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How Important Is the Shock-Absorbing Role of the Real Exchange Rate?

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Abstract

For a better understanding of the shock-absorbing role of the real exchange rate this paper distinguishes between permanent and transitory asymmetric real shocks as sources of its variation. The former are a sign of divergent economic developments, which implies that the real exchange rate can have a shock-absorbing potential only for the latter. For the countries analyzed, Hungary, the Czech Republic, Slovenia, Denmark and the United Kingdom, the real exchange rate does not have a shock-absorbing role. More importantly, the paper identifies significant divergent economic developments in the first three countries that are due to the catching-up process likely to persist in the future. This has some important implications for their strategy to enter the EMU.

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1 Introduction

The process of EU enlargement, which is nearing rapidly, represents a major challenge for the EU member countries and the Accession Countries (ACs). One but important aspect is the ensuing process of joining the EMU, as accession also involves a commitment to enter the EMU at a later date (i.e. for the ACs no opt-out option is available). Associated loss of the exchange rate as an instrument of macroeconomic adjustment represents the second challenge for the ACs. Although the literature associates a single currency with considerable benefits, it could prove costly due to asymmetries between national shocks when a country relinquishes the exchange rate as a shock absorber. For the ACs, with GDP per capita levels well below the EU average, potential costs deserve special consideration.[1] This paper provides an empirical investigation of costs by looking at the sources of real exchange rate variation. Even though we can expect ongoing changes in the economies of the ACs in the period to accession and beyond, we will maintain the assumption that the lessons that can be learned from past economic developments are relevant for the likely consequences of enlargement.

The main source of costs are asymmetric (or idiosyncratic) real shocks.[2] Asymmetric shocks cause divergent movements of output in different countries and thus require different monetary policy measures. A country with independent monetary policy can use its exchange rate as an instrument (provided that it is not rigidly fixed) to shelter the competitiveness of the economy and stabilize output.[3] Efficiency of the nominal exchange rate as a macroeconomic stabilizer implies that the

[1] PPP adjusted GDP per capita in Slovenia reaches 72% of the EU average. This number is between the levels of Greece and Portugal. The avrerage for the ACs as a whole is below 40%.

[2] Considerable costs can arise also due to asymmetries in the national transmission mechanisms of monetary policy. See Ehrmann, (1998) or de Grauwe (2000).

[3] If prices were perfectly flexible then the issue of the shock-absorbing role of the real exchange rate would be irrelevant. But the assumption of staggered price adjustment is closer to reality. In similar vein, we cannot speak about sufficient labor market flexibility that would reduce the problem of asymmetric real shocks in the EMU.

real exchange rate is an efficient *shock absorber* (Artis and Ehrmann, 2000). By fixing the nominal exchange rate the country incurs real costs as it loses an important tool for macroeconomic stabilization. If, on the contrary, the real exchange rate proves to be inefficient as a shock absorber, a country can exploit the benefits of the monetary union without being exposed to any additional costs. Moreover, if the country is mainly subject to asymmetric nominal shocks (which could also originate in the foreign exchange market), monetary union actually effectively removes the source of shocks. In other words, the real exchange rate is an efficient shock absorber if it responds in similar proportions to the same real (supply and demand) asymmetric shocks that significantly affect output. Empirical analysis is oriented towards identifying this characteristic. By concentrating on the real exchange rate rather than just on the nominal exchange rate, the analysis also takes into account the adjustment through prices.

It is important to emphasize that it is only for asymmetric shocks that the exchange rate needs to take on the role of shock absorber. I propose an additional criterion to gauge the shock-absorbing role of the real exchange rate: transitoriness of the shocks. The reasoning presented thus far is correct only under the assumption that all the asymmetric shocks imply a loss of competitiveness. Structural models of real exchange rate determination, presented in section 2, recognize permanent shocks that do not necessarily imply a loss of competitiveness. A permanent deviation of the real exchange rate that these shocks cause should rather be seen as an equilibrium process, which cannot be reverted by monetary policy. In Appendix A I present a simple theoretical model that justifies this notion.

If a country is subject to permanent asymmetric real shocks, then a monetary union will impose real costs not due to the loss of an important stabilizing tool, but because it will exhibit divergent economic developments relative to other members of the union. The critical point here is that centrally managed monetary policy in such cases amplifies the divergences. The ECB, targeting Euro-area wide aggregates, may in such circumstances act procyclically on the economy of the divergent country.[4] This leads to the conclusion that the shock-absorbing role of the real exchange rate should be analyzed only for transitory asymmetric real shocks. If transitory asymmetric real shocks are an important source of output variations, then the shock-absorbing power of the real exchange rate should be an important factor in a country's decision to join a monetary union. If, on the other hand, short-run output variation is dominated by permanent shocks, then the decision should not be based on shock-absorbing argument, but on the potential consequences of divergent economic developments. The results presented below emphasize this distinction.

In an empirical analysis this requires a decomposition of the analyzed system of variables into its permanent and transitory components. The common trends model developed by Warne (1993) proves to be very suitable for this purpose. The P-T decomposition is based on identified cointegrating relations and at the same time the model allows the identification of permanent and transitory components of all three types of structural shocks: supply, demand and nominal. In addition, such decomposition also enables a better comparison of competing models of real exchange rate determination.

Sources of real exchange rate variations (and the shock-absorbing role) have been traditionally analyzed by means of a structural VAR (SVAR). Based on the approach developed by Clarida and Gali (1994), other authors, such as Thomas (1997), Funke (2000), and Artis and Ehrmann (2000), employ a SVAR on first-differenced data. I argue that, by neglecting the information contained in the cointegrating properties and P-T decomposition of the data, the above-mentioned studies use, first, a potentially misspecified model to analyze the sources of real exchange rate variations and, second, do not fully take into account the theories of real exchange rate determination. With regard to the first point, note that a model estimated only in first differences in presence of cointegration omitts the level term Πy_{t-1}, where the matrix Π is reduced rank. Without this term the system has a different moving average

[4]An interesting example of procyclical monetary policy stances on national level in the EMU can be found in Björkstén and Syrjänen (1999).

representation and an incorrect impulse response function.

The second point follows from the underlying theoretical model in Clarida and Gali (1994). Their model is a version of Obstfeld's (1985) open-economy model, in which only permanent supply and nominal shocks are present. Because permanent demand shocks in the theoretical model do not have an effect on the real exchange rate, transitory demand shocks are also allowed in order to obtain demand shocks as another source of real shocks that affect the real exchange rate. However, the demand shocks empirically identified in the system in first differences are a linear combination of first differenced permanent *and* transitory demand shocks, such that it is not clear whether the structural shocks empirically identified are permanent or transitory and whether the results comply with the underlying theoretical model. This could lead to misleading conclusions about the shock-absorbing role of the real exchange rate.

The second aim of the present paper is to use the empirical results to derive some policy implications about the timing and procedures of joining the EMU. In particular, this study argues that the Maastricht criteria might be inappropriate as a convergence criteria for the ACs. Macroeconomic development in the catching-up process might prove to be in conflict with the Maastricht inflation criteria. Faced with an inflation differential due to the Balassa-Samuelson effect, the ACs will have to trade growth (real convergence) for nominal convergence.

Transition specific economic developments make the methodological approach proposed in this paper particularly important for the ACs. Structural theories of real exchange rate determination offer in this case a better explanation of macroeconomic behavior (Coricelli, Jazbec, 2001). However, since the weakness of existing studies cannot be made apparent only by looking at transition specifics, I use the common stochastic trends model not only for Hungary, the Czech Republic and Slovenia, but also for Denmark and the UK. The latter countries are of special interest because they have chosen not to be part of the EMU. For each country the system of variables consists of an output measure (index of industrial production), CPI based measure of the real exchange rate, domestic and foreign inflation, and domestic and foreign (German) nominal 3-month interest rate in the period 1993-2001. High frequency data (monthly basis) are used due to the data intensive econometric technique employed.[5]

The paper is organized as follows. Section 2 offers an overview of the relevant theoretical issues for the analysis of sources of real exchange rate variations and the shock-absorbing power of the real exchange rate. In Section 3 I present an overview of existing empirical studies. Section 4 presents the econometric methodology and the data. Section 5 presents the results, and section 6 concludes.

2 Persistence of Real Exchange Rate Movements

A broad consensus nowadays in the literature is that the real exchange rate movements exhibit high persistence. Thus PPP is far from holding instantaneously. A higher real exchange rate in more developed countries is another stylized fact, implying also that higher growing countries experience real appreciation. Froot and Rogoff (1995) offer a survey of theories on PPP and long-run real exchange rate behavior. They report inconclusive empirical evidence on PPP in the long run. This leads them to suggest two broad guidelines for further research in this field; one being the use of more powerful econometric techniques, the second being the issue of survivorship bias. By using the common stochastic trends model and by analyzing the ACs, this paper contributes to both areas of research.

The major development in terms of the econometric techniques since 1995 has been the use of panel unit-root tests and panel cointe-

[5]The data are collected from IMF IFS database. Apart from the industrial production index for Slovenia, all the data are seasonally unadjusted. For Slovenia no sufficiently long series for the 3-month T-bill rate is available and money-market rate was used as the second best choice.

gration procedures. Not surprisingly, these new techniques have been most widely used to test PPP, and tend to provide a stronger support for PPP hypothesis. However, as Banerjee et al. (2001) demonstrate, this test can be very over-sized in the presence of long-run cross-unit relationships, so that the null hypothesis of a unit root is rejected very often, even if correct. Similar evidence can be found in Engel (2000).

Structural models of deviations from PPP emphasize more fundamental supply and demand factors that cause the real exchange rate to deviate permanently from its previous level. The Balassa-Samuelson effect induces a systematic permanent component into the real exchange rate through the effect of productivity growth differential between tradeable and non-tradeable sector on the relative price of traded to non-traded goods. An important result from Rogoff (1992) is that temporary productivity shocks in the tradeable sector also introduce a unit root in the real exchange rate if agents use international capital markets to smooth their consumption of tradeables.

Intertemporal optimizing models (Lane and Milesi-Ferretti (2000)) suggest that higher net foreign assets induce an appreciation of the real exchange rate. Very important also are the models that emphasize the demand side effects. These can have a persistent effect on real exchange rate if capital and labor are not instantly mobile across sectors. Froot and Rogoff (1991), De Gregorio, Giovannini and Wolf (1994) and Rogoff (1992) concentrate on the role of government spending, which is commonly seen as falling disproportionately on non-tradeable goods. There can be a similar effect of private sector demand and changes in consumer preferences.

In the literature, pricing to market behavior is also suggested as an explanation of real exchange rate movements. Obstfeld and Rogoff (2000), however, propose the role of the distribution sector in prices as a better explanation. Their conclusions are empirically confirmed by MacDonald and Ricci (2001), who find the effects of the distribution sector to be very similar to the Balassa-Samuelson effect.

Many open economy macroeconomic models, such as the Mundell-Fleming-Dornbusch model, link the changes in the real exchange rate to real interest rate differentials. These are likely to be transitory and should account for some variation of the real exchange rate around its long-run trend. From the empirical eveidence on PPP and from the brief descriptions of models of real exchange rate determination above, it follows that a proper analysis requires a permanent-transitory decomposition of the real exchange rate and of other variables chosen in the analysis. In addition, because permanent deviations from PPP are theoretically plausible, the decomposition should be based on cointegrating relations.

Structural models of real exchange rate determination provide a very good explanation of the commonly observed trend of real exchange rate appreciation in the ACs. Because the results of the analysis for the three candidate countries are of particular interest in this paper, I describe the transition specific determinants of the real exchange rate separately in the next subsection.

2.1 Real Exchange Rate Determination in the ACs

It can be commonly observed for the ACs that the real exchange rate followed a typical transition pattern: following initial undervaluation, the real exchange rate relative to the EU subsequently appreciated. Figure 1 plots the real exchange rate for the countries under study relative to Germany in the period 1992-2001. There is a clear tendency to appreciate for all the ACs, while this is not the case for Denmark and the UK. Roubini and Wachtel (1998) offer two broad explanations. First, the appreciation was a response to the initial undervaluation of the real exchange rate. And second, with changes in fundamentals the real equilibrium exchange rate embarked on a path of trend appreciation in line with structural models of the real exchange rate. Following Halpern and Wyplosz (1996) and Kraynjak and Zettelmeyer (1997) we can outline five main factors determining the real exchange rate path in transition economies.

