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THE RELATIVE IMPORTANCE OF SYMMETRIC AND ASYMMETRIC SHOCKS: THE CASE OF UNITED KINGDOM AND EURO AREA

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Editorial

On the occasion of the 65th birthday of Governor Klaus Liebscher and in recognition of his commitment to Austria's participation in European monetary union and to the cause of European integration, the Oesterreichische Nationalbank (OeNB) established a "Klaus Liebscher Award". It will be offered annually as of 2005 for up to two excellent scientific papers on European monetary union and European integration issues. The authors must be less than 35 years old and be citizens from EU member or EU candidate countries. The "Klaus Liebscher Award" is worth EUR 10,000 each. The winners of the third Award 2007 were Harald Badinger and Gert Peersman. Gert Peersman's winning paper is presented in this Working Paper, while Harald Badinger's contribution is contained in Working Paper 135.

In this paper, Gert Peersman shows how a simple model with sign restrictions can be used to identify symmetric and asymmetric supply, demand and monetary policy shocks in a two-country structural VAR. The results can be used to deal with several issues that are important in the OCA-literature. Whilst the method can be applied to many countries, the author provides evidence for the UK versus the Euro Area which is compared versus the US as a benchmark. An important role for symmetric shocks with the Euro Area in explaining UK output fluctuations is found. However, the relative importance of asymmetric shocks, being around 20 percent in the long-run, cannot be ignored. In contrast, the degree of business cycle synchronization seems to have been higher with the US. Moreover, the historical average reaction of the policy rate to symmetric aggregate demand shocks was stronger in the UK than the Euro Area. The paper also confirms existing evidence of the exchange rate being an important independent source of shocks in the economy.

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The Relative Importance of Symmetric and Asymmetric Shocks: the Case of United Kingdom and Euro Area*

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April 2007

Abstract

In this paper, we show how a simple model with sign restrictions can be used to identify symmetric and asymmetric supply, demand and monetary policy shocks in a two-country structural VAR. The results can be used to deal with several issues that are important in the OCA-literature. Whilst the method can be applied to many countries, we provide evidence for the UK versus the Euro Area which are compared versus the US as a benchmark. An important role for symmetric shocks with the Euro Area in explaining UK output fluctuations is found. However, the relative importance of asymmetric shocks, being around 20 percent in the long-run, cannot be ignored. In contrast, the degree of business cycle synchronization seems to have been higher with the US. Moreover, the historical average reaction of the policy rate to symmetric aggregate demand shocks was stronger in the UK than the Euro Area. We also confirm existing evidence of the exchange rate being an important independent source of shocks in the economy.

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1 Introduction

A lot of questions in the international business cycle literature are still unresolved. In particular, the Optimal Currency Area (OCA) debate is still open and very topical. Consider, for instance, the entry of a large number of accession countries to the European Union that also might join the Eurozone relatively soon. On the other hand, Sweden and the United Kingdom recently decided not to enter or, at least, to postpone the introduction of the euro. In this paper, we tackle some important issues of the OCA-literature using a simple two-country structural vector autoregression (SVAR) framework. Specifically, we show how to estimate the relative importance of symmetric and asymmetric shocks in explaining the business cycles of potential currency area members. In addition, the framework also allows us to analyze whether average historical monetary policy reaction to symmetric shocks was different at the individual country level and the model can be used to investigate the role of the exchange rate in the economic adjustment process. Both questions are also very relevant in the OCA-literature. We provide empirical evidence for the United Kingdom (UK) versus the Euro Area (EA) and compare the results vis-à-vis the United States (US) as a benchmark. The issues are directly reflected in the five economic tests, announced by the UK government, that would need to be met to become a member of the Euro Area.[1] The methodology, however, can easily be applied to other countries as well.

In the context of a single currency, the resemblance of the business cycles of the participating countries is a major concern. Some synchronization of shocks and cycles is required to have a single stance of monetary policy that is acceptable for the individual countries. For instance, a common monetary policy expansion in response to a negative aggregate demand shock that is symmetric across countries should be adequate. In contrast, differences in cyclical situations and underlying shocks can complicate monetary

[1] The five economic tests are (i) Are business cycles and economic structures compatible with Eurozone interest rates on a permanent basis? (ii) If problems emerge, is there sufficient flexibility to deal with them? (iii) Would joining the euro create better conditions for firms making long-term decisions to invest in Britain? (iv) What impact would entry into the euro have on the UK's financial services industry? and (v) Would joining the euro promote higher growth, stability and a lasting increase in jobs?

policy. If asymmetric disturbances are important there will often be the occasion that an asymmetric policy response is required, which is impossible in a monetary union. It is therefore important to know the relative importance of symmetric and asymmetric shocks across members of a currency area to evaluate its costs and benefits.

In a seminal paper, Bayoumi and Eichengreen (1993) apply SVARs to compare the correlations of supply and demand shocks across European countries and US states. Their work has been extended or updated by Chamie et. al. (1994), Erkel-Rousse and Mélitz (1995) and Artis (2003) among others. A crucial problem in this literature is that these papers only focus on structural shocks not taking into account the propagation mechanism, whilst the global business cycle is determined by the interaction between the two. In addition, spill-over effects across countries are completely ignored. Countries constituting a monetary union mostly have close trade linkages. Even idiosyncratic shocks could then rapidly be transmitted to the other countries to become effectively 'common' or symmetric shocks (Bergman and Hutchison, 1998). On the other hand, a shock can be purely common (e.g. oil price shocks) and still produce opposite output effects. In the end, what really matters to evaluate the adequacy of a single monetary policy however is the *impact* of a shock on the economy, not whether the shock is idiosyncratic or common. In this paper, we take this problem seriously and estimate the dynamic effects of symmetric and asymmetric shocks on a set of macroeconomic variables, among them the global business cycle. Moreover, the shocks are identified in a way that is relevant in the context of the OCA-literature. To identify the shocks, we use a form of sign restrictions introduced by Faust (1998), Uhlig (1999) and Canova and De Nicoló (2002) and extended by Peersman (2005). We elaborate their method by making a distinction between symmetric and asymmetric shocks. The former are identified as shocks that generate an effect which has the same sign in both areas under investigation. In contrast, asymmetric shocks have the opposite impact in both areas. The relative importance of both disturbances to explain the business cycle can then be estimated. We find an important contribution of symmetric shocks with the Euro Area to explain the UK business cycle. However, the role of asymmetric shocks is economically significant and cannot be ignored. Moreover, we find a higher degree of business cycle synchronization between the UK and the US in the long-run.

