



OECD Economics Department Working Papers No. 523

Identifying Determinants  
of Germany's International  
Price Competitiveness: A  
Structural VAR Approach

**Martin Meurers**

<https://dx.doi.org/10.1787/407563327012>

**Unclassified**

**ECO/WKP(2006)51**



Organisation de Coopération et de Développement Economiques  
Organisation for Economic Co-operation and Development

**08-Nov-2006**

**English text only**

**ECONOMICS DEPARTMENT**

**ECO/WKP(2006)51**  
**Unclassified**

**IDENTIFYING DETERMINANTS OF GERMANY'S INTERNATIONAL PRICE COMPETITIVENESS  
- A STRUCTURAL VAR APPROACH**

**ECONOMICS DEPARTMENT WORKING PAPERS No. 523**

**by**  
**Martin Meurers**

All Economics Department Working Papers are available through OECD's website at  
[www.oecd.org/eco/working\\_papers](http://www.oecd.org/eco/working_papers)

**JT03217342**

Document complet disponible sur OLIS dans son format d'origine  
Complete document available on OLIS in its original format

**English text only**

## ABSTRACT/RÉSUMÉ

### Identifying determinants of Germany's international price competitiveness – A structural VAR approach

The paper employs a structural vector auto-regression (SVAR) along the lines of Blanchard and Quah (1989) and Clarida and Gali (1994) to identify the sources of changes in German international price competitiveness over the past 30 years. This leads to a separation of the driving forces of the real exchange rate into real demand, supply, and nominal shocks. Based on this decomposition, it is analysed whether real exchange rate changes have helped to stabilise output in the post re-unification period and whether such changes have facilitated the ongoing structural adjustment process of the German economy. The results indicate that real demand and nominal shocks have been the main drivers of the real exchange rate in the past, whereas output fluctuations have been almost entirely due to supply shocks. In particular, it turns out that improvements of Germany's price competitiveness in the second half of the 1990s have been primarily the result of a relative domestic demand restraint and hardly that of supply side expansions.

*JEL classification:* C32, F31, F41

*Keywords:* Real exchange Rate, SVAR, Historical decomposition, German international competitiveness.

\*\*\*\*\*

### Recherche des déterminants de la compétitivité-prix internationale de l'Allemagne à partir d'un modèle vectoriel autorégressif (VAR) structurel

Dans la lignée de Blanchard et Quah (1989) et de Clarida et Gali (1994), les auteurs s'appuient sur un modèle vectoriel autorégressif structurel (SVAR) pour déterminer l'origine des variations de la compétitivité-prix internationale de l'Allemagne ces 30 dernières années. Cette méthode permet de décomposer les forces agissant sur le taux de change réel en chocs sur la demande réelle, en chocs sur l'offre et en chocs nominaux. À partir de cette décomposition, on se demande si les variations du taux de change réel ont contribué à stabiliser la production durant la période postérieure à l'unification et si elles ont facilité l'ajustement structurel en cours de l'économie allemande. Les résultats montrent que les chocs sur la demande réelle et les chocs nominaux sont les principaux facteurs qui ont influé sur le taux de change réel dans le passé, alors que les fluctuations de la production sont dues presque entièrement aux chocs sur l'offre.

*JEL Classification:* C32, F31, F41

Mots clés : Taux de change réel, système vectoriel auto-régressif structurel, décomposition historique, Compétitivité internationale de l'Allemagne

**Copyright OECD, 2006**

**Application for permission to reproduce or translate all, or part of, this material should be made to: Head of Publications Service, OECD, 2 rue André-Pascal, 75775 Paris Cedex 16, France.**

## TABLE OF CONTENTS

IDENTIFYING DETERMINANTS OF GERMANY'S INTERNATIONAL PRICE COMPETITIVENESS – A STRUCTURAL VAR APPROACH.....	4
Germany's price competitiveness in a historical and an international perspective.....	4
Related work on determinants of the real exchange rate.....	6
The theoretical model.....	8
The econometric analysis.....	12
The data.....	12
Unit-root and cointegration tests.....	13
The econometric framework.....	15
Analysis of the structural VAR.....	16
Summary and policy conclusions.....	25
BIBLIOGRAPHY.....	27

### Tables

1. Standard deviation of G7 real-exchange rates.....	6
2. Results of Unit-Root-Tests.....	14
3. Results of Johansen's Cointegration test.....	14
4. Forecast error variance decompositions.....	23

### Figures

1. Germany's international price competitiveness.....	5
2. Relative output and price development.....	13
3. Inflation differential between Germany and trading partners.....	13
4. Identified supply shocks and relative productivity changes.....	18
5. Identified demand shocks and changes of the relative import share in GDP.....	18
6. Identified money shocks and changes in real interest rate differential.....	19
7. Impulse-response functions.....	21
8. Historical decomposition of the real exchange rate.....	24

**IDENTIFYING DETERMINANTS OF GERMANY'S INTERNATIONAL PRICE  
COMPETITIVENESS – A STRUCTURAL VAR APPROACH**

by  
**Martin Meurers<sup>1</sup>**

**Germany's price competitiveness in a historical and an international perspective**

1. Against the backdrop of Germany's high degree of international integration, improvements in international competitiveness, which is simply a synonym for real exchange rate depreciations, are often regarded as a key to bring the country back on a sustainable growth path with lower unemployment.<sup>2</sup> Unlike frequently supposed in public debates, however, the real exchange rate is not a macroeconomic variable that can be directly targeted through economic policy. Quite the opposite is true. In fact, it is an endogenous price variable that reflects demand and supply side responses of consumers and real and financial investors to national and international macroeconomic shocks. Ultimately, these responses should restore a macroeconomic equilibrium.<sup>3</sup>

2. The analysis of this paper explicitly builds on this endogenous character of the real exchange rate as it identifies what kind of shocks have been the major drivers for the real exchange rate in the past 30 years. This information is of particular policy relevance, as it highlights to what extent the German real exchange rate has helped to stabilise economic fluctuations in the past and whether supply side reforms are reflected in improvements of international price competitiveness.

3. To set the stage for the analysis it is useful to begin with a short review of the evolution of the German real exchange rate over the past 30 years and to put the developments into comparison with those in other major countries. Over this time span Germany's international price competitiveness has been

---

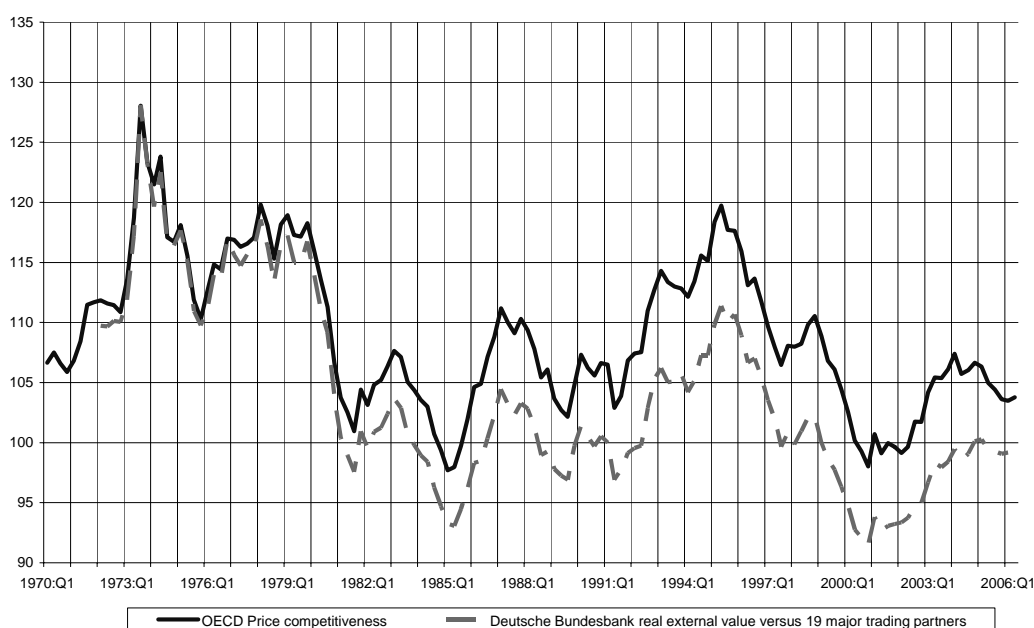
1. This Working Paper was produced during my secondment from the German Ministry of Economy and Labour to the Germany Desk in the Country Studies Branch of the Economics Department at the OECD. I am particularly grateful to A. Wörgötter, E. Wurzel, A. Fuentes, for helpful comments and suggestions, to M. Morgan for substantial help with the data and the econometrics, and to S. Gascard and S. McNally for formatting and proof-reading of the draft document. All remaining errors are certainly my own responsibility.

2. The shares of Germany's imports and exports of goods and services in GDP have grown significantly over the past decade. While standing around 25% in the early 1990s the import and export shares climbed to over 35% and 40%, respectively, in the year 2005.

3. This role of the real exchange rate in international adjustment hinges on the (implicit) assumption of imperfect competition that prevents perfect arbitrage on international goods markets. This assumption, which is empirically well supported by numerous studies on international trade flows, see, *e.g.*, Goldstein and Khan (1985), implies finite long-run price elasticities of trade flows and long-run departures from purchasing power parity (PPP). For this argument, see also Duval (2002).

subject to substantial fluctuations (see Figure 1). In the 1970s the breakdown of the Bretton Woods System as well as the two major oil-price shocks stand out as events with a significant impact on the real exchange rate in both directions. While in the 1980s the real exchange rate was relatively stable, it has again displayed larger swings since the early 1990s. The development of Germany's price competitiveness after reunification can be basically separated into three different trend episodes.