First, after the initial drop, income started to rise again as formerly inefficient production lines responded to market forces by rapid productivity increases. The disproportionate increase in demand for non-tradeables that followed resulted in appreciation of the real exchange rate. (De Gregorio, Giovannini, and Wolf, 1994). Second, the productivity differential between the tradable and non-tradable sectors has been increasing since the early days of transition. Trend appreciation of the real exchange rate then follows according to the Balassa-Samuelson effect.

Third, price liberalization had a similar effect. Most of the natural resource prices as well as public utility prices in transition economies were administered. The general price level in transition economies was for this reason below the price levels in countries with comparable PPP-adjusted GDP. Real appreciation following price liberalization can thus be seen as adjustment to a new unregulated equilibrium. Fourth, the tax reform in transition economies changed most of the relative prices. The tax reform was needed to increase the efficiency of the fiscal system in face of the changes in economic systems.

Finally, increase in productivity induced an increase in high potential returns on capital. The dynamics of the transition process warranted the potential long-run gains, which attracted foreign capital either in the form of direct investment or as a portfolio investment in emerging stock markets. Central banks have normally engaged in sterilized intervention and to the extent sterilization was not perfect, capital inflows contributed to real exchange rate appreciation. It could be added that capital inflows are likely to have a stronger effect in the future as the abolishment of all capital controls makes a successful sterilization much more difficult.

I have presented above five explanations for trend appreciation of the real exchange rate in the ACs. An important question in this respect is whether real appreciation implies a loss of competitiveness or not. Jazbec (2001) argues that the real exchange rate appreciation is not a signal of exchange rate misalignment and competitiveness loss, but an appreciation of the long-run equilibrium real exchange rate, being determined by the optimal response to the underlying structural and fundamental changes in the economy.[6] Based on Roubini and Wachtel (1998), Jazbec (2001) provides arguments as to why the long-run equilibrium real

[6] Loss of competitiveness resulted if the real exchange rate appreciation was caused

exchange rate may have appreciated in response to the changes in the macroeconomic fundamentals. First, significant increases in productivity growth observed in the region may not imply a loss of competitiveness measured in terms of unit labor costs. Second, significant presence of the Balassa-Samuelson effect implies real appreciation of the CPI-based real exchange rate. Again this does not imply a loss of competitiveness, but rather a productivity driven increase in the relative price of non-traded to traded goods. And third, structural reforms have led to capital inflows that have financed both investment demand for non-tradable factors of production and non-tradable goods and services. Consequently, an increase in the relative price of non-tradable goods to tradeables shows up as an appreciation of the CPI-based real exchange rate.

The results presented in this paper show support for the structural explanations of clearly observed appreciation of the real exchange rate in the ACs under study. Cointegration analysis, coupled with the structural models that emphasize the supply and demand side determinants of the real exchange rate, is then used to provide better theoretical grounds for identifying restrictions that yield the identification of permanent and transitory real and nominal shocks.

Moreover, based on permanent-transitory decomposition we can apply a stricter criterion for the shock-absorbing power of the real exchange rate. For asymmetric permanent real shocks the shock absorbing role of the real exchange rate is not relevant. As these shocks cause a permanent deviation of the real exchange rate, their effects cannot be overturned by monetary policy. In this vein they are seen as leaving the competitiveness of the economy unchanged, and rather reflect the underlying structural changes in the economy. This point is especially important for the issues of accession process and the accession criteria. The issue of shock absorbing power of the real exchange rate is thus addressed only for *transitory and asymmetric* real shocks, and only if they account for a large share of output innovations.

by capital inflows that transferred disproportionately in consumption relative to investment.

3 Sources of RER Variations and Its Shock-Absorbing Role

A standard approach to studying the sources of real exchange rate innovations is the use of structural VAR analysis. To the best of my knowledge, this has not yet been applied to the issue of the forthcoming enlargement of the EU, whereas it has been extensively used to analyze the pros and cons of adopting a common currency in the EMU. Among the vast pool of literature applying VAR techniques to the analysis of monetary policy, Canzoneri et al. (1996), Thomas (1997), Funke (2000) and Artis and Ehrmann (2000) can be singled out as the most relevant. They address similar questions arising from OCA theory on different sets of European countries and their results will provide a benchmark also for the analysis of the related issues for the countries examined in this paper.

Studies commonly use Clarida and Gali (1994) as a reference in the choice of the system of variables and identification of structural shocks. Clarida and Gali base their choice of identifying restrictions on their version of the Obstfeld (1985) open economy macro model, which in a trivariate system of relative variables[7] yields the identification of three types of structural shocks: a supply shock, a demand shock and a nominal shock. The first two shocks are real shocks. Only the supply shock is allowed to have a permanent effect on output and the nominal shock is restricted to have a zero long-run effect on the real exchange rate. Their findings for the interactions between the US and Japan, Germany, the UK and Canada are consistent with the Mundell-Fleming theory and provide a very interesting benchmark for all other studies since their main conclusion is that real shocks determine almost all of the variation of output, and demand shocks dominate the short-run innovations of the real exchange rate.

Canzoneri et al. (1996) use a similar identification scheme on a system of variables with real relative government consumption in place of

[7] Log of domestic output minus log of foreign output, equivalent for inflation. The real exchange rate is a relative variable by definition.

relative prices. Relative variables for Austria, the Netherlands, France, Italy, Spain and the UK are specified with relation to Germany. Their conclusions about the dominant role of supply shock for output innovations are in line with those of Clarida and Gali, with the main distinction being the fact that roughly the same dominant share (about 60%) of real exchange rate innovations is now attributable to nominal shocks. As the real exchange rate and output do not respond in similar proportions to the same types of shocks, the authors conclude that the real exchange rate does not play a shock-absorbing role.

Another study in a similar vein is the one by Funke (2000), who, again using the identification scheme by Clarida and Gali (1994), compares the UK with Euroland as a whole and concludes that less than 20 % of real exchange rate variation is accounted for by supply shocks, which points to the limited shock-absorbing role of the real exchange rate.

Thomas' (1997) paper also considers the identification schemes used by Clarida and Gali (1994) using Swedish data. He reports the dominant role of supply shocks for output variation for Sweden also. The real exchange rate is, especially on shorter horizons, unresponsive to supply shocks and is predominantly driven by demand shocks (around 60%). The real exchange rate thus has a limited shock-absorbing role. In additon, he shows that demand shocks are largely due to fiscal policy shocks and concludes that joining the EMU would not impose significant real cost on Sweden.

In the study of four open economies, Canada, Denmark, Sweden and the UK, Artis and Ehrmann (2000) provide theoretical arguments for the choice of a different VAR specification. They emphasize that a VAR consisting of only relative variables accounts only for asymmetric shocks and does not provide an indication of whether shocks are predominantly symmetric or asymmetric. Furthermore, the studies described above assume no differences in the transmission mechanisms of shocks in different economies. Artis and Ehrmann propose an alternative, 5-dimensional specification of the VAR, consisting of output growth, foreign and domestic interest rate, domestic inflation and the change in nominal exchange rate. They impose, first, restrictions on the long-run effects in the style of Blanchard and Quah (1989), second, zero contemporaneous effects of nominal shocks on output, and, third, a relation between monetary policy and exchange rate shocks as in Smets (1997).[8] They identify supply and demand shocks and three types of nominal shock, originating in domestic monetary policy, foreign monetary policy and exchange rate market.

Their findings can be summarized as follows: first, only the UK is subject to asymmetric supply and demand shocks; second, monetary policy in Canada and the UK can effectively stabilize output; third, in none of the countries is the exchange rate very responsive to supply and demand shocks; fourth, with the exception of Canada, exchange rate is largely driven by its own shocks; and finally, exchange rate shocks mostly do not distort output and/or prices.

A shortcoming of all these studies is the use of standard SVAR analysis. As argued in the Introduction, neglecting the cointgerating properties of the data leads to inference based on a potentially misspecified moving average representation of the model. An improvement in this direction is the study by Alexius (2001). She analyses the sources of real exchange rate fluctuations in the Nordic countries in a cointegrated VAR, thus distingushing between permanent and transitory shocks. The reported results broadly differ from the basic findings of Clarida and Gali: long-run fluctuations in the real exchange rate are dominated by supply shocks and not by demand shocks (important only in the medium term). This confirms the importance of structural models of real exchnage rate determination. Short-run variations are dominated by transitory shocks, which are not divided into real and nominal shocks, as Alexius concentrates on the models with one cointgrating relation only.

This paper also uses a cointegrated VAR. The system of variables is different from the system in Alexius (2001), which in addition to the analysis of the real exchange rate variations also allows an investigation

[8]Smets (1997) proposed an identification scheme designed to distinguish whether the shocks to the interest rate and the exchange rate are due to monetary policy shocks or whether they are due to the Central Bank's responses to shocks to the exchange rate that could arise from specultive capital movements, changes in the risk premium or foreign interest rate changes.

of the shock-absorbing role of the real exchange rate. Inclusion of nominal interest rates as in Artis and Ehrmann (2000) allows us to determine whether a certain country has been predominantly subject to symmetric or asymmetric shocks. Moreover, a richer set of cointegrating relations allows the discrimination between real and nominal transitory shocks. These two departures from the specifications of Alexius allow the identification of asymmetric and transitory real shocks, which are the only type of shocks where the real exchange rate can effectively take its role as a shock absorber.

4 The Common Stochastic Trends Model

The common stochastic trends model makes use of cointegrating relations to identify different structural shocks. Cointegration relations are used for permanent-transitory decomposition of the data, which is what makes this procedure different from the conventional structural VAR analysis.

The idea for this originates in King, Plosser, Stock and Watson (KPSW) (1991) who have shown how cointegration properties of data can be used for identification purposes. Their analysis is oriented towards identifying permanent productivity shocks as the shocks to common stochastic trends for output, consumption and investment - a long-run restriction implied by real-business-cycle models. The nature of the KPSW approach is described in Pesaran (1998), who is, however, not explicit about the identification of particular permanent stochastic trends and transitory shocks. A complete description of the estimation procedures and statistical inference can be found in Warne (1993). Warne's procedure has been implemented for different issues in Mellander et al. (1992) and in Favero at al. (1997).

By taking into account cointegrating relations the number of just-identifying restrictions is reduced significantly and the analysis is placed on better theoretical grounds. With a p-dimensional system and r cointegrating relations we can identify $p - r$ permanent shocks or common stochastic trends that are orthogonal to the r transitory shock components. Here the identification of both types of shocks, permanent and transitory, is of interest. For identification of transitory shocks $r(r-1)/2$ additional restrictions are needed. These restrictions cannot be statistically tested such that they have to be based on economic theory. I employ contemporaneous restrictions similar to the ones encountered in Bernanke and Mihov (1995) or Bagliano and Favero (1999). In the present case with $p = 6$ and $r = 2$ or 3 (depending on the country), 1 or 3 restrictions are imposed, one of them being a zero contemporaneous effect of monetary policy shock on foreign variables.

For the permanent shocks $(p-r)(p-r-1)/2$ restrictions are needed, where we can make use of the usual type of long-run restrictions from Blanchard and Quah (1989), like zero long-run effect of demand shocks and nominal shocks on output and zero long-run effect of nominal shocks on the real exchange rate. Indeed, this yields a triangular structure of permanent components. Altogether, in comparison to the usual SVAR where $p(p-1)/2$ just-identifying restrictions are needed, this procedure reduces the number of non-testable restrictions needed by $rp - r^2$.

Furthermore, one of the cointegrating relations identified is the central bank's reaction function and shocks to this relation are identified as monetary policy shocks. Using this information one can avoid calculating the monetary condition index, normally used to discern the weight central banks put on the exchange rate target and on the interest rate target (monetary target). This is normally deduced from exchange rate and interest rate shocks as in Smets (1997). With the KPSW approach, however, the CB's reaction function is identified directly. Furthermore, the inspection of the significance of α matrix coefficients gives us an indication as to whether such restrictions are supported by the data.