As a side issue, the empirical framework allows us not just to analyze the relative importance of symmetric and asymmetric shocks but also two other topical issues in the OCA-literature. Even if symmetric shocks dominate the business cycle, the required interest rate reaction at the individual country level might be different which could also complicate monetary policy. For instance, if economic structures are different or the propagation mechanism is dissimilar, it is perfectly possible that an optimal interest rate response is different in the two areas even after a symmetric shock. Our method allows us to partly investigate this issue. In particular, it is possible to examine whether the interest rate reaction to symmetric shocks was historically different in the UK and Euro Area. Indeed, we find that the average interest rate reaction to aggregate demand shocks was significantly stronger in the UK than the Euro Area.

Another important issue is the role of the exchange rate in the economic adjustment process. The loss of a flexible exchange rate as an automatic stabilization mechanism might be a substantial cost for a country joining a monetary union. A different situation arises if the foreign exchange market fails to offer any stabilization benefit. It may even be that the exchange rate is an independent source of shocks and imbalances to the economy are driven by irrational movements in financial markets rather than economic fundamentals (Buiter, 2000). Structural VARs are often used to determine the role of the exchange rate but disagree in their results.[2] A shortcoming of most of these papers is that the VARs are estimated in relative variables, e.g. relative output, relative prices and the interest rate differential. This implies that the same propagation mechanism in both countries or areas is assumed, which can bias the results. Other papers estimate a one-country open economy VAR without relative variables which can also generate biased results because no distinction is made between symmetric and asymmetric shocks. Our more general two-country framework without relative variables incorporates these shortcomings. We confirm the evidence of the exchange rate being an important independent source of shocks in the

[2] Clarida and Gali (1994), Funke (2000) and Chadha and Prasad (1997) find an important role for the exchange rate acting as a stabilization mechanism. On the other hand, Artis and Ehrmann (2000), Canzoneri et. al. (1996) and Farrant and Peersman (2006) find that the exchange rate seems mostly to reflect shocks originating in the foreign exchange market itself.

economy.

The rest of the paper is structured as follows. Section 2 briefly explains the methodology and the empirical model. Results are reported in section 3. A distinction is made between the analysis of impulse response functions, the relative importance of symmetric and asymmetric shocks and the factors driving exchange rate fluctuations. Finally, section 4 concludes.

2 Methodology

Structural VARs have become a basic analytical tool in modern macroeconomics, in particular the analysis of shocks. Accordingly, VARs are often used to analyze the above mentioned topics. We elaborate the existing models by making a distinction between symmetric and asymmetric shocks in a two-country VAR. We first define symmetric and asymmetric shocks in a context useful for the OCA-literature in section 2.1. In section 2.2, we implement the restrictions in a recent model of Farrant and Peersman (2006) which disentangles aggregate supply, aggregate demand, monetary policy and exogenous exchange rate shocks. Estimation results for the UK-EA and UK-US are discussed in section 3.

2.1 The identification of symmetric and asymmetric shocks

According to the OCA theory, the member countries of a currency area should experience similar movements of the business cycle. Differences in cyclical situations and underlying disturbances can complicate monetary policy because a single interest rate is then not optimal for the individual member countries. As a consequence, an important part of the costs to join the Euro Area or other currency areas depends on the synchronization of the business cycles or the relative importance of symmetric and asymmetric shocks. One of the five economic tests set by the UK government to become a member of the Euro Area requires cyclical convergence so that they and others could live comfortably with the same interest rate on a permanent basis.

The traditional OCA literature typically focuses on asymmetric shocks. Only if the countries of a monetary union share similar shocks to their economy, a common monetary policy is acceptable for all the individual countries and the lower is the cost of giving up an independent monetary policy. Influential empirical papers like Bayoumi and Eichengreen (1993), Chamie et. al. (1994), Erkel-Rousse and Mélitz (1995) and Artis (2003) apply SVARs for individual countries and compare the correlations of supply and demand shocks as a criterion to join a monetary union. A crucial problem of these papers is the focus on the correlation of structural shocks not taking into account the propagation mechanism. The global business cycle is, however, determined by the interaction of structural disturbances and economic dynamics. Moreover, fast spill-over effects across countries are not taken into account. Members of a currency area typically have close trade linkages. Accordingly, even pure idiosyncratic shocks could then be passed-trough to the other countries. In the context of a monetary union with one single central bank, the latter does not create serious difficulties. Specifically, the required monetary policy reaction will be similar or, at least, in the same direction. On the other hand, pure common shocks[3] are not necessary innocuous because they can sometimes generate opposite effects across countries. For example, if one country is a net exporter of oil and the other a net importer, a common oil shock will end up having effects of opposite signs on the two economies. This type of shocks can create substantial problems in a monetary union. When measuring costs and benefits of a single currency, it is therefore important to define a shock depending on its impact on the economy irrespective of being common or idiosyncratic. This is exactly what we do in this paper. The way we identify a shock is determined by its impact and takes into account the potential spill-over effects of trade linkages. In addition, the underlying model we introduce in section 2.2 is a two-country VAR which allows us to consider the complete economic dynamics of the shocks and the global business cycle.

We define a shock as being respectively symmetric or asymmetric when:

$$sign\left[R(A)^{pq}_{t+k}\right] = sign\left[R(B)^{pq}_{t+k}\right] \tag{1}$$

$$sign\left[R(A)^{pq}_{t+k}\right] \neq sign\left[R(B)^{pq}_{t+k}\right] \tag{2}$$

[3] E.g. the way they are defined in dynamic factor models (Forni et. al., 2000).

where $R(A)^{pq}_{t+k}$ and $R(B)^{pq}_{t+k}$ are the impulse response functions of variable p at lag k to a shock in q at time t in country A and B respectively. Accordingly, a symmetric shock has the same impact on a set of macroeconomic variables in both countries in terms of its *signs*. In contrast, the signs of the impact of an asymmetric shock are the opposite in both countries. The magnitude of the impact and the propagation mechanism can, however, still be different. This will be determined by the estimation results. Spill-over effects across countries are also taken into account which is what matters for countries sharing one currency. Consider, for instance, an idiosyncratic shock in country A. If this shock is largely transmitted to country B through trade, a common monetary policy stance can still be appropriate for both countries. This shock will be identified as being symmetric with our method. A crucial aspect of this method is then the implicit timing allowed for the spill-over effects to take place, i.e. the value of k. In order to have an acceptable monetary policy stance for both countries in a currency union, spill-overs effects should take place relatively quick. If we impose the restrictions to be contemporaneously binding, only immediate spill-over effects of idiosyncratic shocks are considered as symmetric shocks. In contrast, if we introduce the restrictions only after a number of lags, sluggish spill-over effects are also considered as symmetric shocks. The robustness for alternative values of k will be discussed in section 3, where we present the results. In the next section, we show how to implement the restrictions in an existing SVAR model.