**Figure 1. Germany's international price competitiveness**  
Based on consumer prices



The Bundesbank indicator uses a weighting scheme based on Germany's external trade in the manufacturing sector between 1995-1997. The 19 countries considered are Austria, Belgium, Canada, Denmark, Finland, France, Greece, Great Britain, Ireland, Italy, Japan, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United States. See Deutsche Bundesbank (2001), Monthly Report, November 2001. The OECD indicator uses yearly updated weights that are based on import and export market shares in the manufacturing sector of 42 countries (30 OECD countries, seven Dynamic Asian Economies, and five major emerging market countries). The index is set to 100 in the year 2000. For details on the method of calculation see *OECD Economic Outlook Sources and Methods* (<http://www.oecd.org/eco/sources-and-methods>).

4. The reunification boom from 1990 to 1992, during which the German business cycle decoupled from the slowdown in other industrial countries, was accompanied by a substantial real appreciation. This passed over into a protracted period of devaluations which began in 1995 and lasted until the year 2000. In 2002, the real-exchange rate started to follow a trend-like appreciation path again. Only since 2005 this trend seems to have come to a halt.

5. Compared to other G7 countries, the extent of Germany's real exchange rate fluctuations has been small, however (see Table 1). Only France has been exposed to smaller exchange rate fluctuations than Germany. This result holds over various sub-samples and is also robust to factoring out a possible trend component (which might be caused by Balassa-Samuelson-effects) and the impact of oil-price fluctuations. Even after reunification when Germany was confronted with fundamental structural adjustment problems, real exchange rate fluctuations were relatively modest in comparison to those in other countries. The United Kingdom and Italy, for example, experienced huge depreciations of their currencies during the crises of the European Monetary System in 1992. Japan faced a 50% real appreciation in the early 1990s, following the burst of the equity and housing bubble, and Canada has been

confronted with a more than 20% real appreciation during the past three years, which, among other factors, can be attributed to high global demand for commodities.

**Table 1. Standard deviation of G7 real-exchange rates**  
Per cent

Sample	USA	JPN	GER	GBR	FRA	ITA	CAN
<i>unconditional standard deviation</i>							
<b>1970-2005</b>	<b>10.6</b>	<b>31.5</b>	<b>5.4</b>	<b>11.3</b>	<b>4.4</b>	<b>8.4</b>	<b>13.2</b>
1970-1990	11.5	28.1	5.6	10.3	3.9	8.9	7.5
1991-2005	8.3	9.4	5.1	10.4	3.6	7.5	10.3
<i>adj. for time trend and oil price fluctuations</i>							
<b>1970-2005</b>	<b>10.5</b>	<b>15.2</b>	<b>4.9</b>	<b>8.7</b>	<b>3.3</b>	<b>8.0</b>	<b>7.3</b>
1970-1990	11.4	14.4	5.1	8.9	3.5	7.9	6.1
1991-2005	8.9	16.8	4.6	8.6	3.1	8.0	8.7

Own calculations based on OECD price competitiveness indicators

6. Given the huge size of the reunification shock (with the merger of East and West German statistics in the first quarter 1991, GDP per capita fell by almost 7%) Germany's relatively modest real exchange rate fluctuations provide a further motivation to investigate the potential of the real exchange to stabilise the German economy more rigorously. As a first step this task requires to analyse whether real macroeconomic shocks are sufficiently reflected in exchange rate movements. Only if this were the case, the real-exchange would have the potential to stabilise output fluctuations by offsetting part of the shocks' impact. As a second step it is then necessary to evaluate whether the adjustment of output has or has not been actually eased by real exchange rate movements. As a hypothesis one could assume that if the response of macroeconomic variables to the real exchange rate is strong, then the real exchange rate does not need to change much to achieve adjustments to a new equilibrium. This might then also explain the relatively modest real exchange rate fluctuations in the German case.

### Related work on determinants of the real exchange rate

7. Most researchers would agree that the theory of Purchasing Power Parity (PPP) fails to explain real exchange rates to a satisfactory extend, even if the focus are longer time horizons and even if PPP is carefully defined in terms of relative prices of tradable goods only.<sup>4</sup> Based on this negative assessment basically two different approaches have been established to analyse the empirical behaviour of real exchange rates. The first approach builds on alternative theories of long-run equilibrium real exchange rates (ERER), in particular the Natural Real Exchange rate Model (NATREX) proposed by Stein (1994) and the Behavioural Equilibrium Exchange Rate (BEER) that can be attributed to Clark and MacDonald (2000). More specifically, this avenue of research leads to econometric estimations, which attempt to explain the time path of the real exchange rate by regressing it on a set of observable "fundamental" variables. This exercise allows the researcher to calculate a contribution of each "fundamental" to exchange rate changes and to identify periods of deviations from the implied long-run equilibrium.

8. The choice of explanatory variables for this exercise is typically motivated by considering fundamental factors that in theory should determine the balance of payments of a country. In particular, these are productivity developments, net-foreign asset positions, terms-of-trade shocks, changes in import content of GDP, and government or alternatively social spending (the sum of private and public

4. For a more detailed discussion on the failure of PPP, see, e.g., OECD (2001), or Rogoff (1996). Evidence for the failure of PPP when only tradable goods are considered is provided, e.g., by Duval (2002).

consumption expenditure). All these variables are expected to affect the balance of payments and thus the real exchange rate over the medium- and long-term. In order to capture short-run deviations from the longer term trends due to poor synchronization of business cycles across countries, real interest-rate differentials are often added as explanatory factor in the analysis. For an extensive overview on the choice of variables, see *e.g.*, ECB (2002) or J.L. Stein (2002).

9. For Germany, estimations of such reduced-form exchange rate equations have been previously carried out, for instance, by Fischer and Sauernheimer (2002) who use cointegration techniques to estimate a model for Germany's effective real exchange rate based on consumer prices for the period 1973:1 - 1998:4. Their set of fundamentals consists of relative total factor productivity, private and public consumption to GDP (as a proxy for time preference), a raw materials import factor (import dependence of production) and imports of final goods to GDP (as proxy for taste shifts away from German products). Major conclusions from their analysis are that productivity and taste shocks have been the major drivers of the German exchange rate and that in real terms the German currency has been overvalued most of the time during the sample period.

10. More recently, the Council of Economic Advisors (2004) estimated a vector-error correction model (VECM) of the German real exchange rate jointly with fundamentals using quarterly data from 1983:1 to 2004:1. As explanatory variables they considered GDP per employee (as a proxy for productivity), the net-foreign asset position, the oil-price (as proxy for terms-of-trade shocks) and finally the interest rate differential. Their results seem to identify productivity differences as the main driver of the real exchange rate. They also find long periods of substantial misalignment, especially in the 1980s.

11. While in general empirical equilibrium exchange rate models are able to explain broad exchange-rate trends over a longer horizon, *i.e.* over horizons of more than two years, they mostly perform quite poorly in the short-run. As a matter of fact, they point to frequent and prolonged periods of currency misalignment, or put differently, a huge portion of exchange rate movements that cannot be explained by fundamentals. Another problem of the reduced-form approach is that many fundamentals cannot be observed as accurately as they enter the underlying theoretical models, giving further room for uncertainty about the "true" equilibrium path. Finally, the relevance of individual fundamentals seems to change over time, depending on the exchange rate regime and the degree of international integration and policy coordination, which might cause structural breaks in the exchange rate equations.

12. Because of these drawbacks the analysis of German price competitiveness that is carried out in this paper will rather draw on a different methodology which essentially goes back to Clarida and Gali (1994). In their approach the driving factors of the real exchange rate are identified indirectly through the estimation of a structural vector auto-regression (SVAR). As a reference point the authors use a simple two-country open economy macro model with sticky prices, originally developed in Obstfeld (1985). The model is able to summarise business-cycle variations between countries or regions by no more than three endogenous variables, namely the relative output level, the real exchange rate, and the relative aggregate price level. These three variables in turn are driven by three types of fundamental shocks occurring in one country relative to the other: a) relative supply or productivity shocks, b) relative demand shocks, and c) relative money or financial markets shocks.

13. Since the model allows for nominal rigidities in the short-run, all three endogenous variables are at least temporarily affected by all types of shocks. However, under the assumption that markets clear in the long-run and that long-run output is solely driven by supply shocks, the equilibrium of this three variable system is triangular in the shocks, *i.e.*, neither do demand and money shocks have a long-run impact on output, nor do money shocks have a long-run impact on the real exchange rate. This specific result in turn provides a sufficient number of restrictions in order to identify the individual shocks through a standard Blanchard-Quah (1989) structural VAR analysis.



14. In their seminal paper, Clarida and Gali (1994) investigate bilateral real exchange rates of Germany, Japan, Great Britain, and Canada *vis-à-vis* the United States. Their results indicate a strong role of nominal shocks in the determination of real exchange rates, especially in the first two countries. In addition, the impulse-response functions for their identified shocks fit the predictions of the sticky-price Mundell-Flemming-Dornbusch model quite well, as they, *inter alia*, imply exchange rate overshooting in response to nominal shocks. Chadha and Prasad (1997) applied the Clarida-Gali approach to investigate the relationship between the real exchange rate and the business cycle in Japan. Interestingly, their results suggest that the sharp real appreciations of the Yen in 1993 and 1995 can also be attributed primarily to monetary shocks. Unfortunately, the economic source of these shocks remains hard to interpret, however.

