tag{A2'}$$

We treat the premium as exogenous.

The second modification concerns the monetary policy. In Clarida and Gali (1994) the monetary policy was not explicitly modelled, its role was limited to be the one of the possible sources of nominal shocks taking effect through the money supply. Since one plausible explanation for the (nearly) non-stationarity of Hungarian inflation during the '90s is that the implicit inflation target of the monetary policy was itself non-stationary[15], we tried to introduce such a behaviour into the model directly. This attempt was made through replacing the LM equation with a Taylor-type policy rule equation.

For simplicity, we dropped the output term from the original formulation used in Taylor (1993). We took changing inflation target into account by letting it (π*) to vary from period to period:

$$i_t = E_t \pi_{t+1} + \varphi\left(\pi_t - \pi^*_t\right) \tag{A3'}$$

The long run behaviour of endogenous variables is influenced to a large extent by the specification of exogenous processes. We allow the risk premium (ρ) to follow either random walk or stationary AR(1) process, but similar to Clarida and Gali (1994) the (natural rate of) output (y) and autonomous demand (d) is supposed to contain a unit root. For simplicity, we don't include partial correction term in the specification of the latter (i.e. $\gamma = 0$ in (A5)). We describe the evolution of inflation target as a random walk with downward drift. The four exogenous processes:

$$y_t = y_{t-1} + \varepsilon_t \tag{A4'}$$

$$d_t = d_{t-1} + \delta_t \tag{A5'}$$

$$\rho_t = \beta_\rho \rho_{t-1} + \nu_t \tag{A6'}$$

$$\pi^*_t = \pi^*_{t-1} - \phi + \mu_t \tag{A10}$$

Within the framework of this small model we have essentially four endogenous variables (*y, p, i* or *r, q*) and four sources of exogenous shocks: disturbances of supply (ε), demand (δ), monetary policy (μ) and risk premium (ν). In our setup two nominal shocks are distinguished: monetary policy shocks influence the inflation target, premium shocks have effect through the UIP condition. Solving equations (A1)-(A2')-(A3') by using (A4')-(A5')-(A6')-(A10) and assuming rational expectations we get the 'flexible price' solutions for inflation and real exchange rate:

$$\pi_t = \frac{1}{\varphi}\left(1 + \sigma \frac{1-\beta_\rho}{\eta + 1 - \beta_\rho}\right)\rho_t + \pi^*_t \tag{A11}$$

[15] For a deeper analysis of Hungarian monetary policy reaction function see Csajbók and Varró (2001).

$$q_t = \frac{1}{\eta}\left(y_t - d_t\right) + \sigma \frac{1}{\eta + 1 - \beta_\rho} \rho_t \tag{A12}$$

The most significant change relative to the Clarida-Gali model is the prominent role of risk premium. Its long run effect depends on the β_ρ parameter: if it's less than unity, the premium shocks die out from both endogenous variables with the same speed as they disappear from the risk premium itself. In contrast, if the premium follows random walk, its shocks permanently changes the level of inflation and real exchange rate, too[16]. We consider this point as relevant in case of Hungary, because some indicators of Hungarian risk premium, such as DEM-denominated sovereign bond spreads, etc. showed highly persistent dynamics during the '90s.

The second interesting result is that the supply and demand shocks have no permanent effect on the level of inflation. This finding may question the validity of our identifying restrictions (and those of many other authors), but also may be attributed to the simplicity of the model. It's also clear from (A11) that inflation fully moves together with inflation target, so if monetary shocks make the latter permanently deviate, they have the same long-term impact on inflation. With other words: even in the absence of demand, supply and premium shocks, permanent shocks to inflation target can cause non-stationary inflation.

[16] The former effect may seem counterintuitive, thus it requires some explanation. This phenomenon could be understood from the monetary policy rule. If – from example – the central bank let the higher level of risk premium to appear fully in interest rates, the rule would imply a higher inflation consistent with higher interest rates. This is due to the facts, that our 'disinflationary' inflation target doesn't respond to inflationary and premium shocks and that the interest rate policy doesn't directly responds to premium shocks.