2.2 The underlying model and restrictions

Once we have defined symmetric and asymmetric shocks, we can introduce the restrictions in an SVAR to estimate the relative importance of the shocks in explaining business cycle fluctuations. We implement the restrictions in the model of Farrant and Peersman (2006) for several reasons. First, they estimate the effects of aggregate supply, aggregate demand, monetary policy and exchange rate shocks using an SVAR with sign restrictions. The advantage of their procedure is that no zero constraints need to be imposed to identify the shocks. The restrictions are much more general and easier to implement when economic theory only provides qualitative rather than quantitative information about the effects of shocks. Because a symmetric and asymmetric shock, as defined in section 2.1, is also identified using the signs of its impact, it is very convenient to start with the Farrant and Peersman (2006) model. Second, their identified shocks are also appropriate for our analysis. Bayoumi and Eichengreen (1993) only identify aggregate supply and demand shocks. Others have also identified monetary policy shocks because the latter can influence the historical correlation of aggregate demand shocks.[4] Idiosyncratic monetary policy shocks are, however, not relevant anymore in a monetary union. Consequently, the impact of these shocks should be filtered out. Third, the model contains the short-term nominal interest rate for both countries which can be considered as the monetary policy instrument. As a result, it will be possible to evaluate whether central banks have historically reacted differently to symmetric shocks once we have extended the model. After all, even perfect symmetric shocks can require a different monetary policy reaction due to, for instance, a different monetary transmission mechanism. Finally, the model also allows us to investigate the role of the exchange rate in the economic adjustment process which is also an important topic in the OCA-literature. Farrant and Peersman (2006), like Clarida and Gali (1994), estimate a two-country model in relative variables which assumes the same propagation mechanism in both countries. A side issue of our approach is that we can check the robustness of their results in a two-country VAR without this assumption.

Farrant and Peersman (2006) use sign restrictions that are derived from a stochastic two-country open macro model with sticky prices developed by Clarida and Gali (1994), based on Obstfeld (1985) and Dornbusch (1976). All variables represent home relative to foreign levels. The restrictions, i.e. the signs of the impulse response functions in the short-run can be summarized in the following matrix, where $y - y^*$ is relative output, $p - p^*$ relative prices, $i - i^*$ relative interest rate and q the real exchange rate.[5]

	$y - y^*$	$p - p^*$	$i - i^*$	q
relative supply	$\geqslant 0$	$\leqslant 0$	$\leqslant 0$	?
relative demand	$\geqslant 0$	$\geqslant 0$	$\geqslant 0$	$\leqslant 0$
relative monetary policy	$\leqslant 0$	$\leqslant 0$	$\geqslant 0$	$\leqslant 0$
exchange rate	$\geqslant 0$	$\geqslant 0$	$\geqslant 0$	$\geqslant 0$

[4] For instance Chamie et. al. (1994).

[5] A rise in q is a depreciation of the real exchange rate. All variables are log-levels, except the interest rates which are in percent.

The intuition of these restrictions is very appealing and consistent with a large class of other conventional theoretical models if we take into account the monetary policy strategy in the countries under investigation, i.e. developed countries. Because the restrictions are imposed as $\leqslant$ or $\geqslant$, a zero reaction is still possible. A positive relative supply shock has a positive effect on relative output, a negative effect on relative prices and there is a fall in the nominal interest rate differential. Whilst a depreciation of the real exchange rate is expected in the long-run, the short-run effect is uncertain in the Clarida and Gali (1994) model. Moreover, a positive supply shock may be accompanied by an upward shift in the aggregate demand curve if there is a rise in domestic real wealth and consumers have a home bias in consumption.[6] As a result, no restriction is imposed on the reaction of the real exchange rate and the data determines the sign of this response. After a positive relative demand shock, relative output, relative prices and relative interest rate all rise. In addition, there is an appreciation of the real exchange rate which should act as a stabilizer. A restrictive relative monetary policy shock leads to a fall in relative output and prices and an appreciation of the exchange rate. Finally, an exogenous depreciation of the exchange rate causes output and prices to increase and the central bank reacts by increasing the interest rate in order to offset inflationary pressures. Farrant and Peersman (2006) impose the restrictions to be binding the first four quarters after the shocks for output and prices and one quarter for the interest rate differential and real exchange rate.[7]

Clarida and Gali (1994) and Farrant and Peersman (2006) estimate the model in relative variables, which implies that also relative shocks are identified. However, this does not provide any information about the importance of these shocks for the country as a whole. It is, for instance, possible that relative shocks explain only a very small proportion of total output fluctuations in a certain country. On the other hand, what really matters in the OCA-literature is the relative importance of symmetric and asymmetric shocks. We therefore extend the Farrant and Peersman (2006) model to two countries without relative variables and make a distinction between symmetric and asymmetric shocks as described in section 2.1. An additional advantage is that we do not have to assume anymore that

[6] See Detken et al. (2002) or Bayoumi and Eichengreen (1994).