The common stochastic trends model treats driving trends of the economy as stochastic processes. Moreover, the number of these trends is lower than the number of relevant macroeconomic variables (Mellander et al., 1992). Following Johansen (1995) we can write a VAR process in its error-correction form (VEC model):

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Phi D_t + \varepsilon_t, \tag{1}$$

which embodies the assumption of cointegration, because the matrix $\Pi = \alpha\beta'$ has reduced rank. D_t contains deterministic terms. The variance-covariance matrix of reduced form residuals is denoted by Σ. The basic idea behind the common stochastic trends model can be seen from the Granger's representation theorem, which under assumption of cointegration and assumption $|\alpha'_\perp \Gamma \beta_\perp| \neq 0$ (Johansen, 1995) [9] leads to the following solution for X_t:

$$X_t = C \sum_{i=1}^{t} (\varepsilon_i + \Phi D_i) + C^* (L) (\varepsilon_t + \Phi D_t) + A, \tag{2}$$

where A depends on initial values and it holds $\beta' A = 0$, L is the lag operator, where $C = \beta_\perp (\alpha'_\perp \Gamma \beta_\perp)^{-1} \alpha'_\perp$ is reduced rank and the power series $C^* (\lambda)$ is convergent for all λ on and inside the unit circle. The process is thus decomposed into two parts, the non-stationary common trends part $C \sum_{i=1}^{t} \varepsilon_i$ and its stationary counterpart $C^* (L) \varepsilon_t$. A very important consequence of Granger's representation theorem is also the fact that $\beta' X_t$ is stationary since $\beta' C = 0$. However, this restriction does not identify the underlying structural shocks (supply shocks, monetary policy shocks, etc.) such that additional restrictions need to be imposed on the process in order to identify these. For our purpose it is useful to suppress the dummies and assume that D_t contains a constant such that we can explicitly express X_t as

$$X_t = C \left(\xi_0 + \rho t + \sum_{i=1}^{t} \varepsilon_i \right) + C^* (L) (\varepsilon_t + \rho) + A, \tag{3}$$

Turning now to the structural model we can write the data generating process - a common trends model as (Warne, 1993)[10]

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[9] $\Gamma = I - \sum_{i=1}^{k-1} \Gamma_i$

[10] In both components we can include also deterministic shift components (shift and pulse dummies) (Melllander et al., 1992). In this case we would have: $X_t =$

$$X_t = X_0 + \Upsilon\tau_t + \Psi(L)\,v_t, \tag{4}$$

where v_t is a p-dimensional vector of white noise *structural* errors with $E(v_t) = 0$ and $E(v_t v_t') = I_p$. The $p \times p$ matrix polynomial $\Psi(\lambda) = \sum_{i=0}^{\infty} \Psi_i \lambda^i$ is convergent for all λ on and inside the unit circle. X_0 depends on initial values and can be given a distribution such that it is stationary (Johansen, 1995). The trend or growth component of the structural model is represented by $\Upsilon\tau_t$. As in Nelson and Plosser (1982) it is treated as a stochastic process, namely as a vector random walk with drift. The loading matrix Υ is of dimension $p \times (p - r)$ and has a reduced rank $k = p - r$, equal to the number of common stochastic trends in the process, such that we can write

$$\tau_t = \mu + \tau_{t-1} + \varphi_t. \tag{5}$$

The innovation in the non-stationary part of the process, φ_t, is white noise. Using this we can write the common trends model in (4) as

$$X_t = X_0 + \Upsilon\left(\tau_0 + \mu t + \sum_{i=1}^{t} \varphi_i\right) + \Psi(L)\,v_t. \tag{6}$$

With the analogy to (5) we can say that whenever we have cointegration, such that the number of common trends k is smaller than p, there exist exactly $r = p - k$ linearly independent vectors that are orthogonal to the loading matrix Υ, or put more directly, for the matrix β containing the cointegrating vectors it holds that $\beta'\Upsilon = 0$.

With this approach to SVAR modeling we gain some important economic characteristics. First, some shocks in the economy are allowed to have a persistent effect. Moreover, the number of these shocks is smaller than the dimension of the model, such that there exist steady state relations in the economic model. And third, allowing for correlation between

$X_0 + \Upsilon\tau_t + \Psi(L)(v_t + \Phi D_t)$ and $\tau_t = \mu + \mu^* D_t + \tau_{t-1} + \varphi_t$, where D_t is a vector of dummies used. This has been in fact used in the estimation part, but for better clarity of notation and without loss of generality I will supress this term in this section.

φ_t and v_t common trends not only have a growth effect on the economy but also influence fluctuations about steady state relations (Warne, 1993). As noted also by Clarida and Gali (1994), permanent shocks account for the bulk of the short-run variation in the real exchange rate.

Comparing the corresponding elements in (3) and (6) we find that

$$\Upsilon\varphi_t = C\varepsilon_t,\ \Upsilon\Upsilon' = C\Sigma C',\ \text{and}\ \Upsilon\mu = C\rho, \tag{7}$$

such that the estimation of the loading matrix Υ of the common trends depends on the estimates of Σ and C, which requires the inversion of the VAR model in its error-correction (VEC) form.

For easier identification of required parameters, that are further on used also for inference in the common stochastic trends model (impulse response analysis, forward error variance decomposition), Warne (1993) shows how the VEC model can be written as a restricted VAR (conditional on cointegration relations) system for general dimension of the VAR and general rank restriction. He takes a $p \times p$ non-singular matrix M given by $[S_k'\ \beta]'$ that satisfies $S_{i,k}C \neq 0$ for all $i = 1, ..., k$. Furthermore, $\alpha^* = [0\ \alpha]$, a $p \times p$ matrix and the polynomial matrices $D(\lambda)$ and $D_\perp(\lambda)$ are defined as

$$D(\lambda) = \begin{bmatrix} I_k & 0 \\ 0 & (1-\lambda) I_r \end{bmatrix},\ D_\perp(\lambda) = \begin{bmatrix} (1-\lambda) I_k & 0 \\ 0 & I_r \end{bmatrix}$$

Adding to this also the definitions: $\theta = M\rho$ and $\eta_t = M\varepsilon_t$ a restricted VAR (conditioned on cointegrating relations) follows by premultiplying (6) by M, defining a p-dimensional random variable y_t as $y_t = D_\perp(L) MX_t$ and by rearranging (Warne, 1993):

$$B(L)\, y_t = \theta + \eta_t, \tag{8}$$

where $B(L) = M[A^*(\lambda) M^{-1} D(\lambda) + \alpha^*\lambda]$. The last r elements of y_t are given by the r cointegrating relations. The first k elements are chosen by setting $S_k = \beta_\perp'$,which was also the approach taken in this paper. From Theorem 1 in Warne (1993), which is a version of Granger's representation theorem, follows a relation that is very useful in the estimation of common trends model:

$$C(\lambda) = M^{-1} D(\lambda) B(\lambda)^{-1} M \tag{9}$$

This is obtained by pre-multiplying $y_t = B(L)^{-1} \theta + B(L)^{-1} \eta_t$ by $M^{-1} D(\lambda)$, using the definitions above and the property $(1-\lambda) I_p = D(\lambda) D_{\perp}(\lambda)$. It follows that $C(1) = C = M^{-1} D(1) B(1)^{-1} M$. From this we see the usefulness of estimation of the restricted VAR. By estimating $B(1)$ and inverting it, knowing M and - $= M \Sigma M' = E(\eta_t \eta_t')$, there is a clear correspondence with estimates of C and Σ, and from (7) finally Υ.

To sum up, the common trends parameters are estimated by first estimating β using Johansen's procedure,[11] which is sufficient to determine the matrix M and to construct the vector series y_t, described by the structural VAR. Second, maximum likelihood estimation of (8) yields the estimate of $B(1)$ and third, the matrix of common trends parameters can be calculated. Matrix Υ contains pk parameters. It has already been established that $\beta' \Upsilon = 0$. With β obtained in the first step this yields $(p-k)k$ restrictions. Thus, to identify all the parameters of Υ additional $k(k-1)/2$ restrictions have to be imposed. These are motivated by economic theory and are normal restrictions used for identification in an ordinary SVAR. Specifically, for $k = 3$ the long-run restriction that only supply side shocks permanently affect output and that nominal shocks do not permanently affect the real exchange rate are imposed. These three restrictions are consistent with a wide range of economic models (see section 2) and imply that the top $k \times k$ block of matrix Υ is lower triangular. Thus,

[11] King et al. (1991) and Mellander et al. (1992) let the parameters of β be determined by underlying economic theory.

$$\Upsilon = \begin{bmatrix} \Upsilon_{11} & 0 & 0 \\ \Upsilon_{21} & \Upsilon_{22} & 0 \\ \Upsilon_{31} & \Upsilon_{32} & \Upsilon_{33} \\ \Upsilon_{41} & \cdots & \Upsilon_{43} \\ \vdots & \ddots & \vdots \\ \Upsilon_{61} & \cdots & \Upsilon_{63} \end{bmatrix}$$

and coefficients Υ_{11} to Υ_{33} represent $k(k+1)/2$ uniquely determined parameters. Moreover, other coefficients: Υ_{41} to Υ_{63}, satisfy the restrictions imposed by cointegration relations and are linear combinations of identified β-coefficients and uniquely determined parameters Υ_{11} to Υ_{33}.

Identification of the long-run coefficients on the k common trends is not sufficient if all the parameters of the common trends model are of interest, and implications from impulse responses and variance decomposition are to be analyzed. To this aim, the $p \times p$ *identification matrix* Γ is of special interest. It implies diagonality of $\Gamma\Sigma\Gamma'$, such that the vector of structural disturbances can be written as

$$v_t = \Gamma\varepsilon_t. \tag{10}$$

Furthermore, $R(1) = C(1)\Gamma^{-1}$ denotes the *total impact matrix*, such that a component of v_t represents a permanent innovation (φ_t) if the corresponding element in $R(1)$ is non-zero. In conjunction with the long-run coefficients of the common trends the following relation logically holds: $R(1) = [\Upsilon\ 0]$, implying that if Γ identifies the common trends model, the permanent innovations are associated with the common trends.

The Γ matrix must be chosen so that the permanent innovations are equal to φ_t and are independent to transitory innovations ψ_t. Furthermore, the transitory innovations have to be mutually independent (Warne, 1993). If these properties of Γ are satisfied, the following equivalence between moving average representations holds:

$$\Delta X_t = \delta + C(L)\,\varepsilon_t = \delta + R(L)\,v_t, \tag{11}$$

where $R(\lambda) = C(\lambda)\,\Gamma^{-1}$. The component $R(L)\,v_t$ in the last notation represents the *impulse response function* of ΔX_t. The identification of structural transitory shocks follows by imposing some restrictions on Γ matrix. It can be noted that we can conformably partition the vector of structural disturbances as

$$v_t = \begin{bmatrix} \varphi_t \\ \psi_t \end{bmatrix} = \begin{bmatrix} \Gamma_k \\ \Gamma_r \end{bmatrix} \varepsilon_t = \Gamma\varepsilon_t \tag{12}$$

To give the transitory innovations an economic interpretation, restrictions are based on their contemporaneous effect on X_t. In this case consider $R(0) = C(0)\,\Gamma^{-1} = \Gamma^{-1}$, such that we have to impose $r(r-1)/2$ restrictions on Γ^{-1}.[12] This can be done in different ways, in this paper elements (1,4), (1,5) and (5,4) were set to zero in the case of $r = 3$, meaning that the first transitory innovations - monetary policy shocks - and the second transitory innovations do not have a contemporaneous effect on output and that monetary policy shocks do not have a contemporaneous effect on foreign inflation rate. These restrictions are standard in the SVAR literature (Favero, 2001).

Caution should be applied when results of the SVAR analysis are used for policy advice. Estimated parameters are not invariant to policy changes (Favero, 2001), and it is thus important to ensure that the estimation period includes only one monetary policy regime. In the present case this holds true completely for Hungary, Denmark, Slovenia and the UK, whereas the Czech Republic introduced some changes in their exchange rate regime within the estimation period.

For similar reasons we should look at the results only as a description of past economic developments. Pegging the currency in the ERM II system and joining the EMU will represent significant regime shifts.

[12] For Hungary, Slovenia, the Czech Republic and Denmark with cointegrating rank equal to 3, 3 restrictions were imposed, for the UK with rank 2 only 1 was needed.

The results presented below should therefore be understood as an indication of the economic state (and differences with respect to EU countries), which will probably persist in the future.

5 Cointegration Analysis

The choice of the lag in the VARs for each country was based on the values of the SC and HQ information criteria with the complementary reduction tests for each step of lag reduction.[13] A final lag length of three was chosen for the Czech Republic and Hungary, whereas two lags proved to be sufficient for Slovenia, Denmark and the UK. Achieving a sufficient parsimony of the VARs was crucial since the number of estimated parameters in a 6-dimensional system quickly exceeds the limit that would still enable a valid statistical inference in the cointegrated VAR model.