15. Canzoneri *et al.* (1996) investigate the role of monetary shocks with regard to the advent of the European Monetary Union. If there are asymmetric real macroeconomic shocks between the member countries of a currency union, then, according to the theory of optimal currency areas (Mundell, 1961), sacrificing one's own currency and thus an independent monetary policy poses a substantial cost in terms of macroeconomic stabilisation. Based on bilateral real exchange rates between Germany and other EMU partners during 1970 and 1985, Canzoneri *et al.* indeed find that output fluctuations between countries are almost entirely driven by asymmetric real demand and supply shocks. However, since the real exchange rate in turn has only marginally responded to real shocks, and has rather behaved like an asset price, they conclude that the real exchange rate has not played the role of a shock absorber. Hence, the costs of entering the currency union might be in fact lower as it often has been stressed. Against the same background, Funke (2000) applies the structural VAR approach to study macroeconomic shocks in the current euro area and the United Kingdom. Using quarterly data for the period 1980:1 to 1997:4 he finds that the real ECU exchange rate is primarily driven by non-monetary demand shocks. Since he also observes that basically supply shocks are the main driver of business cycle differences between the United Kingdom and the euro area he concludes that the UK economy would not be harmed by joining the euro. One has to add some cautious warnings regarding this conclusion, however. As Artis und Ehrmann (2000) point out, Funke's results might imply just the opposite to his conclusion. The finding that output is not driven by those shocks that dominate the real exchange rate might well be the result of a perfect immunization of output through offsetting real exchange rate changes.

16. Recent papers which address similar questions apply more advanced identification strategies than the original Clarida-Gali analysis. Farrant and Peersman (2005), for instance, use sign restrictions introduced by Faust (1998), Uhlig (1999) and Canova and De Nicoló (2002) instead of long-run zero restrictions. Artis and Ehrmann (2000), Fisher and Huh (2002), and Alexius und Post (2005) use a combination of short and long-run restrictions.

17. All previously mentioned studies make use of a special feature of the structural VAR analysis, namely, that based on the identified shocks it is possible to completely pin down the historical sources of real-exchange rate fluctuations for the respective countries. This is the main advantage of the SVAR approach in comparison to the reduced-form estimations of equilibrium exchange rates, where the researcher has to make a subjective a-priori-selection of relevant observable fundamentals and where he has to accept substantial unexplained exchange rate variations in his empirical model. The theoretical model underlying the parsimonious identification strategy for the SVAR analysis is explained more in detail in the following section.

### **The theoretical model**

18. The subsequent empirical analysis is based on a stochastic open economy macro model with rational expectations that is explicitly set forth in Clarida and Gali (1994). The model stands in the Mundell-Flemming-Dornbusch tradition and captures primarily short- and medium-term output and price dynamics. As a simplification a two-country setting is adopted (home country versus aggregate of all

trading partners) and it is assumed that the relevant structural parameters are identical in all countries. This greatly facilitates the model's formal exposition as all interesting variables can be simply expressed as the difference between the two regions' individual macroeconomic aggregates. For instance, the relevant output variable  $y_t$  of the model encompasses the difference of the output between the home country and the output of major trading partners:  $y_t \equiv y_t^h - y_t^p$ . All variables except the interest rate are expressed in natural logarithms. With these conventions, the complete model can be summarised by the following equations:<sup>5</sup>

$$(1) \quad y_t^d = d_t + \delta q_t - \sigma [i_t - E_t(p_{t+1} - p_t)]$$

$$(2) \quad m_t - p_t = y_t - \lambda i_t$$

$$(3) \quad i_t = E_t(s_{t+1} - s_t)$$

$$(4) \quad p_t = (1 - \theta)E_{t-1}p_t^e + \theta p_t^e$$

19. The equations represent aggregate demand, money market equilibrium, the interest rate parity (short-run balance of payments equilibrium), and the aggregate price-setting behaviour (short run aggregate supply). Relative aggregate demand  $y_t^d$  depends on an exogenous demand shock  $d_t$  (e.g. discretionary variations in public expenditure), the real-exchange rate  $q_t = s_t - p_t$  (nominal exchange rate minus price difference) and the expected real interest rate differential  $i_t - E_t(p_{t+1} - p_t)$ . Monetary shocks enter the model by variations in the quantity of money  $m_t$ , which might represent both, shocks in relative national money supplies as well as shocks to relative national demands for real money balances. Finally, the price setting equation implies that prices in period  $t$  are a weighted average of the market clearing price  $E_{t-1}p_t^e$  expected in period  $t-1$  and the actual market clearing price in period  $t$ . Thus, the degree of sluggishness in the model is related to the parameter  $1 - \theta$ . If  $\theta = 0$ , then prices are predetermined one period in advance and short-run output fluctuations solely depend on aggregate demand. If, in contrast,  $\theta = 1$  then prices are fully flexible and output adjusts instantaneously to its long-run level, which by assumption is entirely determined by supply shocks  $y_t^s$ , hence:  $y_t = y_t^d = y_t^s$ . Supply shocks in the model can be very broadly interpreted. They might encompass advances in technology but also tax reform or any kind of product and labour market policies that have the potential to increase output and employment.

20. To solve for the model dynamics, the stochastic processes of the shock terms have to be specified explicitly. Following Clarida and Gali, for supply and nominal shocks we assume a simple random walk process, which implies exclusively permanent supply and money shocks  $y_t^s$  and  $m_t$ , whereas demand shocks are allowed to have a permanent and a transitory component. In particular, it is assumed that a fraction  $\gamma$  of any demand disturbance in  $t-1$  is reversed in period  $t$ . Formally, the three shocks are then given by:

$$(5) \quad y_t^s = y_{t-1}^s + \eta_{s_t},$$

---

5. For simplicity, the identical formulation is used as in Clarida and Gali (1994). For more details on how to derive the solution of the model the reader may refer to the original reference or to Obstfeld and Rogoff (1996), Chapter 9.

$$(6) \quad m_t = m_{t-1} + \eta_{N_t},$$

$$(7) \quad d_t = d_{t-1} + \eta_{D_t} - \gamma \mathcal{M}_{D_{t-1}},$$

where  $\eta_{S_t}, \eta_{N_t}, \eta_{D_t}$  are orthogonal independent identically distributed error terms with mean zero. The long-run equilibrium of the model can be derived by simply assuming instantaneously adjusting prices, which implies that  $\theta = 1$ . This assumption, however, does not mean that all adjustments in the model are over. If there is a temporary component in the demand shock ( $\gamma > 0$ ), then further adjustments are expected to take place in the future. Thus, strictly speaking long-run equilibrium here means an equilibrium after all price and wage adjustments are concluded but not necessarily that the temporary component of the demand shock has been reversed. In such an equilibrium the levels for the three interesting endogenous variables are then given by:

$$(8) \quad y_t^e = y_t^s$$

$$(9) \quad q_t^e = (y_t^s - d_t) / \delta + (\delta(\delta + \sigma))^{-1} \sigma \gamma \mathcal{M}_{D_t}$$

$$(10) \quad p_t^e = m_t - y_t^s + \lambda(1 + \lambda)^{-1} (\delta + \sigma)^{-1} \gamma \mathcal{M}_{D_t}$$

21. Apart from the postulated property of exclusively supply side determined output, these equations imply the following long-run macroeconomic responses to the shocks:

- a) Positive supply shocks (*e.g.* increases in productivity of the home country relative to trading partners) lead to a real depreciation and a decline in the relative price level in the long run. This result owes to the fact that the additional supply will only match demand when the price for the home good falls relative to that of the foreign good, and the home country is able to export some of the additional production. Furthermore, world real interest rates will be lower in the new equilibrium, since the reduction of net-exports in the foreign countries has to be compensated by an endogenous rise of other demand components there.
- b) Positive real demand shocks lead to a real appreciation in the long run, and in the case of a temporary shock component ( $\gamma > 0$ ) will also raise the relative price level. Because output is purely supply determined the composition of demand in both the home and the foreign country have to be changed in response to the demand shock. This is achieved through higher relative international prices for the goods of the home country and a crowding out of some of its net-foreign demand. In turn, this means higher net-exports of foreign countries. To align demand and supply there, other demand components have to be crowded out, which implies a rise in the world real interest rate. The size of the long-run appreciation of the home currency negatively depends on  $\gamma$ , the extent to which demand shocks are temporary. The reason for this is that the partial reversal of the demand shock in  $t+1$  creates relative deflation expectations in period  $t$ . This implies a positive nominal and a real interest differential between the home and the foreign country which in turn also crowds out some relative domestic demand. Therefore, the crowding out through the real appreciation can be smaller than in the case of purely permanent demand shocks. In the case of entirely permanent demand shocks equation (10) suggests that the relative price level does not change at all. Therefore the required real appreciation is entirely achieved through a rise in the nominal value of the home currency.

- c) Finally, expansionary monetary shocks (*e.g.* relatively stronger money growth in the home country) only lead to a parallel rise in the relative price level and the nominal exchange rate leaving the real exchange rate constant. In other words, PPP holds in the case of nominal shocks.

An important feature of the three-variable system (8) to (10) is that it is triangular in the shocks in the long run. As we will see below this provides the necessary number of restrictions for the identification of the three structural shocks from an estimated VAR system.