[7] Because the interest rate and the exchange rate are considered as being very flexible variables, in contrast to output and prices.

the propagation mechanism of the shocks is symmetric in both countries. The variables which will be used in the empirical VAR are: domestic output (y_t), prices (p_t) and nominal interest rate (i_t), foreign output (y_t^*), prices (p_t^*) and nominal interest rate (i_t^*) and the real bilateral exchange rate (q). In order to identify the shocks, the following restrictions are introduced:

	y	p	i	y^*	p^*	i^*	q
symmetric supply	$\geqslant 0$	$\leqslant 0$	$\leqslant 0$	$\geqslant 0$	$\leqslant 0$	$\leqslant 0$	?
symmetric demand	$\geqslant 0$	$\geqslant 0$	$\geqslant 0$	$\geqslant 0$	$\geqslant 0$	$\geqslant 0$	?
symmetric monetary policy	$\leqslant 0$	$\leqslant 0$	$\geqslant 0$	$\leqslant 0$	$\leqslant 0$	$\geqslant 0$	?
asymmetric supply	$\geqslant 0$	$\leqslant 0$	$\leqslant 0$	$\leqslant 0$	$\geqslant 0$	$\geqslant 0$	?
asymmetric demand	$\geqslant 0$	$\geqslant 0$	$\geqslant 0$	$\leqslant 0$	$\leqslant 0$	$\leqslant 0$	$\leqslant 0$
asymmetric monetary policy	$\leqslant 0$	$\leqslant 0$	$\geqslant 0$	$\geqslant 0$	$\geqslant 0$	$\leqslant 0$	$\leqslant 0$
exchange rate	$\geqslant 0$	$\geqslant 0$	$\geqslant 0$	$\leqslant 0$	$\leqslant 0$	$\leqslant 0$	$\geqslant 0$

The restrictions are fundamentally still the same as in Farrant and Peersman (2006), but generalized to symmetric and asymmetric shocks. A symmetric positive supply shock is a shock which has a positive effect on output and a negative effect on prices and the nominal interest rate in both countries simultaneously. After a positive symmetric aggregate demand shock, both countries experience a rise in output, prices and the interest rate. A symmetric restrictive monetary policy shock (rise in the nominal interest rate) has a negative effect on output and prices in both countries. As such, spill-over effects of idiosyncratic shocks are considered as 'symmetric' because that is what matters in the context of a currency union. The symmetric shock can, however, still have a different impact in terms of magnitude or propagation mechanism. If we want to examine whether monetary policy has reacted differently to symmetric shocks in the past, we simply have to compare the responses of i and i^*.

The identification of asymmetric supply, demand and monetary policy shocks is similar. A positive asymmetric supply shock in country A has a positive effect on output and a negative impact on prices and the nominal interest rate in country A. Since the shock is asymmetric, the opposite impact in terms of signs takes place in country B. After a positive asymmetric aggregate demand shock, output, prices and the interest rate rise in country A and fall in country B.[8] In addition, there is an appreciation of the real exchange rate. To disentangle an asymmetric aggregate demand from an asymmetric monetary policy shock, the co-movement of the interest rate reaction with output and prices is negative after a policy shock whilst being positive after an aggregate demand shock in both countries. Finally, an exogenous exchange rate shock is introduced. A positive exchange rate shock (depreciation in country A), has a positive effect on output, prices and nominal interest rate in country A, while there is a fall in all three variables in country B.[9] If the latter shock explains a large part of exchange rate and output fluctuations, the exchange rate can be considered as a potential source of shocks.

3 Results

In this section, we provide empirical evidence for the United Kingdom versus the Euro Area. The synchronization of the business cycles and the role of monetary policy and the exchange rate are important issues in the assessment of the UK government to enter the Euro Area. As a benchmark, we compare the results with a two-country VAR for the UK and the US. The analysis can easily be extended to other countries as well. The sample period for all estimations is the post Bretton Woods period, 1974-2002.[10] Consider the following specification for a vector of endogenous variables Y_t:

$$Y_t = c + \sum_{i=1}^{n} A_i Y_{t-i} + B\varepsilon_t \quad (3)$$

where c is an $(n \times 1)$ matrix of constants, A_i is an $(n \times n)$ matrix of autoregressive coefficients and ε_t is a vector of structural disturbances. The endogenous variables, Y_t, that we include in the VAR are domestic output (y_t), prices (p_t) and nominal interest rate (i_t), foreign output (y_t^*), prices (p_t^*) and nominal interest rate (i_t^*) and the real bilateral exchange rate (q). The VAR-model is estimated in log-levels (except the interest rates).

[8] Or output, prices and the nominal interest rate in country B, at least, do not rise because we use $\leqslant$ and $\geqslant$ restrictions.

[9] See also Farrant and Peersman (2006) for a comprehensive discussion of these restrictions.

[10] Estimations for shorter sample periods are available upon request but do not alter the main conclusions of the paper.

Lag length is determined by standard likelihood ratio tests and AIC information criterion which turns out to be two for EA-UK and US-UK.

Following Uhlig (1999) and Peersman (2005), we use a Bayesian approach for estimation and inference.[11] Our prior and posterior belong to the Normal-Wishart family used in the RATS manual for drawing error bands. Because there are an infinite number of admissible decompositions for each draw from the posterior when using sign restrictions, we use the following procedure. To draw the "candidate truths" from the posterior, we take a joint draw from the posterior for the usual unrestricted Normal-Wishart posterior for the VAR parameters as well as a uniform distribution for the rotation matrices. We then construct impulse response functions. If the impulse responses to an individual shock are consistent with the imposed conditions for this shock, the results for the specific shock are accepted. Otherwise, the draw is rejected, which means that this draw receives zero prior weight. Based on the draws kept, we calculate statistics and report the median responses, together with 84th and 16th percentiles error bands. For output and prices, the time period over which the sign constraints are binding, k, is set equal up to four quarters. For interest rates and the real exchange rate we only impose a restriction during one quarter because these are more flexible variables.[12] More specifically, basic estimations are done with $k = 0, \ldots, 4$ for output and prices and $k = 0, 1$ for the interest rate and real exchange rate. We also discuss the results for a higher starting value of k (i.e. $k = 2, \ldots, 4$ for output and prices and $k = 2$ for interest rate and real exchange rate), which allows a longer period for spill-over effects to take place.

The estimation results can deliver us some policy relevant conclusions. We first perform an impulse response analysis in Section 3.1, which provides us information about the plausibility of the estimations and allows us to compare the monetary policy response in both countries. The relative importance of symmetric and asymmetric shocks is discussed in Section 3.2. Finally, section 3.3 describes the contribution of all shocks to the exchange rate.

[11] For a full explanation of the methodology, see Peersman (2005).