The test reported in Table 1 reveal few signs of misspecification of the selected models. For high-frequency data big transitory shocks are not uncommon. and produce some residual autocorrelation; however, this problem cannot be solved by increasing the lag length or including the moving average term in the error process (Juselius, 2001). Only shocks exceeding 3 standard deviations were accounted for by dummies. Nevertheless, this quite successfully eliminated the problems with residual autocorrelation, but still left some signs of non-normality. The latter was present in the interest rate (and to a smaller extent for inflation rate) equations in the models for Denmark, the UK and Slovenia. However, it has been checked that non-normality was due to excess kurtosis and not due to skewness. Because cointegration results are moderately robust against excess kurtosis (Juselius, 2001) (and ARCH effects (Hansen and Rahbeck, 1999), I proceeded with the analysis. In addition, stability of

[13]All the data and detailed estimation results are available from the author upon request. All series have also been tested for the presence of a unit root. ADF tests could not reject the null of a unit root in all series. In addition, within each system I have tested if unit vectors corresponding to each variable lies in the space spanned by β vectors. The corresponding null of stationarity was always rejected.

the parameter estimates was tested with 1-step Chow tests and no signs of breaks were found.

Table 1: Model misspecification tests

Country	**LM(1)** ($\chi^2_{(36)}$)	**LM(4)** ($\chi^2_{(36)}$)	**Normality** ($\chi^2_{(12)}$)
Slovenia	40.58 (0.28)	32.56 (0.63)	20.55 (0.06)
Hungary	53.26 (0.04)	31.17 (0.70)	15.03 (0.24)
Czech Rep.	53.42 (0.04)	36.42 (0.45)	19.68 (0.07)
Denmark	73.74 (0.00)	27.60 (0.84)	10.91 (0.54)
UK	54.39 (0.03)	31.74 (0.67)	15.26 (0.23)

*LM test are the test for residual autocorrelation. Associated p-values in parentheses.

The choice of cointegrating rank was based on the trace tests and $\lambda -$ max tests. However, consistency of the choice of rank was checked with eigenvalues of the companion matrix and the significance of the adjustment coefficients to the rth cointegration relation. Discussion of the choice criteria can be found in Hendry and Juselius (2001). Based on the tests, rank 3 was chosen for Slovenia, Hungary, the Czech Republic and Denmark. There are also some signs of rank 4 for Slovenia; however, rank 3 was preferred for two reasons. First, reported critical values are asymptotic and these can correspond to a larger size of the test due to the small sample size and presence of dummy variables in the model. Second, four cointegrating relations are not economically meaningful. We would expect to find one relation corresponding to monetary policy rule, describing the steady state relation between interest rate, output, the real exchange rate and inflation. The second relation is expected to describe a modified PPP relation (Juselius, 1995). In case of a third relation, this would describe the supply side connection between output, real exchange rate and interest rates. For the UK rank 2 was chosen.

To keep the exposition compact the estimated cointegrated relations are reported only for Slovenia and the UK, presented in Tables 2 and 3. The first cointegration relation reported in the tables is the monetary policy rule, with coefficient signs consistent with economic theory.

Interest rate is negatively related to output and the real exchange rate, and positively to inflation. For the UK this relation is augmented with the foreign interest rate.

The second cointegration relation is important, since foreign variables are likely to exhibit significant adjustment to these relations even if we are considering a very small economy as the home country. For Slovenia this relation corresponds to a PPP relation modified with a real interest rate differential (see also Juselius (1995). For the UK the relation between the real interest rate only proved to lie in the space spanned by vectors of β.

A third cointegrating vector for Slovenia (and with the same structure also for Hungary, the Czech Republic and Denmark) is somehow more difficult to interpret. It confirms a negative relation between the output and real exchange rate already observed from the first relation. It also shows that a trend driving output positively affects interest rate differential.

Table 2: Estimated β and α parameters for Slovenia

	y	**R**	$\boldsymbol{\pi}$	**i**	$\boldsymbol{\pi}^*$	$\mathbf{i}^*$
$\widehat{\beta}_1$	1.00*	0.82*	-0.023*	0.006*	0.00	0.00
$\widehat{\beta}_2$	0.00	1.00	0.013*	-0.013*	-0.024*	0.024*
$\widehat{\beta}_3$	1.00*	1.067*	0.00	-0.005*	0.00	-0.016*
$\widehat{\alpha}_1$	-0.053	-0.052*	11.45*	15.36	0.528	-2.274*
$\widehat{\alpha}_2$	-0.056	-0.070*	5.174*	19.62*	0.216	-2.526*
$\widehat{\alpha}_3$	-0.027	0.063	-8.506*	-8.394	1.102	3.733*

* indicates significance

Table 3: Estimated β and α parameters for the UK

	y	**R**	$\boldsymbol{\pi}$	**i**	$\boldsymbol{\pi}^*$	$\mathbf{i}^*$
$\widehat{\beta}_1$	1.00	0.054*	-0.033*	0.028*	0.00	0.012*
$\widehat{\beta}_2$	0.00	0.00	1.00*	-1.00*	0.895*	-0.895*
$\widehat{\alpha}_1$	-0.136*	-0.153	1.321	0.678	3.362*	3.480*
$\widehat{\alpha}_2$	-0.002*	-0.004	-0.097*	0.055*	-0.026	0.054*

* indicates significance

6 Impulse Responses and Variance Decomposition - Interpretation of Real Exchange Rate Variation

This section reports the estimation results of the common stochastic trends model. Again for compactness, the impulse responses presented in Appendix B are plotted only for Slovenia and the UK. Forward error variance decomposition, being crucial for the issue of shock-absorbing power, is reported for all countries under analysis in Tables 4 to 8. (See also comments on tables in the Appendix.) Conditional on the number of cointegrating relations, three or four permanent shocks and three or two transitory shocks have been identified.

The results are evaluated along the points spelled out in the Introduction. First, I briefly discuss the sign and shape of impulse responses for Slovenia and the UK. The discussion is constrained only to these two countries because the results for the former share many similarities with the results for other ACs, and the results for the UK share similarities with those for Denmark. Major differences will be spelled out, so that being brief in this part causes no loss of generality. Second, by looking at the impulse responses of domestic and foreign interest rate, it is identifed whether different types of stochastic shocks hitting the economies are predominantly symmetric or asymmetric. If the responses are in the same direction (and/or of similar magnitude) this can be understood as a sign that the appropriate responses of monetary policies in the two countries facing a shock are in the same direction. On the other hand, different stances of monetary policy are appropriate facing an asymmetric shock, which is reflected as impulse responses of interest rates in the opposite direction (and/or of different magnitudes). Third, results of forward error variance decomposition are used to discuss the shock-absorbing role of the real exchange rate for transitory asymmetric real shocks. Finally, we briefly turn our attention to the division of real exchange rate innovations between nominal and real shocks.

In the literature presented in section 3 the categorization of shocks is usually associated with the Mundell-Flemming model.[14] However, not always have the results presented been able to pass the "duck test",[15] with Thomas (1997) being just one example. For present analysis not only are the impulse responses of the real exchange rate to different permanent shocks consistent with the structural models for the AC, but this is also the case for the two developed countries analyzed in this paper. I consider this as a support for the methodological approach used, that incorporates the permanent-transitory decomposition required by the structural models of real exchange rate determination.

Figures 2 to 13 in the Appendix report the impulse responses to three permanent and three transitory shocks for Slovenia, and impulse responses to four permanent and two transitory shocks for the UK. The impulse response to a permanent supply shock (Figure 2) in Slovenia implies the presence of a Balassa-Samuelson effect. Consistently with the model, the shock drives up the inflation differential between Slovenia and Germany that appreciates the real exchange rate, and as the inflation gap narrows (after approximately 6 months) the real exchange rate stabilizes at a lower level. This pattern is observed also for other ACs, which leads us to conclude that there is indeed a productivity differential growth between the tradeable and non-tradeable sector driving the real exchange rate in the described manner.

The impulse response in Figure 3 is less straightforward to explain, but keeping in mind that it reflects transition specific factors, a tentative explanation was offered in section 2.1. This type of response is consistent with the processes of price liberalization and capital inflows (not only equity flows, but also issues of commercial debt due to real interest rate differential), both representing structural (in the economic sense)

[14]According to Mundell-Fleming theory, a positive supply shocks results in the permanent increase in output and in permanent depreciation of exchange rate due to excess supply of home goods. A positive demand shock creates excess demand for home goods, increases prices and results in temporary increase in output and in permanent appreciation of exchange rate. A positive nominal shock lowers the home interest rate and leads to a depreciation of real exchange rate, which is only temporary, as also the positive effect on output is.

[15]"If it walks like a duck, and quacks like a duck; then it must be a ..."

shocks.[16] It also bears an important policy implication. In the face of such structural developments, which have real exchange rate appreciation as a consequence, any type of sterilized intervention on the foreign exchange market, performed by the central bank, aimed at permanently improving the competitiveness of the economy, has only a temporal effect on output, but increases the real interest rate differential. The latter could have subsequently negative effects on output and induce capital inflows at an even higher scale.

For a country like Slovenia it is the nominal shocks (Figure 4) that can be most closely related to the disinflation process. Because inflation was initially at 2-digit levels, a positive response of output to disinflation should not come as a surprise, since it brings with it a decrease in real interest rates.

Transitory shocks are plotted in Figures 5-7. An expansionary monetary shock decreases real interest rates, which boosts output and depreciates the real exchange rate in the short run. Figure 6 presents the responses to a temporary real shock exhibiting classical features of a demand shock. A temporary supply shock in Figure 7 produces similar effects to a permanent supply shock, however due to its short life it cannot be associated with permanent productivity increases.

For all of the impulse responses for Slovenia described above it holds that the responses of both of the foreign variables are negligible compared to domestic counterparts. The results can therefore be considered robust, since they prove to be consistent with the feature of a small economy like Slovenia.

The impulse responses for Hungary and the Czech Republic are very similar. In particular the impulse response to a permanent supply shock of both is consistent with the Balassa-Samuelson effect. The second important common feature is the response to a "demand" effect that reflects the transition specifics.

[16] Normally one would, in this type of exercise, think of a government spending shock as a typical demand shock. This has not been very true of the ACs in the past decade, therefore the notation "demand" shock is maintained here for comparability.

Figures 8-13 present the impulse responses for the UK. For the permanent positive supply shock we see that the response of the real exchange rate after the initial apppreciation is in line with the Mundell-Fleming model. The impulse response to a permanent negative demand shock is in line with the interpretation of a classical demand shock. A temporary negative effect on output is associated with a depreciation of the real exchange rate and with a decrease in inflation.

Figures 10 and 11 present the impulse responses to a domestic and foreign nominal shock respectively; the first being positive and the second negative. The domestic nominal shock yields expected responses, while the foreign one causes divergent movements of inflation and interest rates. This sign of asymmetry has important implications for a membership in a monetary union as these shocks account for a significant share of short-run variation in output (see the discussion below).

The two transitory shocks (Figures 12 and 13) correspond to a monetary policy shock and a real transitory shock respectively. Both are in line with economic theory. The response to a monetary policy shock is very similar to the one found for Slovenia with one significant and important difference: it leads to a comparable response of foreign variables.[17] This reflects the higher economic size of the UK relative to Germany.

As was the case with the ACs, Denmark too shares many similarities with the UK. This makes these two countries distinctly different from the first group; a result that was expected. The main difference between Denmark and the UK is the response to a positive supply shock. For Denmark it is also consistent with the Balassa-Samuelson hypothesis.

As discussed above the symmetric and asymmetric shocks are categorized according to the impulse responses of the domestic and foreign interest rate. For the UK we can observe signs of asymmetry for permanent and transitory supply shocks, and for foreign nominal shocks. Is this the case against joining EMU for the UK? The answer is not

[17] Visual inspection of the impulse responses to a monetary policy shock reported here and the ones reported for the UK by Ehrmann (1998) shows a remarkable resemblance.

clear. Asymmetry of nominal shocks makes a case in favor of monetary union, since monetary union effectively removes the source of shocks. Besides that, the real exchange rate does not have a shock-absorbing role for asymmetric transitory supply shocks, such that relinquishing the exchange rate would not impose costs on the UK. The case against is the asymmetry of permanent supply shocks as it is a source of economic divergences (responses of inflation rates show that it leads to inflation differential). However, since the nominal shocks are equally important for short-run output fluctuations (44% of variance on 6 month horizon and 29% at 1 year horizon compared to 27% and 44% of variance for both supply shocks at same horizons)(see Table 5), joining the EMU might be stabilizing for the UK.