22. The short-run responses in the model crucially depend on the formulation of the price setting equation. Clarida and Gali derive explicit dynamic solutions based on the price setting rule (10) which implies that all three variables contemporaneously depend on all three types of shocks. Noteworthy, this includes the case that expansionary money shocks temporarily raise output and lead to a real depreciation. The dynamic solutions also imply exchange rate overshooting à la Dornbusch (1976), if the elasticity of aggregate demand with respect to interest rate and exchange rate changes is sufficiently small, precisely if  $1 - \delta - \sigma > 0$ . Interestingly, if the parameter restriction implies an overshooting to monetary shocks then this also implies an undershooting to real demand and supply shocks. The propagation of the shocks in the model for the case that  $1 > \theta > 0$  and under the assumption of a more rapid response in the money market than in the goods market (which implies Dornbusch-Overshooting), can be described as follows:

- a) A positive supply shock in the home country lowers the relative equilibrium price for the home good ( $p_i^e$ ) as well as its current price and temporarily leads to an expected negative inflation differential *vis-à-vis* the foreign countries. The decline in domestic prices causes a temporary fall of domestic nominal interest rates which in turn leads to a nominal depreciation. From both lower domestic prices and a lower value of the domestic currency follows a real depreciation which stimulates domestic demand and output. The expansion of output and the real depreciation continues until the nominal interest rate has risen to its new equilibrium level, which is lower than the previous one. During this process real interest rates could either rise or fall depending on the parameters in the aggregate demand and the money demand function.
- b) A positive real demand shock in the home country is transmitted through a temporary relative expansion of output and a rise in the equilibrium price level as well as through temporarily expected relative inflation. This is accompanied by a rise in nominal interest rates and a nominal and real appreciation of the home currency, which leads to a crowding out of domestic demand towards the initial output level. It also leads to higher demand in the foreign country and a rising price level and interest rate there. If the demand shock is entirely permanent ( $\gamma = 0$ ) then domestic inflation translates one to one into foreign inflation. Thus, the relative price level remains constant.
- c) An expansionary nominal shock in the home country raises the current and the expected equilibrium relative price level and temporarily creates relative inflation expectations. This leads to lower nominal and real interest rates, and causes a nominal depreciation of the domestic currency, which exceeds the rise in the relative price level. Consequently, relative output rises in the short-run. The subsequent rise in the relative price level leads to a rise of the nominal and real interest rate to the initial level, which in turn triggers a nominal and real appreciation, such that the real exchange rate is also brought back to its initial level.

23. The true empirical dynamics might be more complicated than suggested by the above model, however. The implied short-run dynamics can change substantially, for example, if one takes into account that supply shocks might also affect consumption and investment. A positive supply shock might induce

forward looking consumers to raise their current consumption due to a wealth effect. Moreover, it leads to an increase in the rate of return to capital, which at least temporarily should boost investment. Through this additional transmission channel a positive supply shock can actually raise aggregate demand so strongly, that this might overwhelm the positive supply side effect and cause a real appreciation and a current-account deficit in the short-run.<sup>6</sup> Apart from this, the short-run dynamics could also be more complex, if sluggish behaviour of economic agents enters in other parts of the model. Finally, in contrast to the simple assumptions that have been made here, the macroeconomic shocks might be actually generated by a higher order ARIMA process. Because of these complications it could be the case that the empirical short-run responses to shocks differ from the model's prediction. Not necessarily this should be taken as an indication of empirical specification problems but rather as a reflection of the lack of a waterproof economic theory about short-run behaviour.

24. A last qualification is required with respect to the empirical counterparts for the model's variables. The original formulation above suggests to use real GDP levels for the output variable  $y_t$ . This poses a serious problem when it comes to incorporating German reunification into the model. National statistics were changed to capture the whole of Germany in the first quarter of 1991. This led to an increase in real GDP by 17.4%. Since this structural effect is permanent, in terms of the model, one would interpret this as a positive supply or productivity shock. This, however, is in stark contrast to economic reality. Because of a very low stock of productive capital in East Germany, average labour productivity of the German economy as a whole fell significantly. At the same time average domestic absorption expanded strongly, fuelled by huge transfers from the west to the east. As a consequence, the current account switched from a surplus of 12 billion to a deficit of 1.2 billion Deutschmarks. So effectively, an adverse supply shock and an expansionary demand shock occurred at the same time. In order to capture these developments correctly in the subsequent VAR analysis, GDP per capita ( $yc_t$ ) will be employed as the relevant output measure. In general, the model implications should be invariant to this amendment, since the macroeconomic equations of the model can be theoretically motivated in a representative agent framework.

### **The econometric analysis**

25. In the following econometric part, the statistical properties of the time series are investigated first. Based on this analysis, the employed structural VAR model is then specified in detail before finally the implications of the identified international macroeconomic shocks are discussed.

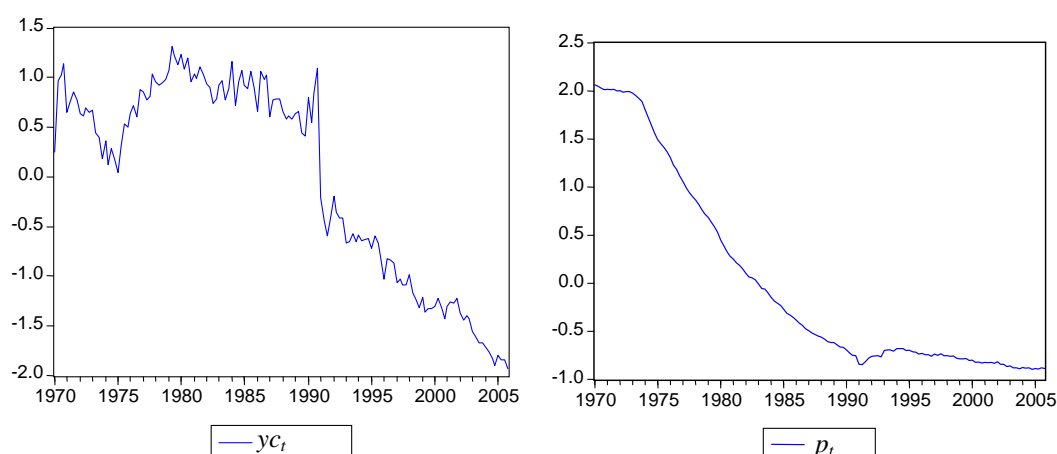
#### ***The data***

26. The time period considered for the estimation of the VAR dates from the first quarter in 1972 to the fourth quarter in 2005. As an empirical counterpart for the real-exchange rate variable, the indicator of Germany's price competitiveness versus 19 most important trading partners based on consumer prices is used, which is regularly published by the Deutsche Bundesbank. The underlying geometric weighting scheme for the individual countries (see Deutsche Bundesbank, 2001) was adopted to compile the variables relative GDP per capita and relative consumer prices, for which the original series were taken from the OECD's Quarterly National Accounts and Main Economic Indicators statistics.<sup>7</sup>

---

6. This argument has been put forward by Alquist and Chinn (2004) as an explanation for the positive relationship of US-Euro productivity differentials and the euro-dollar real exchange rate. NATREX models in general imply an indeterminate reaction of the real exchange rate to productivity shocks over any time horizon; see Fischer and Sauernheimer (2002).

7. Clostermann and Friedmann (1998) give reasons why the real exchange rate based on unit labour costs is not an appropriate measure for Germany's international competitiveness.

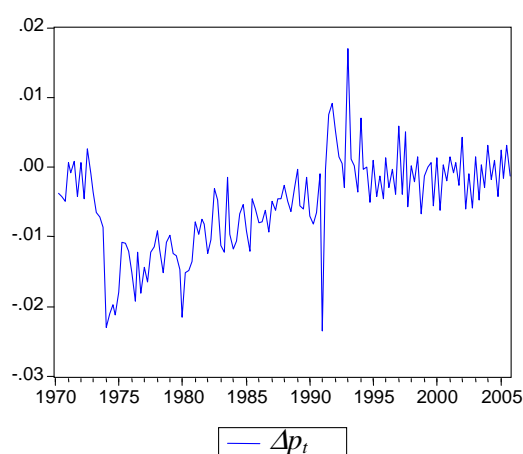
**Figure 2. Relative output and price developments**

Depicted time series are normalised.

27. Figure 2 depicts relative output and price developments of Germany *vis-à-vis* its trading partners. From the graphs it can be seen that the relative per capita GDP of Germany fell significantly due to reunification and afterwards, as foreign competitors grew faster over almost the entire post-reunification period. Conversely, apart from a small episode in the early 1990s, inflation in Germany was lower than abroad over almost the complete sample period.

#### *Unit-root and cointegration tests*

28. The specified stochastic processes for the macroeconomic shocks from above imply that  $yc_t$ ,  $p_t$ , and  $q_t$  ought to be non-stationary in levels, but stationary in first differences. To verify this underlying assumption, both Augmented-Dickey-Fuller-tests, which test the null-hypotheses of non-stationarity, and KPSS tests, which test the converse hypothesis, have been carried out. Since both  $yc_t$ ,  $p_t$  display a trending behaviour, a time trend was considered in the test equations, in addition to a constant term. For the ADF-test equations, the maximum lag length  $L$  was selected by the Akaike-Information-Criterion.

**Figure 3. Inflation differential between Germany and trading partners**

29. The deterministic trend component in the relative price series seems to be insufficiently captured by a linear trend, however. This becomes evident after taking the first difference of this variable, which yields the inflation differential. As Figure 3 suggests, there is some kind of a structural inflation convergence between Germany and its main trading partners over the past 30 years. To account for this convergence a time trend as well as an intercept had to be included also in the test equation for the inflation differential.

**Table 2. Results of Unit-Root-Tests**

Variable	in levels		in first differences	
	ADF-Test	KPSS	ADF-Test	KPSS
$yc_t$	-1.55, L=2	0.33***	-11.01***, L=1	0.42*
$p_t$	-1.29, L=5	0.35***	-3.62**, L=4	0.12*
$q_t$	-2.19, L=3	0.77***	-9.37***, L=0	0.05

30. As the test results in the left part of table 2 show, for all variables there is strong evidence against stationarity in levels. In contrast to this, the ADF-tests for the first differences reject non-stationarity at the 5% significance level, while the KPSS-tests only weakly reject the hypothesis of stationary first differences of the variables. On the basis of these results, it seems justified to treat all variables as integrated of order one, or I(1), in accordance with the model. In addition, it should be noted that the relative price level is only stationary in first differences around a deterministic trend, which implies a quadratic trend in relative prices.