[12] See also Farrant and Peersman (2006), our benchmark model.

3.1 Impulse response analysis

Impulse response functions are reported in Figures 1 and 2 for respectively EA-UK and US-UK. The figures report the median of the posterior (full black lines) together with 84th and 16th percentile error bands (dotted lines) for the basic estimation results, i.e. estimations with contemporaneous imposed sign conditions. The grey lines are the impulse response functions (median of the posterior) using restrictions that are only binding two lags after the shocks, i.e. a longer period for spill-over effects is allowed. For each draw from the posterior, we also draw an impulse response function for the output, prices and interest rate differentials which gives us additional information about the relative impact of each shock in both countries. Given our identification strategy, a symmetric shock can have different output and price effects in terms of timing and magnitude due to differences in economic structure or incomplete pass-through to the other country. On the other hand, the required policy reaction could be different because of asymmetries in the monetary transmission mechanism. Consequently, a single interest rate could even be harmful for the individual countries when confronted with symmetric shocks. We therefore also examine the difference in interest rate reaction to all shocks. Differences in the interest rate response could, however, also be due to suboptimal reaction or different preferences of central banks with respect to, for example, output and inflation. We therefore have to be careful when interpreting the results because it is not possible to figure out what is the exact reason for the different reactions. Overall, we can only examine whether monetary policy historically reacted differently to (symmetric) shocks that moved the economies in the same direction.

After a symmetric supply shock, there is a persistent effect on output and prices and a temporary reaction of the nominal interest rates. The output and price effects are in the short-run significantly greater in the UK than the EA. This is not the case when we consider the effects of a symmetric supply shock in the US and UK, shown in Figure 2. This faster reaction in the UK and US might be a reflection of a more flexible economy and faster propagation mechanism in these countries. However, we do not find a relevant different historical reaction of monetary authorities in both countries because the interest rate differential is not significant different from zero. Interestingly, this is not the case after a symmetric demand shock. A significant higher interest rate shift is found for the

UK compared to the EA. Possibly, this is due to a substantial stronger short-run impact of the shock on output and prices in the former economy. In contrast, in the US-UK VAR, we do not find a different effect on output and interest rates after a symmetric demand shock. On the other hand, there are no significant differences after a symmetric monetary policy shock in the UK and EA. Both countries experience a similar u-shaped reaction of output and a permanent fall of prices after a common restrictive policy shock. Finally, for all three symmetric shocks, we do not find a noticeable reaction of the real exchange rate.

The impulse response functions to an asymmetric supply, demand and monetary policy shock are reported in respectively the fourth, fifth and sixth row of Figures 1 and 2. By construction, we have an asymmetric reaction in both countries for all variables and a significant reaction of the real exchange rate. Somewhat surprising, although only slightly significant, we find an appreciation of the real exchange rate after a positive asymmetric supply shock, a restriction which was not imposed. This rather perverse effect, often also found for other currencies, is also reported in Detken et al. (2002) and Farrant and Peersman (2006) for the Euro Area. The corresponding output effects, however, do not seem to last very long. Variance decompositions, reported in Section 3.2, also indicate that asymmetric supply shocks are relatively unimportant in explaining business cycle fluctuations. Finally, after an exogenous depreciation of the real exchange rate, there is a temporary effect on output in both countries and a permanent effect on relative prices. The real exchange rate, however, returns to baseline after a number of quarters indicating that there is a permanent shift in the nominal exchange rate. In section 3.3, we will investigate the macroeconomic relevance of such disturbances.

Most of these results are very consistent with the impulse response functions in the US-UK. In addition, the results are also very robust with respect to the time period over which the restrictions are binding. If we allow a longer period for the spill-over effects to take place (grey lines in Figures 1 and 2), impulse response functions are very close to the results when also contemporaneous constraints are introduced. The only relevant exception is the reaction of the real exchange rate to an asymmetric demand shock for the US-UK, which is much smaller in the very short-run. To summarize, most impulse response functions behave very plausible. We notice a monetary policy reaction which is greater in the UK compared to the Euro area after a symmetric demand shock.

3.2 The relative importance of symmetric and asymmetric shocks

A central question in this paper is obviously the relative importance of symmetric and asymmetric shocks to explain the business cycles. When the relative contribution of symmetric shocks is very high, synchronization of the business cycles is high and the cost for the UK to join the EA is rather small. As a result, both countries could live comfortably with the same interest rate.[13] In contrast, after asymmetric shocks, the required interest rate reaction is the opposite in both countries and giving up an independent monetary policy can be very costly. As a result, to form a monetary union, it is important that the contribution of asymmetric shocks to the business cycle is as limited as possible. Forecast error variance decompositions of output in both countries are reported in Table 1. We only report the median estimates of the posterior distribution at a horizon of respectively 0, 4 and 20 quarters.[14] The median of the posterior when the restrictions are only imposed 2 lags after the shocks are reported between parenthesis. Using these decompositions, we can measure the relative importance of all shocks.

Consider the EA-UK VAR results. In the very short-run (0-4 quarters after the shocks), there is a major role for symmetric shocks in explaining the UK business cycle: around 75 percent of the forecast error variance. 19 percent is explained by asymmetric shocks and 5 percent by exchange rate disturbances. Taking into account that bilateral exchange rate shocks and asymmetric monetary policy shocks will disappear in a monetary union, there is only around 10-13 percent left which is explained by asymmetric supply and demand shocks. In the long-run (after 20 quarters), however, this share rises to 20-25 percent depending on the horizon of the imposed conditions. When we consider the Euro Area business cycle, the contribution of asymmetric shocks is even much larger, being more than 50 percent in the very short-run and still almost 30 percent in the long-run. Comparing the results with the US-UK VAR, we find a lower contribution of asymmetric shocks in

[13] In section 3.1, we have seen that symmetric aggregate demand shocks could potentially be problematic with respect to the required size of the interest rate reaction. However, the direction of the interest rate move will always be correct and losses are probably limited.

[14] Full results are available upon request.

the long-run, which means a higher synchronization of the cycles in the US and UK.[15] For the latter two countries, however, we find an important role for asymmetric demand shocks in explaining output fluctuations in the short-run. As we will discuss in Section 3.3, these shocks will mainly be accommodated by the exchange rate, neutralizing the impact in the long-run. In sum, we find that symmetric shocks with the Euro Area are very important in explaining the UK business cycle. The contribution of asymmetric shocks, however, cannot be ignored in the long-run. In addition, the UK cycle seems to be more synchronized with the US. The output contribution of asymmetric shocks is much smaller in these two countries.