The results for Denmark show the only asymmetric shocks to be transitory supply shocks. After an initial 67% they still contribute 38% to output innovations at a 6-month horizon, and an important 13% at a two-year horizon (see Table 7). The real exchange rate is, on the other hand, quite unresponsive to the same shocks. Only at a 6-month horizon can 11% of real exchange rate variation be attributed to transitory supply shocks; at all other horizons this number is significantly lower. This means that the real exchange rate does not act as shock absorber.[18] Denmark keeps its nominal exchange rate pegged to the euro within very narrow bounds, such that this result could be expected. It nevertheless means that their decision to stay out of the EMU may be seriously questioned.

One might expect a different picture to be found for the ACs. For Slovenia asymmetry is found for permanent supply shocks and permanent nominal shocks. For other shocks the response of domestic and foreign interest rate is in the same direction, but with large differences in magnitudes. To a lesser extent, this qualifies other shocks as being asymmetric. Based on similar reasoning we can also qualify shocks for Hungary and

[18]From the impulse responses (available upon request) it can also be seen not only that the real exchange rate does not absorb transitory supply shocks, but that it amplifies them, thus counter-stabilizing. The low share of variance of these shocks can also be understood from this perspective.

the Czech Republic as asymmetric, the only exception being transitory supply shocks for the Czech Republic.

Asymmetry of nominal shocks is logically observed if we keep in mind a very different inflationary performance of Slovenia in the past decade. Monetary authorities were very much involved in disinflation, a still ongoing process. Conditional on meeting Maastricht criteria such sources of asymmetric shocks will be removed in the EMU. Asymmetry of supply shocks can be attributed to the catching-up process. Until convergence this feature is likely to persist also in the future and represents an important source of economic divergencies in a monetary union.

Asymmetry of permanent transition specific ("demand") shocks is also expected if we consider the discussion in section 2.1. However, as these shocks are transition specific, they are not likely to persist on the future. As such they will not represent a source of real costs.

Forward error variance decomposition for Slovenia, Hungary and the Czech Republic is presented in Tables 4, 6 and 8 respectively. Asymmetric transitory demand shocks are practically irrelevant in terms of contributions to output variations for all the ACs under analysis, such that their asymmetry will not impose real cost in the EMU. The same is true for transitory supply shocks for the Czech Republic, which are moreover symmetric. On the other hand, transitory supply shocks account for large shares of output variation within a 1-year horizon for Slovenia and Hungary. As the real exchange rate is not efficient for the absorption of these shocks for both countries, it holds that this asymmetry should not be a case against joining the EMU.

In order to keep the presentation of the results on sources of real exchange rate variations complete, let us now turn briefly to the overall importance of real shocks. A remarkable similarity is found among Denmark, the UK and Slovenia. For these countries more than 90% of real exchange rate variations can be attributed to real shocks. Of the real shocks, permanent supply shock are much less important for the UK, holding only about 5% share at all horizons (consistent with the findings of Funke (2000)). For Slovenia and Denmark this share is much higher, between 50% and 60% (70% for Denmark, which is for the long run close to the results of Alexius (2001)). For Hungary the share of nominal shocks is much higher within a 1-year horizon, mainly due to monetary policy shocks. After initial 54%, this share is still high at the 6-month horizon and falls to 10% after 1 year. This result can be associated with Hungary's crawling peg exchange rate regime. The share of permanent supply shocks quickly stabilizes at 25%. The dominant share is (as for the UK) occupied by permanent "demand" shocks. The Czech Republic steps out of the picture with 80% share of permanent nominal shocks within the first year. With a still very high 45% after two years, this share decreases fast afterwards, with supply shocks gaining importance.

7 Conclusion

This paper offers a new insight into the empirical investigation of sources of real exchange rate innovations. The results from such exercises are commonly used to discern potential costs that a country might incur by joining a monetary union as it loses the exchange rate as a shock stabilizer. Unlike other authors, I combine the structural models of real exchange rate determination with a different econometric methodology. The structural models offer a variety of explanations for the empirically observed permanent deviations from the PPP. This leads to explicit consideration of a permanent-transitory decomposition of the system of variables. This has been done for Hungary, the Czech Republic and Slovenia, countries that we are likely to see in the first wave of the EU enlargement and that exhibit an explicit transitional pattern in their real exchange rate. To demonstrate that the proposed methodological approach cannot be considered only as a special case, the analysis is performed also for Denmark and the UK, two countries that have decided to exercise their opt-out clause from the EMU.

The results can be broadly summarized as follows: The real exchange rate does not have a shock-absorbing role in any of the countries, and there are considerable differences in terms of asymmetry of shocks between Denmark and the UK on the one hand, and the ACs on the other. Shocks identified for Denmark are symmetric; for the only asymmetric case (transitory supply shocks) the real exchange rate does not prove to be an efficient shock absorber. The case of the UK is slightly different, as asymmetric supply shocks might have caused problems with divergent developments if the UK had joined the EMU, but on the other hand the EMU might have removed the destabilizing effects of permanent foreign nominal shocks.

Results for the ACs show some similarities that enable us to treat them as a group in this final discussion. For all of them strong asymmetries of permanent shocks and no shock-absorbing power of the real exchange rate are identified. This means that in the discussion of benefits and cost of joining the EMU, divergent economic developments should receive a considerably higher greater than the shock-absorbing role of the real exchange rate.

In particular, there is a strong presence of the Balassa-Samuelson effect, and effects of structural reforms on the real exchange rate. If the latter can be considered transition specific and as such not likely to persist in the future, the former is very likely to persist in the future due to the catching-up process. What are the implications for joining the EMU? Such divergences are also present in the current EMU and represent a challenge for the ECB, which is targeting the Euro-wide inflation rate, but individual countries experience very different national inflation rates. Centrally managed monetary policy targeting average inflation is thus inappropriate for countries exhibiting the most divergent economic developments (Björkstén and Syrjänen, 1999). The same could be the case also for the countries under study here when they join the EMU, such that they need to carefully consider the strategy of entering. This could be even more important on the way to the EMU. After entering the ERM II system, the Maastricht criteria will apply and upon fulfilling these a country will be obliged to join the EMU. Because the Balassa-Samuelson effect brings with it the inflation differential as a consequence of productivity growth (real convergence), countries will have to trade growth for meeting the Maastricht criteria (nominal convergence). In addition, the exchange rate of a currency with a tendency to appreciate can in ERM II find itself closer to the lower bound of fluctuation within reasonable time. This offers an opportunity for a speculative attack, which could prove detrimental for the competitiveness of the economy. For this reason, the Maastricht criteria appear inappropriate for the process of Accession. A more detailed discussion of these issues can be found in Buiter and Grafe (2002). The results presented here can be seen as an empirical link to their conclusions.

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Appendix A

This section presents a simple theoretical proof for the argument set out in the Introduction that permanent changes in the real exchange rate, reflecting underlying structural changes in the economy, cannot be overturned by discretionary measures of monetary policy. For simplicity I concentrate on the case where the productivity growth differential between tradeable and non-tradeable sector causes the real appreciation of the domestic currency - the Balassa-Samuelson effect.

Consider a case of a small open economy. The assumption of domestically mobile factors of production and internationally mobile capital ensures the isolation of Balassa-Samuleson effect independent of demand effects on the real exchange rate. The economy produces two composite goods, tradeables and non-tradeables, with the following constant-returns production functions:

$$Y_T = A_T F\left(K_T, L_T\right), \qquad Y_N = A_N F\left(K_N, L_N\right)$$

Total labor supply is fixed and labor mobility ensures wage equalization between sectors. Denote with μ_{LN} and μ_{LT} labor income shares in non-tradeable and tradeable sector respectively. Then it holds that along a perfect-foresight path we have (see Obstfeld and Rogoff, 1996, p.208):

$$\frac{\widehat{P_N}}{P_T} = \frac{\mu_{LN}}{\mu_{LT}} \widehat{A}_T - \widehat{A}_N \tag{A.1}$$

A hat above the variable denotes the logarithmic derivative. This expression postulates that under a plausible and empirically documented assumption $\mu_{LN}/\mu_{LT} \geq 0$, a higher productivity growth in tradeable sector leads to an increase of the internal price ratio. If we denote with α and β the corresponding shares of non-tradeables in the home and foreign price indeces respectively, we can write:

$$P = P_T^{1-\alpha} P_N^{\alpha}, \qquad P^* = \left(P^*\right)_T^{1-\beta} \left(P^*\right)_N^{\beta}$$

By log-differentiating the ratio of the price indices, using eq. (A.1) and assuming similar technologies we can see how relative productivity shifts induce systematic changes in the log real exchange rate defined as $q = p^f - p = e + p^* - p$:

$$\widehat{q} = \widehat{P} - \widehat{P^f} = \beta \left(\frac{\mu_{LN}}{\mu_{LT}} \widehat{A^*}_T - \widehat{A^*}_N \right) - \alpha \left(\frac{\mu_{LN}}{\mu_{LT}} \widehat{A}_T - \widehat{A}_N \right) \tag{A.2}$$

Note that in the empirical analysis I use a CPI-measured real exchange rate: $q_{cpi} = e + p^f_{cpi} - p_{cpi}$, where e denotes the log of the nominal exchange rate. By denoting the share of imported goods in the CPI with ω and exploiting the assumption of a small open economy, a direct correspondence between the two measures of the real exchange rate follows: $\widehat{q}_{cpi} = (1 - \omega)\, \widehat{q}$.

For the present purpose it is important to note that the result in (A.2) holds in the medium and long run, which allows us to write:

$$\lim_{\tau \to \infty} E_t q_{t+\tau} = \lim_{\tau \to \infty} q_{t+\tau/t} \neq q_t, \tag{A.3}$$

where $E_t\,()$ denotes the expectation operator based on information at time t. Without nominal rigidities productivity growth differential would instantaneously lead to changes in the real exchange rate; however, the usefulness of thelast expression is that it allows us to be imprecise about the exact form of nominal rigidities, lags in the pass-through of foreign inflation, and staggered price adjustment, as it is compatible also with their presence.

Finally, it is useful to exploit the constraints imposed on the exchange rate by basic parity conditions. The nominal exchange rate fulfills the interest parity condition:

$$i_t - i_t^* = e_{t+1/t} - e_t + \varphi_t,$$

where i_t and i_t^* denote the domestic and foreign nominal interest rate respectively, and φ_t is the foreign-exchange risk premium. Using the definition for the real exchange rate we can rewrite the preceding expression as a real interest parity condition:

$$q_{t+1/t} = q_t + i_t - \pi_{t+1/t} - i_t^* + \pi_{t+1/t}^* - \varphi_t. \tag{A.4}$$

Solving this expression forward yields:

$$q_t - \lim_{\tau\to\infty} q_{t+\tau/t} = -\sum_{\tau=0}^{\infty}\left(i_{t+\tau} - \pi_{t+1+\tau/t}\right) + \sum_{\tau=0}^{\infty}\left(i_{t+\tau}^* - \pi_{t+1+\tau/t}^* + \varphi_{t+\tau/t}\right) \tag{A.5}$$

This expression summarizes the basic constraint of monetary policy faced with real appreciation of its currency (positive right-hand side). In the presence of highly mobile capital (which is the case in the ACs), any attempt to reverse real appreciation by increasing the nominal exchange rate will, through higher real interest rates, eventually push the real exchange rate towards its equlibrium path, which is determined by structural changes in the economy. As long as we rule out the extreme case of perfect nominal rigidity this leads to higher average inflation along the adjustment path. Under more plausible assumptions about lags in the effects of monetary policy on prices, and pass-through of foreign inflation, the adjustment occurs within only a few periods, such that it is not optimal for the monetary authorities to attempt to revert the trend in the real exchange rate. The shock-absorbing role of the real exchange rate is thus considered only for transitory asymmetric real shocks.