31. Another implication of the model is that there is no long-run stable relationship (cointegration) between the levels of the variables, which owes to the fact that there are three independent stochastic trends. If one would actually detect cointegration among the variables, it would be necessary to rethink the underlying economic model and modify the estimation strategy. A single cointegration relationship, for instance, would imply that only two independent stochastic trends generate the joint distribution of the three variables. For the economic model to be consistent with such data, this could mean, for example, that real demand shocks are only temporary, which would then increase the number of the long-run restrictions of the model. Moreover, in the econometric analysis one would then also need to consider the long-run relationship between the levels of variables explicitly in the estimation in order to avoid misspecification.

32. In order to test for cointegration, the procedure suggested by Johansen (1988) was applied (see, *e.g.*, Johansen and Juselius, 1990). To carry out Johansen's tests it is first necessary to estimate a vector-error-correction model (VECM) for the three endogenous variables. The appropriate lag length in this VECM was selected according to the Akaike-Information criterion, which suggests a lag length of  $L = 4$ . As the results in Table 3 show, the hypothesis of non-cointegration cannot be rejected even at very low significance levels on the basis of both the trace statistic and the maximum-eigenvalue statistic. Therefore, the model's implication of no-cointegration can be taken as fulfilled by the dataset employed here.

**Table 3. Results of Johansen's Cointegration test**

Sample (adjusted): 1973Q2 2005Q4  
Trend assumption: Linear deterministic trend  
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)				
Hypothesised	Trace	5%		
No. of CE(s)	Eigenvalue	Statistic	Value	p-value.

None	0.068	14.79	29.80	0.79
At most 1	0.040	5.53	15.50	0.75
At most 2	0.002	0.24	3.84	0.62
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesised No. of CE(s)	Eigenvalue	Max- Eigenvalue Statistic	5% Critical Value	P-value
None	0.068	9.26	21.13	0.81
At most 1	0.040	5.29	14.26	0.71
At most 2	0.002	0.24	3.84	0.62

p-values according to MacKinnon, Haug, and Michelis (1999).

In the case that a quadratic trend in the levels of the data was assumed, the Johansen cointegration tests yielded implausible results. To circumvent these problems, the quadratic trend was removed from the relative price series through an ordinary least squared regression and the cointegration tests were carried out with this modified relative price series.

### *The econometric framework*

33. The previous unit-root and cointegration tests imply that the empirical model should be formulated as a vector auto-regression in first differences. Hence, defining  $\Delta X_t \equiv (\Delta y_t, \Delta q_t, \Delta p_t)'$ , and employing a matrix of polynomials in the lag operator  $L$ :  $B(L) = B_0 + B_1L + B_2L^2 + \dots$ , the reduced-form of the VAR, which has to be estimated, can be expressed as:

$$(11) \quad B(L)\Delta X_t = \varepsilon_t,$$

where  $\text{var}(\varepsilon_t) = \Omega$  is the corresponding variance-covariance matrix of the error terms. This VAR can then be inverted into the following moving-average representation:

$$(12) \quad \Delta X_t = C(L)\varepsilon_t, \quad \text{where } C(L) = B(L)^{-1}, \text{ and } C(0) = I.$$

34. If the economic model from above is actually generating the data, then the three endogenous variables should solely depend on the three types of structural shocks. Thus, what we are really interested in is the moving average representation of the following form:

$$(13) \quad \Delta X_t = A(L)\eta_t,$$

with  $\text{var}(\eta_t) = I$ , and  $\eta_t = (\eta_{S_t}, \eta_{D_t}, \eta_{N_t})'$ , where the subscripts  $S$ ,  $D$ , and  $N$  denote supply, demand, and nominal shocks respectively.

35. In general, the estimated reduced form errors  $\varepsilon_t$  are most likely linear combinations of the “true” linearly independent structural shocks  $\eta_t$ . Several helpful relationships between the reduced form (12) and the structural form (13) can be established simply by comparing the coefficients of both systems. From this exercise it follows that  $\eta_t = A_0^{-1}\varepsilon_t$ , which in turn implies that  $A_i = C_i A_0, \forall i: i=1,2,\dots$ . Both results can be combined to obtain a relationship for the long-run multiplier matrix  $A(1) = C(1)A_0$ . From this follows finally an identity for the long run variance-covariance matrix:  $A(1)A(1)' = C(1)\Omega C(1)'$ .



36. The long-run restrictions of the above theoretical model imply that  $A(1)$  should have a lower triangular structure. As elaborated above, since all  $A_i$  for  $i > 0$  are determined by the estimated  $C_i$  matrices from the unrestricted VAR once the matrix  $A_0$  is known, imposing the restrictions will effectively

constrain the elements of the matrix  $A_0 = \begin{bmatrix} a_{011} & a_{012} & a_{013} \\ a_{021} & a_{022} & a_{023} \\ a_{031} & a_{032} & a_{033} \end{bmatrix}$ . As Blanchard and Quah (1989) have shown, the restrictions can be conveniently imposed on  $A_0$  by a lower triangular Choleski decomposition of the estimated long-run variance-covariance matrix  $C(1)\Omega C(1)'$  :

$$HH' = C(1)\Omega C(1)',$$

where  $H$  is a unique lower triangular matrix.

37. After obtaining  $H$ , an estimate of the restricted long-run multiplier matrix, one can calculate  $A_0 = C(1)^{-1}H$  as well as all  $A_i$ , and recover the structural shocks from the estimated reduced form errors  $\varepsilon_t$  through  $\eta_t = H^{-1}C(1)\varepsilon_t$ . Finally, the historical decomposition of  $\Delta X_t$  into the time-paths generated by the individual structural shocks, are given by the following expressions:

$$\text{Historical path generated by supply shocks: } \Delta X_t = C(L) \begin{pmatrix} a_{011}\eta_{S_t} \\ a_{021}\eta_{S_t} \\ a_{031}\eta_{S_t} \end{pmatrix},$$

$$\text{by demand shocks: } \Delta X_t = C(L) \begin{pmatrix} a_{012}\eta_{D_t} \\ a_{022}\eta_{D_t} \\ a_{032}\eta_{D_t} \end{pmatrix}, \text{ and}$$

$$\text{by nominal shocks: } \Delta X_t = C(L) \begin{pmatrix} a_{013}\eta_{N_t} \\ a_{023}\eta_{N_t} \\ a_{033}\eta_{N_t} \end{pmatrix}.$$

### ***Analysis of the structural VAR***

38. For the estimation of the unrestricted VAR in first differences the same lag length  $L=4$  was selected as previously for the cointegration tests. The coefficient matrices  $A_i$  and the structural shocks  $\eta_t$  were then recovered by the identification procedure that was just sketched in the foregoing section. Before analysing the impact of the different shocks on the model's variables it is useful to take a closer look at the identified shocks themselves. This can help to verify the validity of the underlying economic hypothesis, since the shocks should reasonably correspond to observable economic developments, and outstanding shocks should be related to well-known one-time economic events. Such a comparison, however, suffers from some difficulties as the equilibrium exchange rate approach that was briefly sketched in paras 7-11, as it requires economic indicators that adequately capture fundamental exogenous changes in the economy. Therefore, the scope at this point can only be to verify whether the identified shocks are not completely out of line with related fundamentals, *i.e.* both have at least a significant correlation with each other. In contrast to this rather defensive approach, one can argue that if the underlying economic hypothesis for the identification procedure is not statistically rejected (which is clearly the case as will be demonstrated below), then one should take the identified shocks seriously as a mirror of the true fundamental changes in

the economy. Thus, in principle the identified shocks can reveal (new) information about the macroeconomic stance during the sample period that is not visible in many closely monitored economic indicators. In order to facilitate such a distillation of knowledge from the strongly fluctuating shock series, accumulated shock terms will be displayed as an additional piece of information in the following graphs.

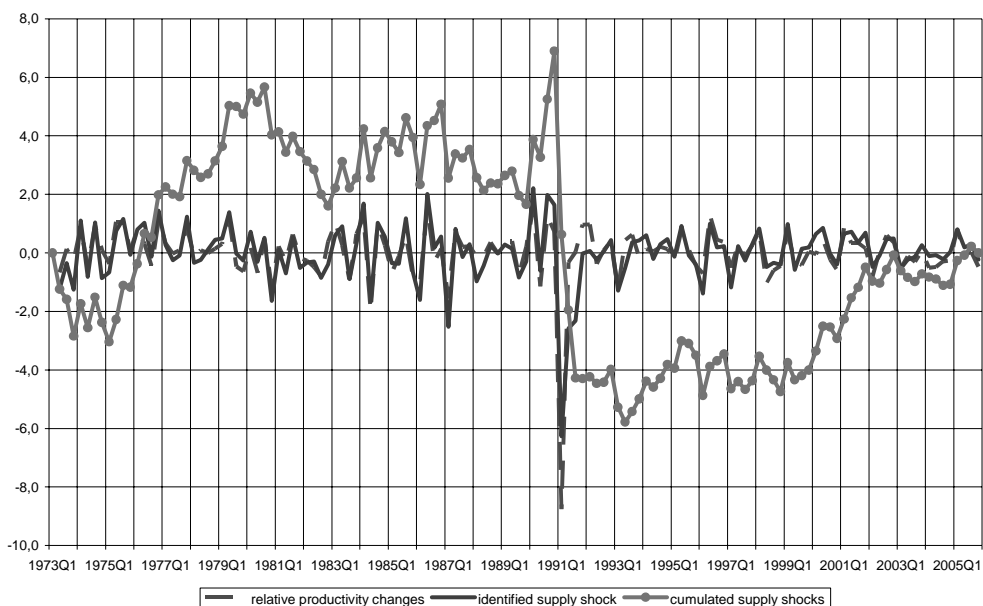
39. Starting with the identified supply shocks, it turned out that these shocks are indeed very closely related to changes in the productivity of German employees *vis-à-vis* the productivity of trading partners (see Figure 4). The correlation between the two amounts to a remarkable 85% over the complete sample. The fact that the shock series correctly captures the adverse supply shock due to reunification provides some additional underpinning for a meaningful interpretation of the identified shocks. Further interesting insights into the identified relative supply side developments can be obtained by accumulating the shocks over the sample period. This exercise highlights that the year 2000 marks the beginning of a series of relative positive supply shocks in Germany that might reflect the initiated process of structural supply side reforms, *e.g.*, tax reform, and the tentative transition to a more flexible labour market.