3.3 The role of the exchange rate

An independent flexible exchange rate can be considered as a mechanism which reacts to fundamental shocks to help stabilizing output and inflation variability. The loss of this automatic stabilizer can be a substantial cost for a country joining a monetary union. In reality, exchange rates are however very volatile and the uncovered interest parity condition fails in econometric estimations. As a consequence, it may be that the exchange rate itself is an independent source of shocks which disturbs the economy. A crucial question is then how relevant are exogenous exchange rate shocks to explain exchange rate fluctuations and, more important, what is the impact of these shocks on output volatility.

There already exist a large body of evidence on the role of the exchange rate in the economic adjustment process. Structural VARs are often used to determine this role. Most of the studies, however, disagree in their results. Clarida and Gali (1994), Funke (2000) and Chadha and Prasad (1997) find an important role for the exchange rate acting as a shock absorber. On the other hand, Artis and Ehrmann (2000), Canzoneri et. al. (1996) and Farrant and Peersman (2006) find that the exchange rate is rather a source of shocks. Most of these papers are, however, estimated in relative variables. This implies that the same propagation mechanism in both countries or areas is assumed, which can bias the results. Artis and Ehrmann (2000) estimate a one-country open economy VAR without

[15] The contribution of symmetric shocks is around 75 percent in the long run for the US-UK. In contrast, this is only 53-57 percent in the EA-UK VAR.

relative variables. The latter can also generate biased results, in particular when there is an important role for symmetric shocks. In contrast to asymmetric shocks, the exchange rate is not expected to react in a significant way to symmetric shocks. In a one-country VAR, however, no distinction is made between symmetric and asymmetric shocks. As a consequence, the estimated stabilization role of the exchange rate to, for instance, an *aggregate* demand shock will be biased. It is very likely that this results in a less important role for the exchange rate to stabilize the economy. Indeed, Artis and Ehrmann (2000) find a substantial contribution of exchange rate noise to explain its fluctuations. Our approach described above takes these points seriously because we estimate a two-country VAR without relative variables. Moreover, we disentangle symmetric from asymmetric shocks and can analyze the role of both in determining the exchange rate. Accordingly, we can also check the robustness of the existing empirical evidence with our more general approach.

Table 2 decomposes the variance of the exchange rate into the contribution of symmetric and asymmetric supply, demand and monetary policy shocks, and pure exchange rate noise for respectively the EA-UK and US-UK. The contribution of exchange rate shocks reflects the role of the exchange rate as a source of shocks. If this contribution is high, there is little role for the exchange rate as a stabilization mechanism. We find a very high contribution of exchange rate noise in the short-run, explaining 45 percent of Sterling-Euro fluctuations within one quarter. This contribution is still substantial in the long-run, i.e. 18 percent after twenty quarters. When we only impose the restrictions from lag 2 after the shocks onwards, the contribution is somewhat lower at 14 percent in the short-run and 15 percent after five years. These values are much higher than the original Clarida and Gali (1994) results and even slightly higher than the Farrant and Peersman (2006) results. On the other hand, the contribution of exchange rate shocks is still remarkably lower than the results obtained in Artis and Erhmann (2000).

More important is obviously the contribution of such noise to output fluctuations, i.e. the business cycle. If this contribution is low, exogenous exchange rate fluctuations are not very harmful. Table 1 also contains the relative contribution of exchange rate shocks to output. In the short-run, this is only 5 percent. The relative contribution, however, rises to around 15 percent after 20 quarters which cannot be ignored. Accordingly, exogenous exchange rate shocks (or at least exchange rate movements not explained by aggregate supply, aggregate demand and monetary policy shocks) are an important source of business cycle fluctuations.

One can argue that it is difficult to investigate whether the exchange rate has been used as a stabilizer or an independent source of shocks for Sterling-Euro because, prior to 1999, the exchange rate is a weighted average of individual countries where interventions in the FX market did not always simultaneously take place. This is certainly true, but the results for the US-UK VAR are very similar. The contribution of exchange rate shocks to total variance of the exchange rate is even higher, both in the short and long-run. On the other hand, the contribution to the global business cycle is somewhat lower, but still between 7 and 10 percent for the UK. Interestingly, we notice a major role for asymmetric aggregate demand shocks to explain exchange rate volatility in the long-run, i.e. 35 percent after 20 quarters, which should stabilize the large asymmetric output effects obtained in the very short-run (see section 3.2).

4 Conclusions

Several countries will probably join EMU in the near future or are facing the choice to join the Eurozone. The traditional starting point for this issue is the theory of Optimum Currency Areas. According to this theory, the member countries of a currency area should experience similar movements of the business cycle. When cyclical situations are different, a single stance of monetary policy is then sub-optimal for the individual countries. Therefore, an important part of the costs to join the Euro Area or other currency areas depends on the synchronization of the business cycles, i.e. the relative importance of symmetric and asymmetric shocks.

In this paper, we have provided evidence for the United Kingdom versus the Euro Area. The results are compared versus the US as a benchmark. To do so, we have estimated two-country structural VAR models. Symmetric supply, demand and monetary policy shocks are identified as well as asymmetric supply, demand, monetary policy and exchange rate shocks. We propose an identification strategy which is based on sign restrictions. The results indicate a very important role for symmetric shocks with the Euro Area in explaining UK output fluctuations. The relative importance of asymmetric supply and demand shocks, however, cannot be ignored. Both shocks explain around 20 percent of output variability in the long-run, which is economically significant. The degree of synchronization seems to be higher with the US, especially in the long-run. We also find a significant stronger average reaction of the UK policy rate to symmetric aggregate demand shocks in our sample period. If this is due to differences in economic structures, these type of shocks can also complicate a single monetary policy.

A related question is the role of the exchange rate which is often considered as being an independent source of shocks instead of being an adjustment mechanism. We have found a considerable role for the exchange rate as an independent source of shocks. Exchange rate disturbances against the Euro explain around 15 percent of UK output fluctuations and almost 20 percent of the exchange rate in the long-run. This finding is economically also important and robust for the US-UK.