Appendix B: Impulse Responses and Forward Error Variance Decomposition

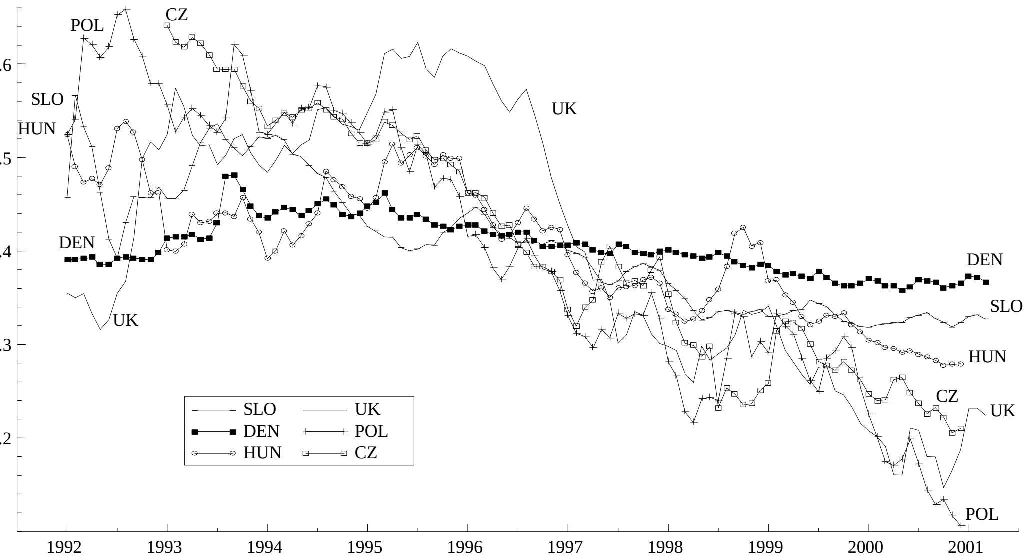


Figure 1: Real exchange rate paths

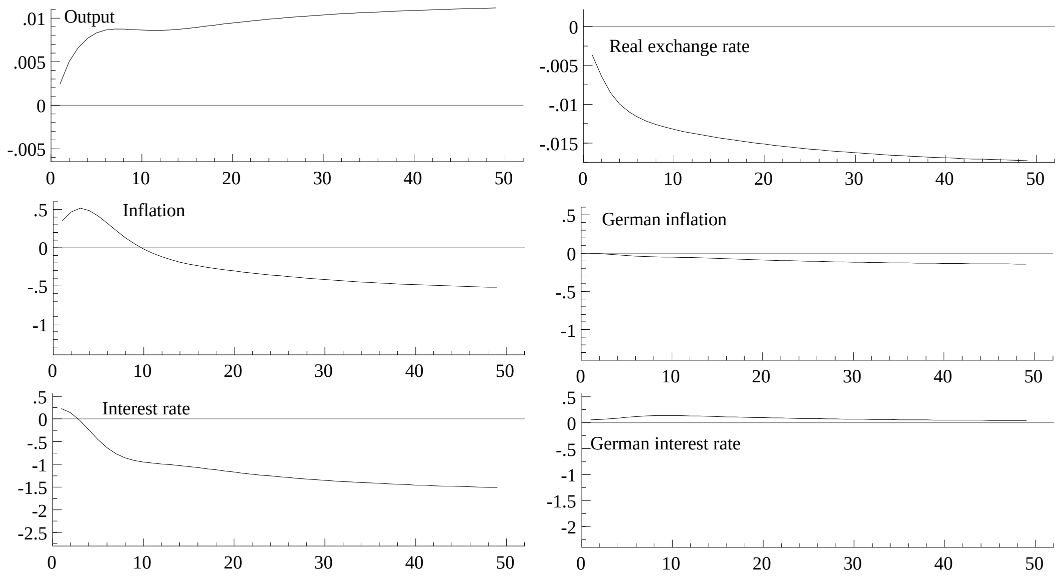


Figure 2: Slovenia - permanent positive supply shock (P1)

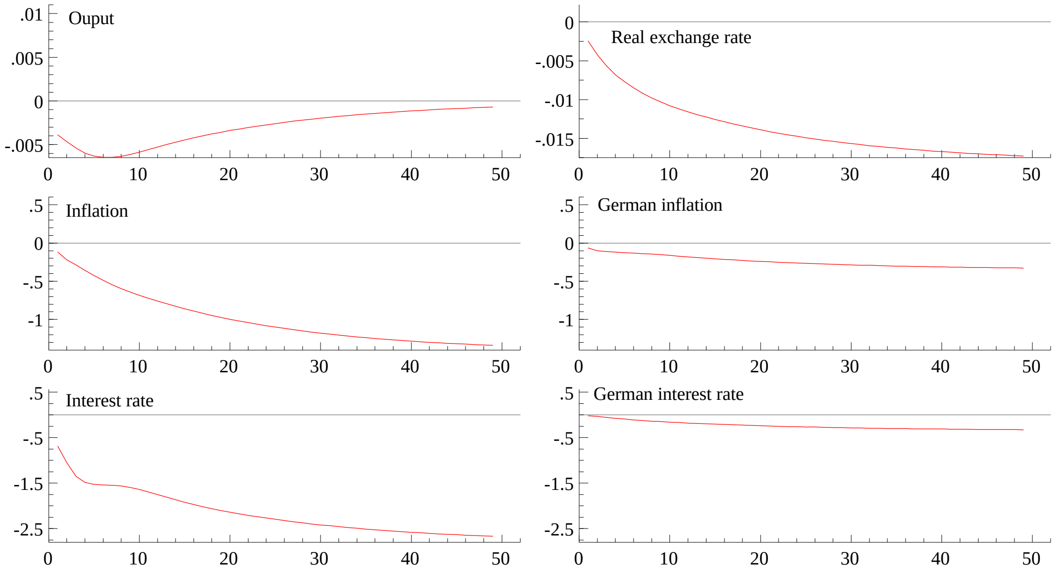


Figure 3: Slovenia - permanent transition specific shock (P2)

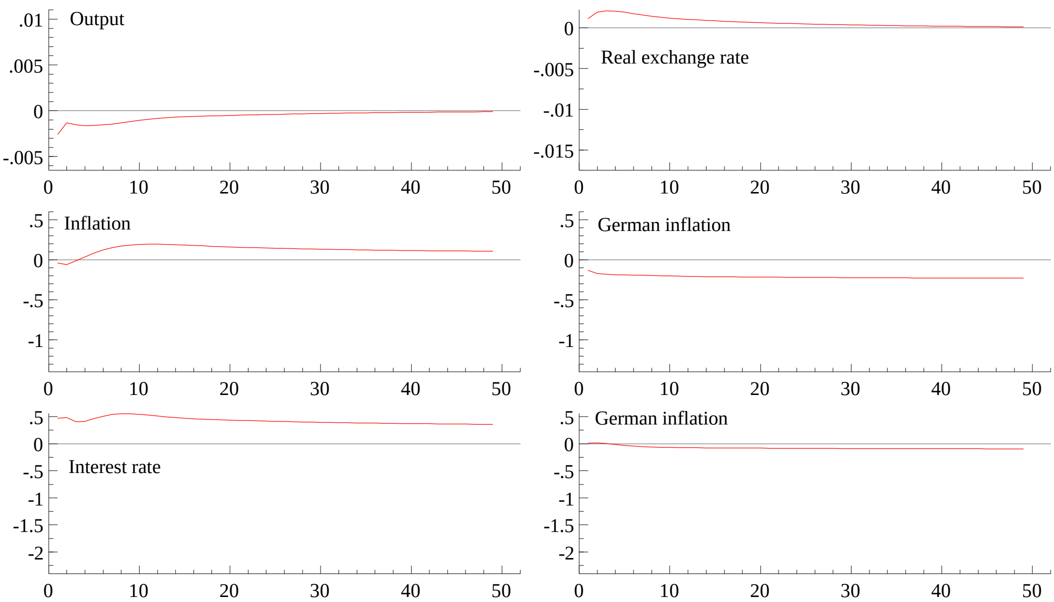
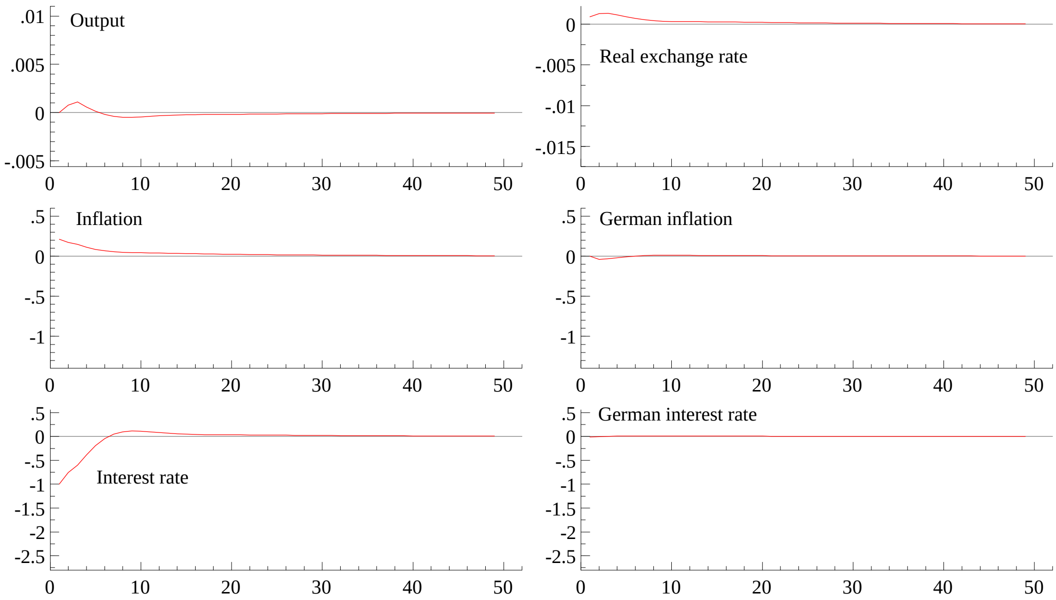


Figure 4: Slovenia - permanent positive nominal shock (P3)



Fugure 5: Slovenia - positive monetary policy shock (T1)

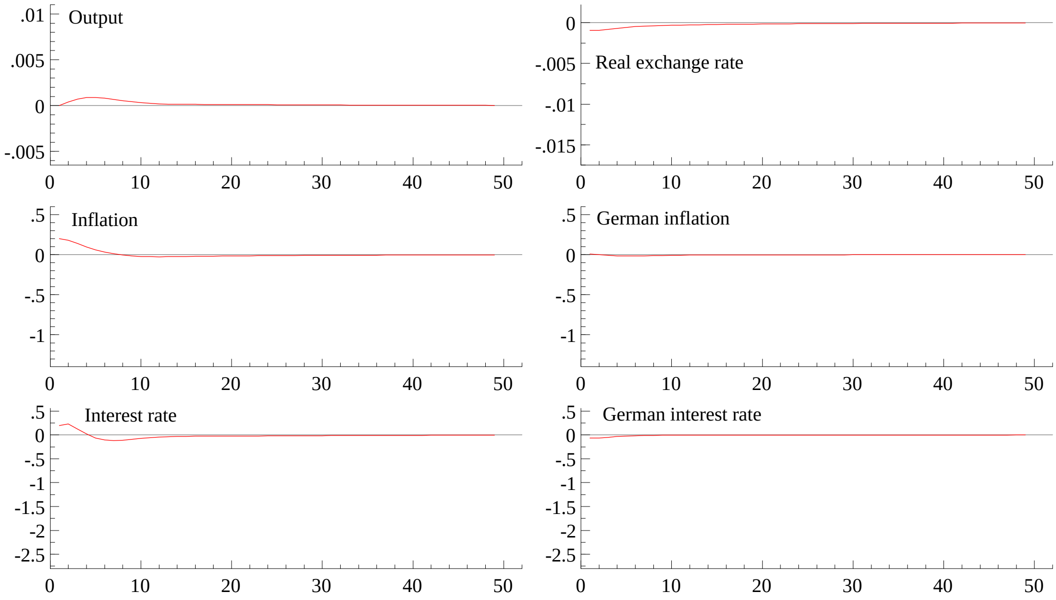


Figure 6: Slovenia - transitory positive demand shock (T2)