40. It was comparatively difficult to find an economic variable that displays a similar time pattern as the identified relative demand shocks. As described above, in directly estimated exchange rate models, demand components in relation to GDP are usually used as proxy variables to capture either changes in time- or home-preferences. Many variants of these measures have a very low or even negative correlation with the identified demand shock, however. This was the case, for instance, for the relative sum of private and government consumption per GDP, which is very often used as a fundamental demand side variable in equilibrium exchange rate studies. The most adequate variable among all these indicators turned out to be the ratio of imports to GDP.<sup>8</sup> Given the low price elasticity of imports in general, this variable should gauge changes in the relative preference for German goods quite well. The (negative) correlation of this variable with demand shocks amounts to 47% over the complete sample, which indicates that an identified adverse demand shock reasonably reflects real demand side macroeconomic developments such as a stronger demand for imports than for domestic production. The relatively high correlation in comparison with those of other demand proxies underscores the importance of Germany's integration into the international trade system for domestic macroeconomic developments. The accumulation of demand shocks suggests an extended demand weakness from 1995 to 2001. Since 2001, however, contrary to the development of domestic demand in Germany, there seems to have been a series of positive relative demand shocks. A closer examination of the proxy variable highlights that this development might not be due to a falling German import quota but to rising foreign imports from Germany in relation to foreign GDP. Thus, the positive demand shocks of recent years can be attributed completely to relatively strong net-foreign demand for German goods.

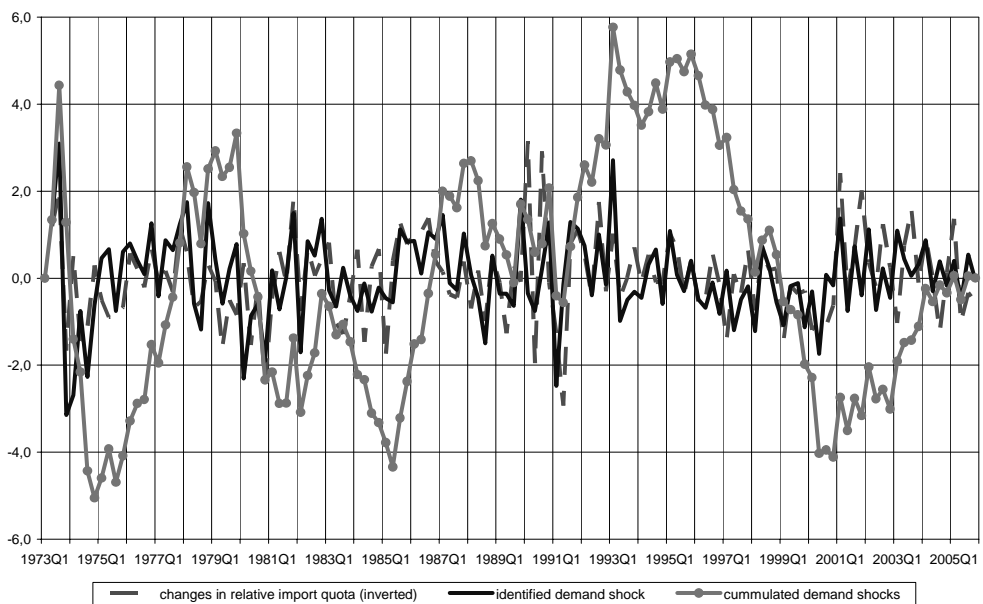
---

8. This variable was calculated by taking the difference between German imports to GDP and German exports (converted in foreign real terms) to foreign GDP. To convert German real exports into foreign real exports they were multiplied by the German real exchange rate index.

**Figure 4. Identified supply shocks and relative productivity changes**



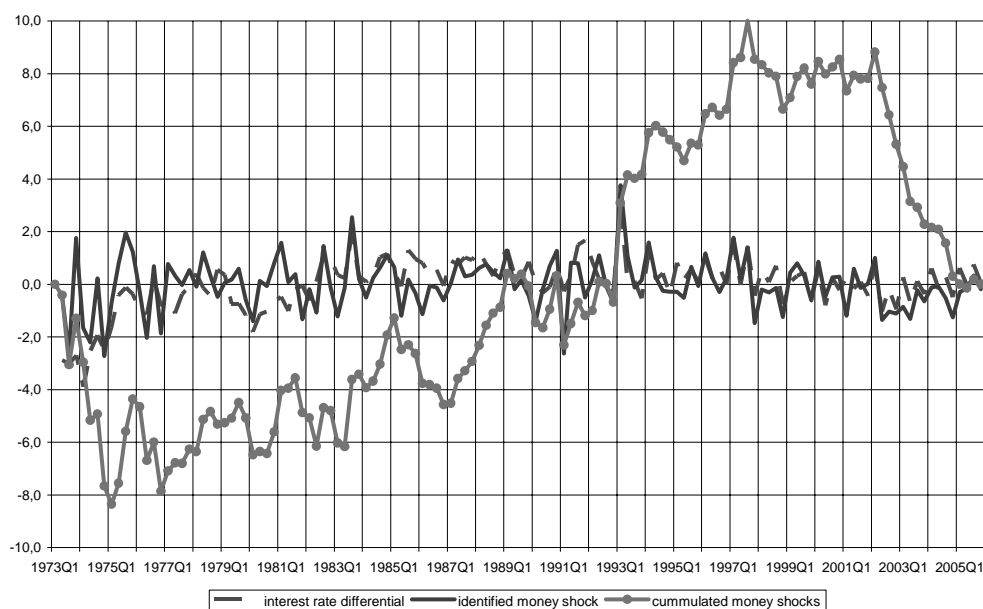
**Figure 5. Identified demand shocks and changes of the relative import share in GDP**



41. The identified nominal shocks turned out to be closely correlated (correlation coefficient over the complete sample of 52%) to the negative short-term (three month) real interest rate differential between Germany and its trading partners, a variable that is supposed to capture relative nominal shocks. The cumulated path of nominal shocks indicates that after the breakdown of the Bretton Woods System, which is identified to constitute an adverse shock (leading to appreciation), monetary shocks tended to have a relatively expansionary impact in the period from 1975 to 1997. From then onwards monetary shocks were rather contractionary again, compared to their average impact over the complete sample. As the proxy variable highlights, this later episode seems to be closely related to relatively high real interest rates in

comparison to major trading partners. Although this episode essentially covers the European Monetary Union, which should in principle have reduced the exposure of member states to international monetary shocks, the magnitude and frequency of such shocks seems not to have vanished from a German perspective.

**Figure 6. Identified money shocks and changes in real interest rate differential**



42. In sum, the previous discussion highlights that the identified shocks reasonably capture real economic developments over the sample period quite well. Nevertheless, the problem of finding adequate fundamental variables becomes more than obvious through the low correlations some of the proxy variables shared with the shocks. As discussed further below, relative demand and nominal shocks, for which the correlation with the established proxy variables only amount to about 50%, play an important role in the determination of the real exchange rate. This might at least to some extent explain the problems of statistical accuracy that is inherent to applications of the equilibrium exchange rate approach.

43. Now we can move on to the analysis of the impact of the identified shocks on business cycle fluctuations and the real exchange rate. As a precautionary note one should mention that as in any structural macro-econometric model, the estimated responses to different shocks might be subject to structural changes over longer time periods. A particular structural change that occurred in the sample period apart from German reunification is the change of the exchange-rate regime, from the breakdown of Bretton Woods in 1973 and the European Exchange Rate Mechanism that started in 1979 to the introduction of the Euro in 1999. As a consequence, the degree of nominal exchange rate flexibility has changed over the sample period, although further investigation of the data points to only one clear-cut change that coincides with the introduction of the Euro. Since the impulse response patterns can in principle depend on the degree of exchange rate flexibility the results from the VAR estimation over the complete sample period might not necessarily represent the response of prices, income and the real exchange rate in the current Euro regime. Taken the aforementioned into consideration, it is useful to look at the long-run responses of the estimated model first. The implied long-run multipliers for the impact of the shocks on the three endogenous variables turned out to be highly significant.