In interpreting the results, some caution is required. It is not possible to say how data generated from a period when the economies operate under a given regime will change when a new monetary regime is established, i.e. the introduction of the euro. An extension of this paper could be an application to current members of the Eurozone some time after the introduction of the new currency, once enough data is available. A related extension is the analysis of other countries who have joined the European Union recently and might introduce the euro relatively soon such as a large number of accession countries.

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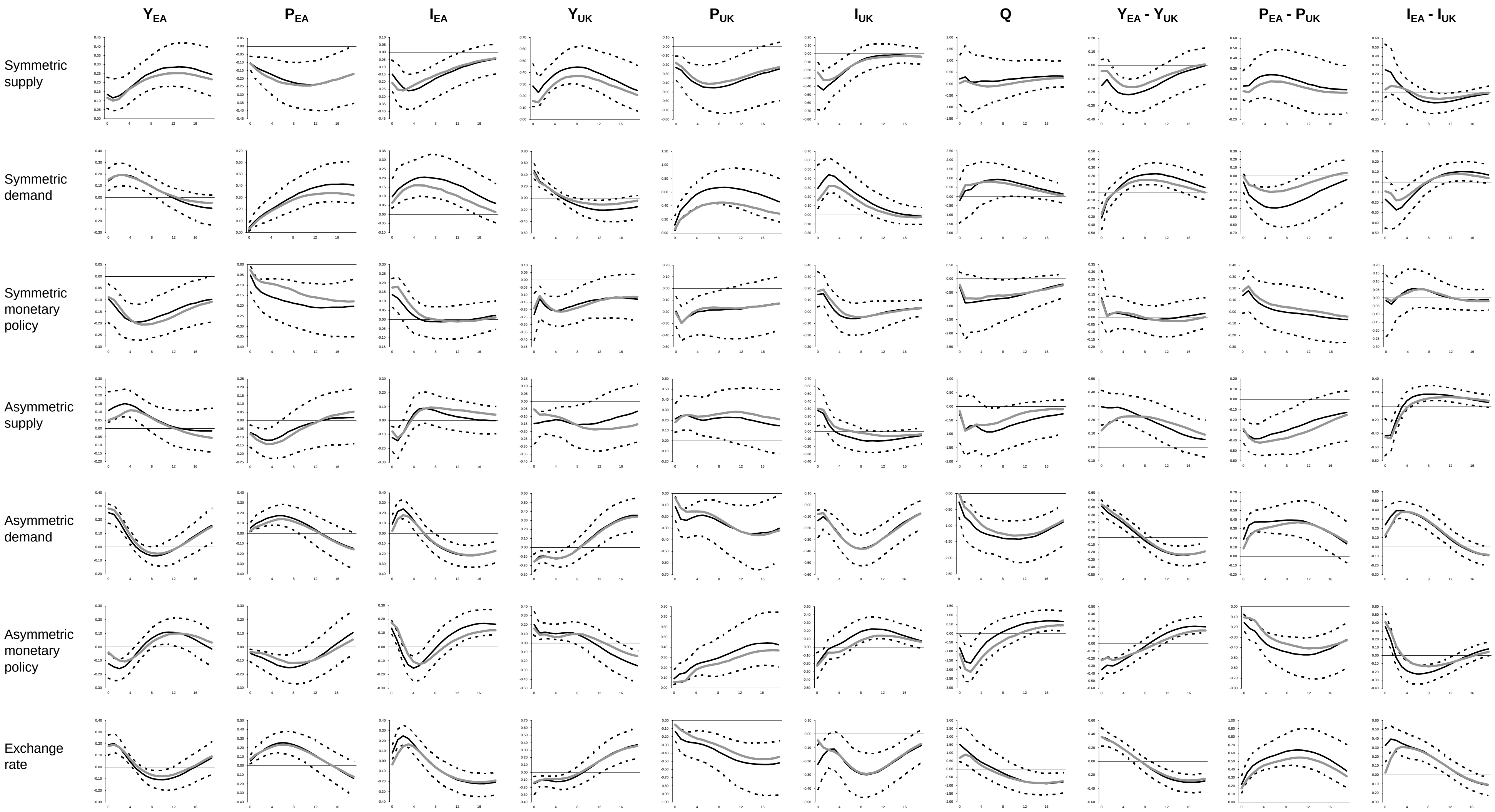
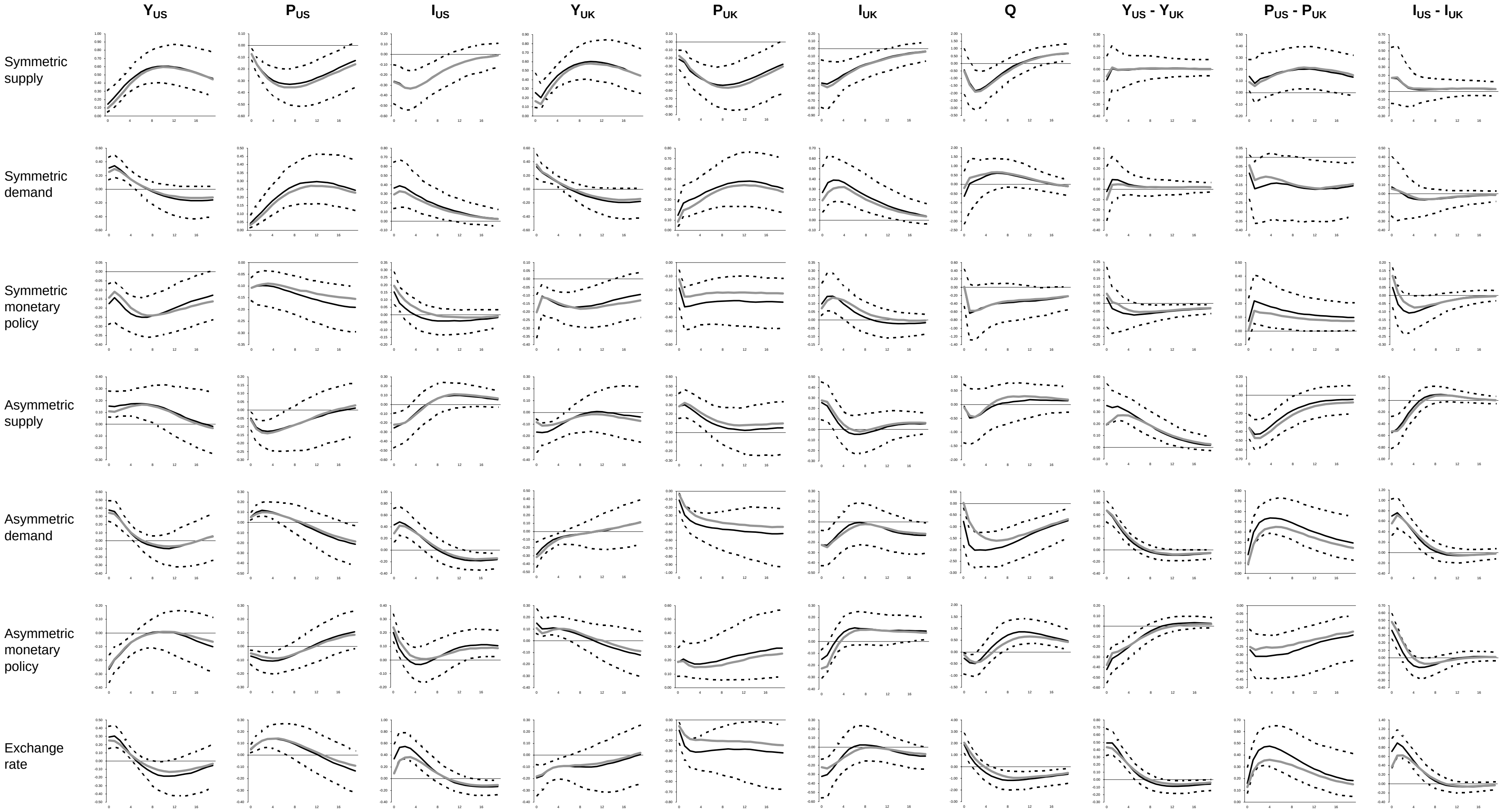
Figure 1 - Euro area / United Kingdom - Impulse response functions