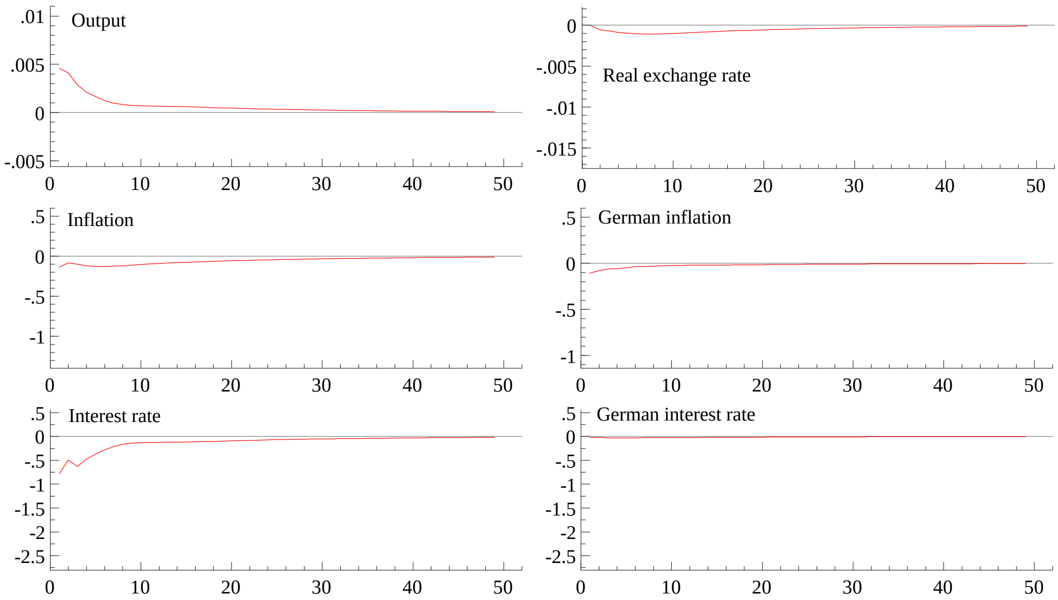


Figure 7: Slovenia - transitory positive supply shock (T3)

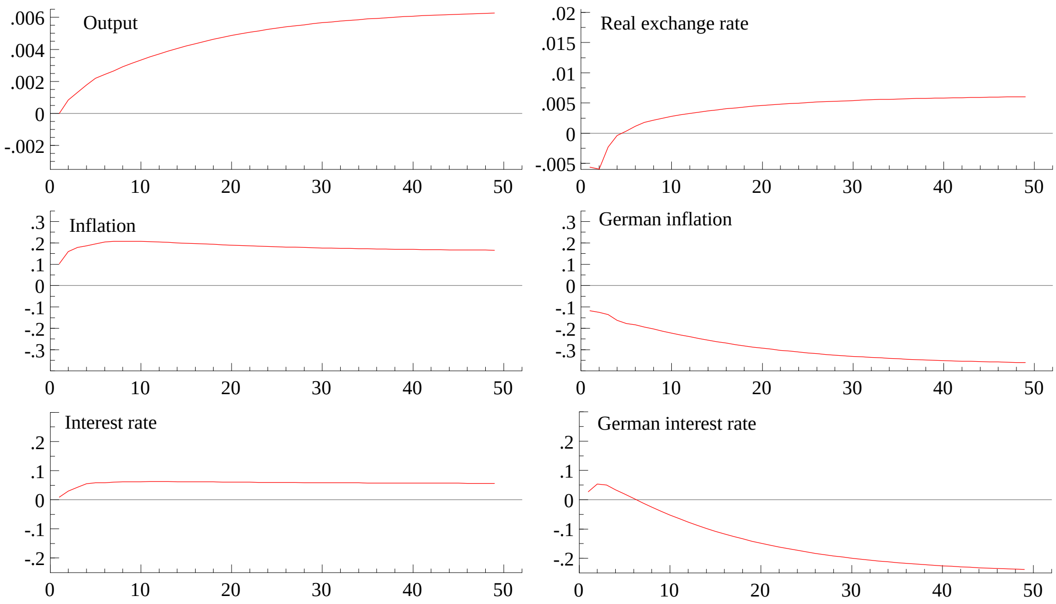


Figure 8: UK - permanent positive supply shock (P1)

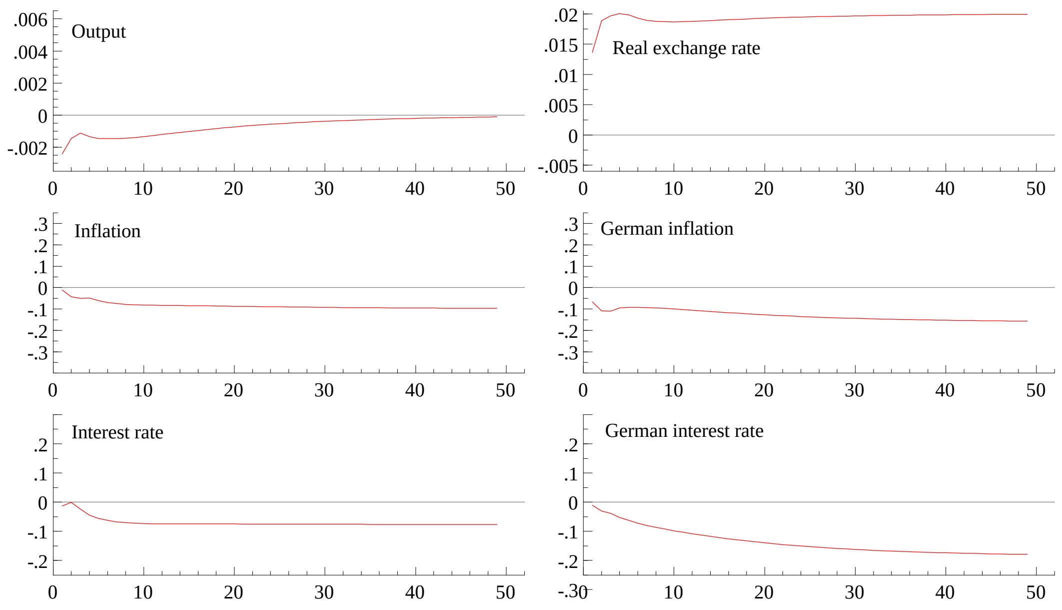


Figure 9: UK - permanent negative demand shock (P2)

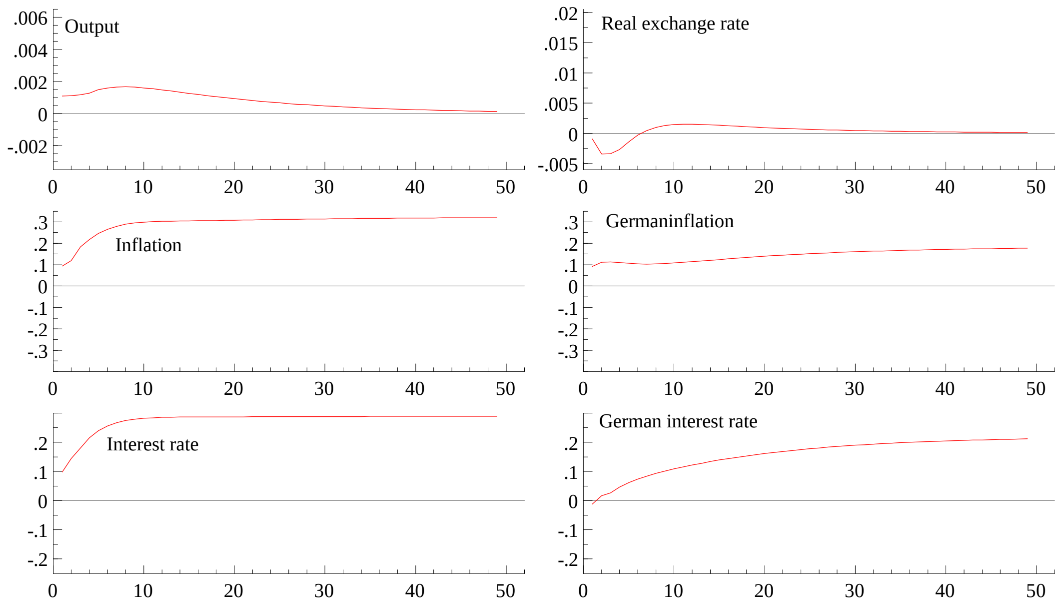


Figure 10: UK - permanent nominal domestic shock (P3)

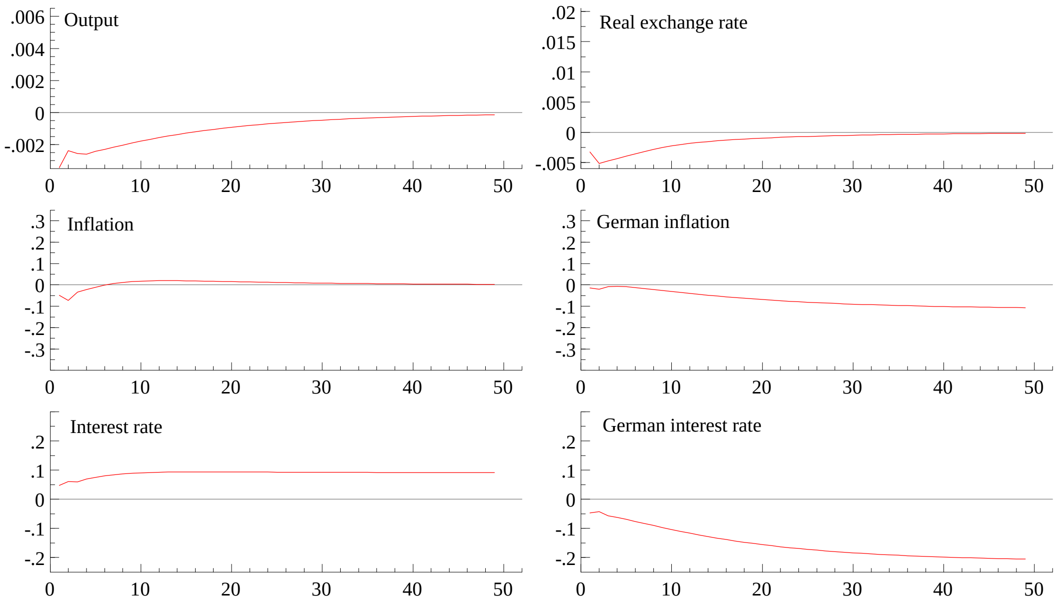


Figure 11: UK - permanent foreign nominal shock (P4)

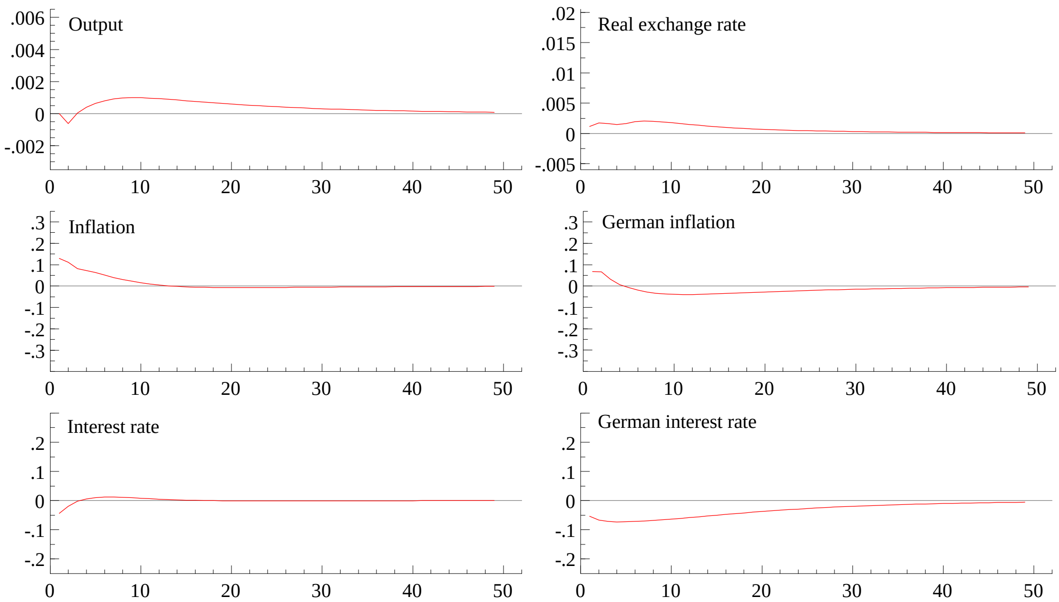


Figure 12: UK - transitory positive monetary policy shock (T1)