	<i>S</i>	<i>D</i>	<i>N</i>
<i>yc</i>	$\hat{A}(1) = \begin{bmatrix} 0.006 & 0 & 0 \\ -0.008 & 0.021 & 0 \\ -0.006 & 0.003 & 0.007 \end{bmatrix}$		
<i>q</i>			
<i>P</i>			

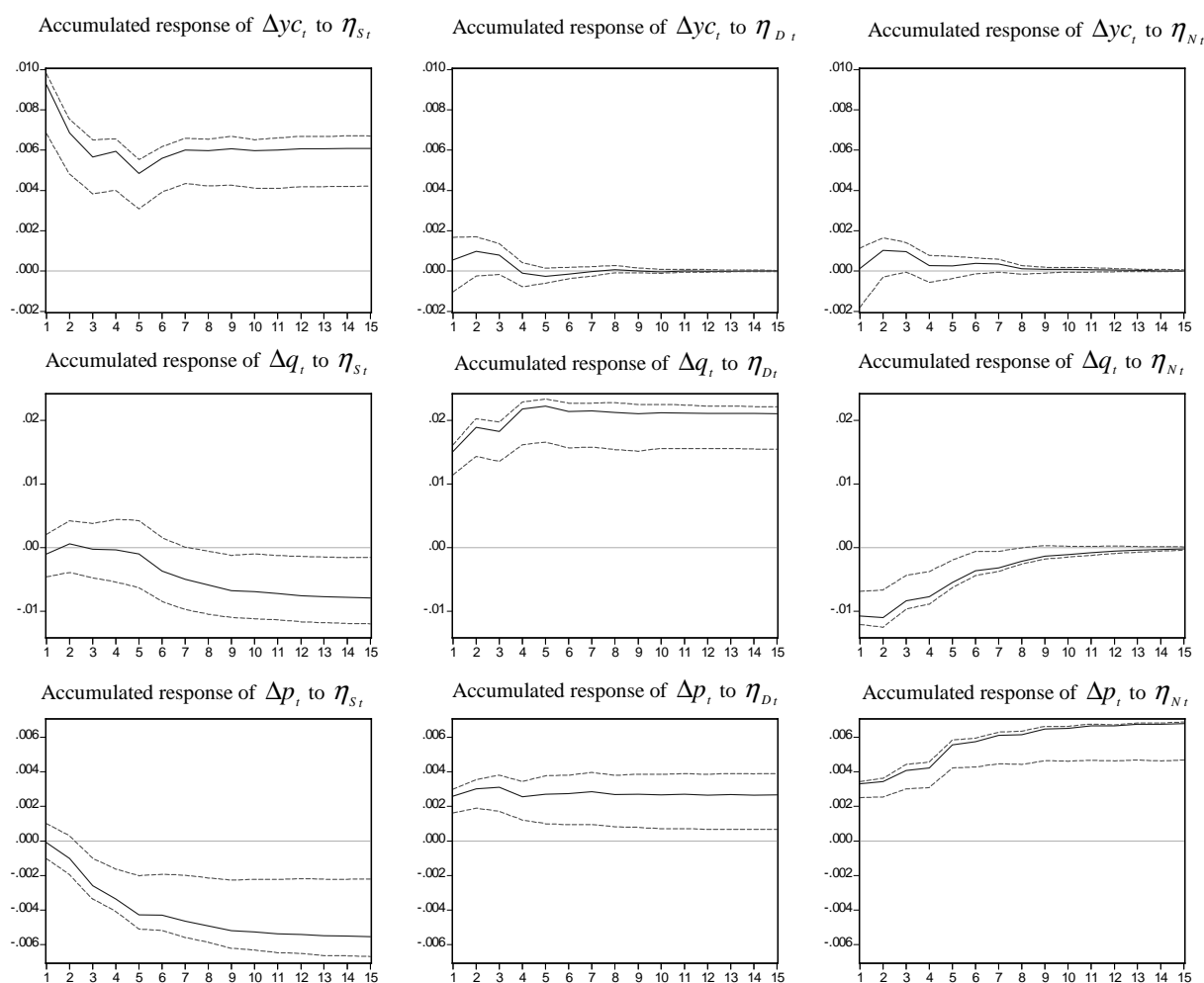
All coefficients are significant at the 1% level on the basis of the so-called z-statistics.

The estimated long-run multiplier matrix above indicates that a positive supply shock leads to a rise of relative output, a real depreciation and a fall of relative prices in the long run (multipliers in the first column). A positive demand shock is restricted to have no long-run effect on output (entry in the first row of the second column is zero), but is estimated to lead to a real appreciation and a rise in the relative price level in the long-run. Finally, nominal shocks are restricted to have only a long-run impact on the relative price level, which was estimated to be positive in response to an expansionary monetary shock. In sum, all the long-run multipliers obtained from the restricted estimation are consistent with the implications of the theoretical model of paras 18-20.

44. Apart from the economic plausibility of the long-run responses to shocks, it is also interesting to examine whether the short-run responses of the economic variables are in line with the theoretical considerations. This can be most practically assessed by so-called impulse response functions (see Figure 7).

**Figure 7. Impulse-response functions**

Accumulated Response to Structural One S.D. Innovations



Dotted lines are 66%-Confidence bounds, which were generated by a Monte-Carlo simulation with 1000 draws from the posterior distribution. A similar Eviews routine (bqboot.prg) can be downloaded from the support web site: <http://www.eviews.com/support/examples/docs/svar.htm>.

45. The impact of a positive relative supply shock for Germany on the model variables is depicted in the left column of the graphs. In the short-run, relative output rises more strongly than in the long-run, while the real exchange rate remains unchanged for about 5 quarters and might even appreciate a bit temporarily. While this response pattern is inconsistent with the simple structure of the model from above, the exchange rate response can be plausible under less rigid assumption, *e.g.*, when temporary demand-side reactions to productivity shocks are taken into account, which might raise the interest rate and induce capital inflows in the short run. The resulting upward pressure on the real exchange rate might then temporarily offset the downward pressure implied by the new long-run equilibrium. An important policy implication of this slow response of the real exchange rate to supply is that structural productivity enhancing reforms take time to show up in improvements of international competitiveness, and hence in a stimulation of the export sector. Instead, such supply shocks are more likely to stimulate domestic investment and consumption in the short run, contrary to the simple assumptions of the underlying model. Finally, the gradual convergence of relative domestic prices to their lower long-run level is in line with what one would expect in the case of short-run nominal rigidities.

46. The responses of the variables to a relative demand shock are depicted in the centre column of Figure 7. A positive demand shock in Germany raises output temporarily, and almost instantly raises the real exchange rate and the relative price level to their higher long-run levels. An expansionary relative monetary shock to Germany (responses depicted in the right column of Figure 7) temporarily stimulates output, leads to a temporary depreciation, and already on impact pushes relative prices to their higher long-run level. The temporary rise in output to real demand and nominal shocks is consistent with short-run price rigidities. Another prominent implication of these rigidities is also inherent in the empirical model. While the relative price level rises instantly in response to a monetary shock, the real exchange rate depreciates. This implies nominal exchange-rate overshooting as suggested by Dornbusch (1976).

47. All in all, the short run responses of the macro variables to the identified shocks are in line with most of the implications of simple dynamics in the theoretical model. Furthermore, the impulse-response functions indicate that the adjustment process to the various shocks is completed after 8 quarters, or roughly 2 years. This implies that the reunification shock as well as a potential monetary shock by a misaligned entry into monetary union (although there is no evidence for this from the identified monetary shocks) should have been digested by the economy a long time ago, and should no longer influence current macroeconomic developments. On the other hand it suggests that the series of positive supply shocks at the end of the sample period might exert a downward pressure on the real exchange rate for some time to come.

48. The second standard tool to analyse the properties of the estimated structural VAR is the so-called forecast error variance decomposition. For each endogenous variable it highlights what proportion of variance of the forecast error over different forecast horizons is due to the individual shocks. In other words, the decomposition reveals the magnitude by which the individual shocks carry over into changes of the endogenous variables, given the same distribution of shocks in the forecasting period as in the past (iid normal by assumption). This information provides some further important insights with respect to the main questions of the paper.

49. The results of the decomposition (see Table 4) show that even in the very short run, relative output fluctuations are almost entirely determined by relative supply shocks, which corresponds to results obtained in former studies. In contrast to this, changes in the real exchange rate are roughly two-thirds driven by relative demand shocks, and only one third by relative nominal shocks. This result contrasts with some earlier studies, which find only a limited impact of real shocks on the real exchange rate. The relative importance of demand shocks in exchange rate determination combined with the relative immunity of relative output to such shocks, suggests that the German real exchange rate plays an important role as an absorber for real and nominal demand side shocks. In contrast to this beneficial role, however, the weak relation of the real exchange rate to supply shocks implies that its stabilising role for such shocks is rather limited. For the past this means that the adverse productivity shock of reunification had been insufficiently reflected in an increase of relative domestic prices, which has postponed the required reduction in domestic demand and might have contributed to the built-up of excess capacity. For the current structural reform process that is visible at the end of the sample period, it implies, in turn, that the positive long-run impact on output might materialise rather slowly as the transmission into a fall of relative prices is hampered by the dominance of the effects from real and nominal demand shocks.

**Table 4. Forecast error variance decompositions**

Quarters	Per cent of Variance in $\Delta y_{c,t}$ due to			Per cent of Variance in $\Delta q_t$ due to			Per cent of Variance in $\Delta p_t$ due to		
	Supply shock	Demand shock	Money shock	Supply shock	Demand shock	Money shock	Supply shock	Demand shock	Money shock
1	99.63	0.35	0.02	0.29	66.22	33.49	0.06	38.06	61.88
2	98.59	0.53	0.89	0.98	67.08	31.94	4.54	36.89	58.57
3	98.57	0.56	0.88	1.15	65.73	33.12	15.37	32.00	52.63
...									
15	97.14	1.43	1.43	3.82	63.26	32.93	0.06	38.06	61.88

50. The most interesting information that can be drawn from the structural VAR is a separation of past exchange rate developments into time-paths that depend only on individual shocks (the so-called historical decomposition). It allows a computation, for example, of the implied path of the real exchange rate if only supply shocks had occurred in the respective sample period.<sup>9</sup> Such shock-dependent series would then comprise of a individual stochastic component and a joint deterministic component (constant and trend). In the following graph (Figure 8), only the stochastic components of these implied exchange-rate paths are shown for all three types of shocks. This ensures that the individual shock-dependent series add up to the complete stochastic component of the historical real exchange rate movements, which is identical to the total forecast error if one had forecasted the real exchange rate path based on the information in the second quarter of 1973.