Note: Median impulse responses from the posterior with 16th and 84th percentiles error bands. Grey line is median impulse response when restrictions are only imposed 2 lags after the shocks

Figure 2 - United States / United Kingdom - Impulse response functions



Note: Median impulse responses from the posterior with 16th and 84th percentiles error bands. Grey line is median impulse response when restrictions are only imposed 2 lags after the shocks

Table 1 - Forecast error variance decomposition of output

Euro area - United Kingdom VAR

	EA output			UK output		
	0 quarters	4 quarters	20 quarters	0 quarters	4 quarters	20 quarters
Symmetric shocks	**28 (28)**	**44 (44)**	**62 (63)**	**76 (77)**	**75 (76)**	**57 (53)**
supply	10 (8)	12 (11)	35 (32)	18 (9)	35 (26)	36 (32)
demand	12 (15)	19 (20)	12 (12)	47 (56)	26 (33)	12 (11)
monetary policy	5 (5)	13 (13)	15 (18)	12 (12)	14 (16)	9 (10)
Asymmetric shocks	**52 (52)**	**43 (41)**	**28 (28)**	**19 (17)**	**19 (19)**	**29 (32)**
supply	7 (3)	11 (6)	8 (7)	5 (2)	7 (5)	7 (9)
demand	37 (47)	20 (30)	11 (14)	5 (8)	6 (8)	13 (16)
monetary policy	9 (3)	11 (5)	8 (7)	9 (8)	7 (6)	9 (6)
Exchange rate shocks	**20 (19)**	**13 (15)**	**10 (9)**	**5 (6)**	**6 (6)**	**14 (15)**

United States - United Kingdom VAR

	US output			UK output		
	0 quarters	4 quarters	20 quarters	0 quarters	4 quarters	20 quarters
Symmetric shocks	**32 (29)**	**52 (50)**	**70 (73)**	**56 (56)**	**65 (63)**	**75 (76)**
supply	5 (5)	25 (24)	52 (55)	17 (9)	39 (31)	60 (59)
demand	21 (18)	19 (19)	10 (9)	28 (36)	17 (23)	10 (10)
monetary policy	6 (6)	9 (8)	8 (9)	11 (11)	8 (9)	6 (7)
Asymmetric shocks	**50 (54)**	**34 (37)**	**21 (20)**	**34 (35)**	**26 (28)**	**18 (17)**
supply	5 (4)	7 (6)	7 (7)	7 (4)	9 (5)	6 (5)
demand	31 (33)	19 (22)	9 (9)	21 (27)	12 (18)	7 (8)
monetary policy	15 (17)	8 (9)	4 (4)	6 (4)	5 (4)	5 (4)
Exchange rate shocks	**18 (17)**	**14 (12)**	**9 (7)**	**10 (9)**	**9 (9)**	**7 (7)**

Note: median values of the posterior, normalised to sum to 100; median when restrictions are only imposed 2 lags after the shocks in parenthesis

Table 2 - Forecast error variance decomposition of the exchange rate

	EA - UK			US - UK		
	0 quarters	4 quarters	20 quarters	0 quarters	4 quarters	20 quarters
Symmetric shocks	**34 (40)**	**38 (33)**	**31 (31)**	**33 (27)**	**42 (54)**	**31 (38)**
supply	12 (13)	11 (9)	9 (9)	16 (16)	27 (35)	18 (23)
demand	14 (17)	15 (14)	12 (12)	16 (10)	12 (13)	9 (10)
monetary policy	7 (10)	12 (11)	9 (10)	1 (1)	4 (6)	4 (5)
Asymmetric shocks	**21 (47)**	**47 (59)**	**50 (54)**	**15 (12)**	**44 (29)**	**50 (43)**
supply	7 (8)	12 (12)	11 (10)	6 (5)	6 (8)	7 (8)
demand	1 (2)	13 (7)	25 (24)	9 (6)	36 (18)	35 (28)
monetary policy	13 (37)	22 (40)	15 (21)	1 (1)	2 (3)	8 (7)
Exchange rate shocks	**45 (14)**	**15 (8)**	**18 (15)**	**52 (60)**	**14 (17)**	**19 (18)**

Note: median values of the posterior, normalised to sum to 100; median when restrictions are only imposed 2 lags after the shocks in parenthesis

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