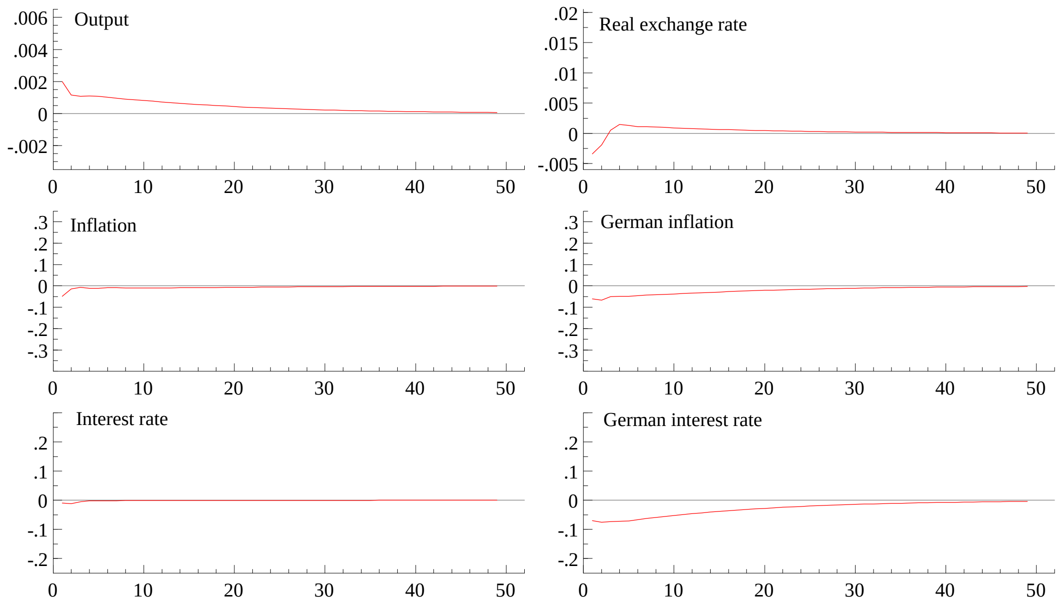


Figure 13: UK - transitory real shock (T2)

Table 4: FEVD for Slovenia									
Step	**Var**	**P1**	**P2**	**P3**	**T1**	**T2**	**T3**	**P**	**T**
	y	0.12	0.31	0.13	0.00	0.00	0.43	0.57	0.43
1m	**R**	0.60	0.26	0.06	0.04	0.04	0.00	0.92	0.08
	$\boldsymbol{\pi}$	0.51	0.06	0.01	0.17	0.17	0.08	0.57	0.43
	i	0.02	0.20	0.09	0.42	0.02	0.25	0.31	0.69
	y	0.52	0.34	0.03	0.00	0.01	0.10	0.89	0.11
6m	**R**	0.64	0.31	0.03	0.01	0.00	0.00	0.98	0.02
	$\boldsymbol{\pi}$	0.52	0.32	0.01	0.06	0.05	0.04	0.86	0.14
	i	0.04	0.63	0.08	0.13	0.01	0.10	0.76	0.24
	y	0.60	0.32	0.02	0.00	0.00	0.05	0.95	0.05
1y	**R**	0.61	0.36	0.01	0.00	0.00	0.00	0.99	0.01
	$\boldsymbol{\pi}$	0.23	0.64	0.04	0.03	0.02	0.03	0.92	0.08
	i	0.15	0.67	0.08	0.06	0.00	0.05	0.89	0.11
	y	0.72	0.23	0.01	0.00	0.00	0.02	0.97	0.03
2y	**R**	0.57	0.42	0.00	0.00	0.00	0.00	1.00	0.00
	$\boldsymbol{\pi}$	0.12	0.82	0.03	0.01	0.01	0.01	0.97	0.03
	i	0.19	0.71	0.05	0.02	0.00	0.01	0.96	0.04
	y	0.86	0.12	0.01	0.00	0.00	0.01	0.99	0.01
4y	**R**	0.53	0.46	0.00	0.00	0.00	0.00	1.00	0.00
	$\boldsymbol{\pi}$	0.12	0.86	0.01	0.00	0.00	0.00	0.99	0.01
	i	0.22	0.74	0.03	0.01	0.00	0.01	0.97	0.03

Comments to the Tables:

Tables 4-8 should be read as follows. Each number contains a share of variance of variable in row i attributed to shock in column j. The first column (P1) stands for the first permanent shock - a supply shock, the second (P2) for the permanent demand shock, the third for the permanent nominal shock (P3) (P4 for permanent foreign nominal shock for the UK). The fourth column (T1) stands for the monetary policy shocks, the fifth (T2) for transitory demand shock, and the sixth (T3) for transitory supply shocks. The last two columns contain the sum of the contributions by the permanent (P) and transitory (T) shocks respectively.

Table 5: FEVD for United Kigdom									
Step	**Var**	**P1**	**P2**	**P3**	**P4**	**T1**	**T2**	**P**	**T**
	y	0.00	0.26	0.05	0.52	0.00	0.17	0.83	0.17
1m	**R**	0.13	0.77	0.00	0.04	0.01	0.05	0.95	0.05
	$\boldsymbol{\pi}$	0.26	0.00	0.21	0.06	0.41	0.06	0.53	0.47
	i	0.01	0.01	0.68	0.16	0.14	0.01	0.86	0.14
	y	0.17	0.16	0.11	0.44	0.02	0.10	0.88	0.12
6m	**R**	0.03	0.89	0.01	0.04	0.01	0.01	0.98	0.02
	$\boldsymbol{\pi}$	0.37	0.03	0.48	0.02	0.10	0.01	0.90	0.10
	i	0.04	0.03	0.82	0.09	0.01	0.00	0.99	0.01
	y	0.37	0.12	0.12	0.29	0.03	0.07	0.90	0.10
1y	**R**	0.02	0.92	0.01	0.03	0.01	0.01	0.99	0.01
	$\boldsymbol{\pi}$	0.33	0.04	0.58	0.01	0.04	0.00	0.96	0.04
	i	0.04	0.05	0.82	0.09	0.00	0.00	1.00	0.00
	y	0.65	0.07	0.07	0.15	0.02	0.03	0.94	0.06
2y	**R**	0.04	0.93	0.01	0.02	0.00	0.00	0.99	0.01
	$\boldsymbol{\pi}$	0.30	0.05	0.63	0.00	0.02	0.00	0.98	0.02
	i	0.04	0.05	0.82	0.09	0.00	0.00	1.00	0.00
	y	0.86	0.03	0.03	0.06	0.01	0.01	0.98	0.02
4y	**R**	0.06	0.93	0.00	0.01	0.00	0.00	1.00	0.00
	$\boldsymbol{\pi}$	0.25	0.06	0.68	0.00	0.01	0.00	0.99	0.01
	i	0.04	0.05	0.82	0.08	0.00	0.00	1.00	0.00

Table 6: FEVD for Hungary									
Step	**Var**	**P1**	**P2**	**P3**	**T1**	**T2**	**T3**	**P**	**T**
	y	0.32	0.07	0.27	0.00	0.00	0.34	0.66	0.34
1m	**R**	0.01	0.37	0.01	0.54	0.00	0.07	0.39	0.61
	$\boldsymbol{\pi}$	0.00	0.11	0.26	0.02	0.59	0.01	0.37	0.63
	i	0.33	0.28	0.08	0.02	0.01	0.28	0.69	0.31
	y	0.62	0.06	0.13	0.01	0.01	0.17	0.81	0.19
6m	**R**	0.16	0.55	0.01	0.25	0.00	0.02	0.72	0.28
	$\boldsymbol{\pi}$	0.01	0.18	0.19	0.01	0.61	0.05	0.38	0.82
	i	0.23	0.68	0.02	0.03	0.01	0.04	0.92	0.08
	y	0.76	0.06	0.06	0.00	0.02	0.09	0.89	0.11
1y	**R**	0.28	0.58	0.25	0.11	0.01	0.02	0.86	0.14
	$\boldsymbol{\pi}$	0.01	0.51	0.01	0.00	0.28	0.00	0.71	0.29
	i	0.15	0.80	0.03	0.02	0.01	0.01	0.95	0.05
	y	0.87	0.05	0.02	0.00	0.01	0.04	0.95	0.05
2y	**R**	0.25	0.69	0.00	0.04	0.00	0.01	0.94	0.06
	$\boldsymbol{\pi}$	0.02	0.80	0.10	0.00	0.08	0.00	0.92	0.08
	i	0.16	0.80	0.01	0.01	0.01	0.01	0.97	0.03
	y	0.95	0.02	0.01	0.00	0.01	0.01	0.98	0.02
4y	**R**	0.25	0.72	0.00	0.02	0.00	0.00	0.97	0.03
	$\boldsymbol{\pi}$	0.03	0.86	0.07	0.00	0.03	0.00	0.96	0.04
	i	0.21	0.77	0.00	0.00	0.00	0.00	0.98	0.02

Table 7: FEVD for Denmark

Step	**Var**	**P1**	**P2**	**P3**	**T1**	**T2**	**T3**	**P**	**T**
	y	0.20	0.03	0.10	0.00	0.00	0.67	0.33	0.77
1m	**R**	0.52	0.05	0.00	0.06	0.32	0.05	0.57	0.43
	$\boldsymbol{\pi}$	0.01	0.95	0.00	0.00	0.00	0.04	0.96	0.04
	i	0.02	0.00	0.39	0.01	0.35	0.22	0.41	0.59
	y	0.49	0.01	0.11	0.00	0.00	0.38	0.61	0.39
6m	**R**	0.75	0.02	0.03	0.01	0.07	0.11	0.80	0.20
	$\boldsymbol{\pi}$	0.03	0.91	0.01	0.00	0.01	0.03	0.95	0.05
	i	0.01	0.16	0.69	0.01	0.10	0.03	0.86	0.14
	y	0.67	0.01	0.07	0.00	0.00	0.23	0.76	0.14
1y	**R**	0.78	0.09	0.03	0.01	0.04	0.06	0.89	0.11
	$\boldsymbol{\pi}$	0.04	0.91	0.01	0.00	0.01	0.02	0.96	0.04
	i	0.00	0.47	0.47	0.01	0.04	0.01	0.94	0.06
	y	0.82	0.01	0.04	0.00	0.00	0.13	0.87	0.13
2y	**R**	0.73	0.20	0.01	0.00	0.02	0.03	0.95	0.05
	$\boldsymbol{\pi}$	0.05	0.90	0.03	0.00	0.01	0.02	0.97	0.03
	i	0.01	0.73	0.24	0.00	0.01	0.00	0.98	0.02
	y	0.90	0.00	0.02	0.00	0.00	0.07	0.93	0.07
4y	**R**	0.68	0.29	0.01	0.00	0.01	0.01	0.97	0.03
	$\boldsymbol{\pi}$	0.05	0.88	0.06	0.00	0.00	0.01	0.98	0.02
	i	0.02	0.83	0.15	0.00	0.00	0.00	0.99	0.01

Table 8: FEVD for the Czech Republic

Step	**Var**	**P1**	**P2**	**P3**	**T1**	**T2**	**T3**	**P**	**T**
	y	0.93	0.02	0.04	0.00	0.00	0.01	0.99	0.01
1m	**R**	0.03	0.03	0.82	0.00	0.05	0.06	0.89	0.11
	$\boldsymbol{\pi}$	0.05	0.00	0.38	0.13	0.30	0.13	0.43	0.57
	i	0.01	0.01	0.23	0.67	0.06	0.02	0.25	0.75
	y	0.93	0.01	0.02	0.01	0.00	0.01	0.97	0.03
6m	**R**	0.02	0.01	0.89	0.06	0.01	0.01	0.93	0.07
	$\boldsymbol{\pi}$	0.23	0.02	0.15	0.25	0.08	0.27	0.39	0.61
	i	0.26	0.14	0.30	0.34	0.03	0.03	0.60	0.40
	y	0.96	0.01	0.01	0.01	0.00	0.01	0.98	0.02
1y	**R**	0.07	0.04	0.82	0.05	0.01	0.01	0.93	0.07
	$\boldsymbol{\pi}$	0.10	0.28	0.35	0.11	0.03	0.13	0.73	0.27
	i	0.30	0.25	0.35	0.08	0.01	0.01	0.90	0.10
	y	0.98	0.01	0.01	0.00	0.00	0.00	0.99	0.01
2y	**R**	0.41	0.10	0.45	0.03	0.00	0.01	0.96	0.04
	$\boldsymbol{\pi}$	0.05	0.47	0.39	0.04	0.01	0.04	0.91	0.09
	i	0.35	0.26	0.37	0.02	0.00	0.00	0.97	0.03
	y	0.99	0.00	0.00	0.00	0.00	0.00	1.00	0.00
4y	**R**	0.70	0.10	0.18	0.01	0.00	0.00	0.98	0.02
	$\boldsymbol{\pi}$	0.06	0.57	0.32	0.02	0.00	0.02	0.95	0.05
	i	0.36	0.25	0.37	0.01	0.00	0.00	0.99	0.01