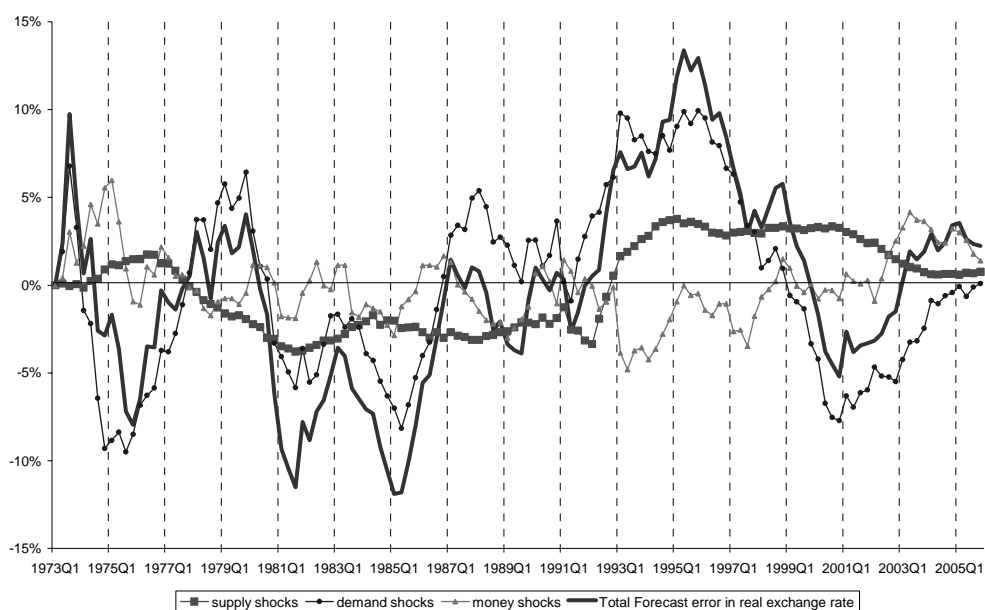
51. The graph highlights many important implications of the structural decomposition. First, while supply shocks played only a minor role in the determination of the real exchange rate over the complete sample, the fall in productivity due to reunification (here dated to the first quarter of 1991) constituted a substantial isolated shift in the new equilibrium real exchange rate. In absence of any other shocks it would have initiated a minor temporary depreciation in 1991 and a substantial long-run revaluation afterwards<sup>10</sup>, which would have been completed not earlier than 1995. Apart from this one time event relative supply shocks virtually played no role in the determination of the real exchange rate until 2001. Since then, however, relative positive supply shocks, which might be related to recent structural reforms, have exerted some downward pressure on the real exchange rate, and have pushed towards a higher international price competitiveness, respectively.

9. For a formal definition, refer to paras 33-37.

10. Consistent with the impulse response pattern, a negative supply shock can temporarily lead to a small depreciation through adverse demand side effects (refer also to paragraph 23). However, because of the dating problem, when exactly economic actors took the effects of reunification into consideration, the short-run implications of supply shocks should only be interpreted with great caution.



**Figure 8. Historical decomposition of the real exchange rate**  
(stochastic components)



52. Second, demand shocks have been clearly the major driver of the real exchange rate over the complete sample. In particular, they play a crucial role in explaining the prolonged appreciation/depreciation cycle that followed German reunification. Such a cycle is also reflected in the changes in the relative import quota to GDP (the selected proxy variable for demand shocks). A closer look at macroeconomic developments during the period 1991-2000 support the idea of a particular demand driven boom-bust cycle.<sup>11</sup> Investment into new capacity grew strongly, in the early years after reunification, foremost in the construction sector, as economic optimism was elevated and the government provided generous subsidies for investment in the New Laender. At the same time private consumption was also booming in the early years as huge west-east transfers provided East-Germans with the means to catch up in private living standards. The beginning recession in 1993 marked the end of this positive demand shock. However, it took some time until economic policy makers and economic actors realised that a fundamental correction of their behaviour was warranted. Wages increased strongly in 1993 despite the looming recession, and government subsidies for investment in East Germany were not significantly cut before 1995. The subsequent correction of over-optimistic investment and consumption plans is reflected in real-exchange rate developments from 1995 onwards as a series of negative demand shocks pushed towards a substantial real depreciation. Until 2001 the German import share in GDP rose by more than 7-percentage points relative to the import share of trading partners. The bulk of the relative fall in domestic production can be traced back to the outstanding weakness of investment, in particular in construction, that characterised this period.

53. Also the real appreciation from 2002 to 2004 has been primarily triggered by relative positive demand shocks for Germany. This seems peculiar at first sight, given that Germany has suffered from a particular weakness of domestic demand in this period and that, congruent to this, Germany's import share in domestic GDP increased by 3% over that period. An explanation for this counterintuitive result can be obtained by a closer look at the selected proxy variable for relative demand shocks, however. In fact, Germany's *relative* import quota (import share of German GDP relative to the share of German exports in

11. See Wurzel (2005) for a more thorough discussion of post-reunification macroeconomic developments.

the trading partners' GDP) has *declined* by 10-percentage points until 2004 due to a substantial increase in foreigners' propensity to import German products. This might help to explain why German exports remained fairly strong despite the substantial real appreciation.

54. Finally, as suggested by the underlying restrictions, monetary shocks have relatively little impact on the level of the real exchange rate.<sup>12</sup> The breakdown of the Bretton Woods System seems to be plausibly identified by the model as an adverse financial market shock that exerted short-term upward pressure on the real exchange rate which was then subsequently corrected. From 1999, the year of the de-facto introduction of the euro, to the year 2001, virtually no exchange rate movements can be attributed to nominal shocks. Since then, however, monetary shocks have been abating, which at least between 2002 and 2003 can be attributed to the high positive short-term real interest differential between Germany and the US that prevailed at that time. The relatively tighter monetary environment in Germany might also reflect temporary asymmetries in the stance of the business cycle between euro member countries.

### Summary and policy conclusions

55. In this paper real demand and supply shocks as well as nominal shocks have been identified as the three driving forces for macroeconomic developments in Germany and its main trading partners over the past 30 years. The short-run and the long-run impact of these shocks on relative output, price and real exchange rate fluctuations are broadly consistent with the implications of the Mundell-Flemming-Dornbusch type model that provides the necessary identifying restrictions for this analysis.

56. The identified shocks suggest that long-term movements in the Germany's international price competitiveness have been primarily caused by relative real demand shocks, which are related to autonomous demand shifts between German and foreign goods. Real demand shocks play a crucial role in explaining the prolonged appreciation/depreciation cycle that followed German reunification, and they are also the main factor for the recent appreciation since 2002. While in the former case these shocks can be associated with the relative strength and weakness of domestic demand in Germany, in the latter case they rather result from foreign demand shifts towards German goods. In contrast to the importance of demand side disturbances, supply shocks played a far less prominent role in the determination of the real exchange rate. Only the adverse supply shock of reunification and a series of positive supply shocks after 2000, which might reflect structural reform efforts, led to significant changes in the implied equilibrium exchange rate. Finally, while monetary shocks do not affect the long-run real exchange rate per definition, in the short-run they seem to have had an expansionary impact during most of the 1980s and 1990s, and only since early 2002 seem to exert some pressure towards a real appreciation.

57. Overall, the analysis of the paper underlines that international price competitiveness is an inadequate indicator for the success of structural supply side reforms. In the past decade it has been rather downward pressures on the demand side that induced a real depreciation. As the exchange rate developments of the past three years demonstrate, the impact of positive supply shocks can be thwarted by international demand and monetary developments. Moreover, as was highlighted by the impulse-response analysis, even an isolated increase of potential output would only slowly translate into a real depreciation, such that the role of the German export sector in supporting the adjustment to a higher growth and lower unemployment equilibrium seems limited.

The conclusions drawn from the identified shocks in the paper might be put under scrutiny by further research that employs alternative underlying theoretical hypotheses and also alternative empirical

---

12. For a better understanding of Figure 8, it might be useful to note that after an isolated monetary shock the real exchange rate would reverse to the zero line, whereas in the case of isolated real demand and supply shocks, the real exchange rate would converge to a new equilibrium level that is not necessarily zero.

identification schemes. For instance, one could check the robustness of the results by employing the identification scheme of Fisher and Huh (2002), who analyse a VAR of relative output, the real exchange rate and the trade balance without imposing the restriction of PPP in the long-run in case of nominal shocks. A further possible extension would be to look for changes in the response patterns over time by estimating the model for different sub-sample periods. This might highlight, for instance, whether the adjustment process has changed due to recent structural reforms or other regime shifts such as the entry into European Monetary Union.

## BIBLIOGRAPHY

- Alexius, A. and E. Post (2005), “Exchange Rates and Asymmetric Shocks in Small Open Economies”, *Uppsala University Working Paper*, 2005:10.
- Alquist R. and M. Chinn (2002), “The Euro and the Productivity Puzzle: an Alternative Interpretation”, *National Bureau for Economic Research Working Paper*, No. 8824
- Artis and Ehrmann (2000), “The Exchange Rate – a Shock Absorber or a Source of Shocks”, *CEPR Discussion Papers*, No. 2550.
- Blanchard, O. and D. Quah (1989), “The Dynamic Effects of Aggregate Demand and Supply Disturbances”, *American Economic Review*, Vol. 79, No. 4, pp. 655-73, September.
- Canova F. and G. De Nicoló (2002), “Monetary Disturbances Matter for Business Fluctuations in the G-7”, *Journal of Monetary Economics*, Vol. 49, pp. 655-73.
- Canzoneri, M.B., J. Valles and J. Vinals (1996), “Do Exchange Rates Move to Address International Macroeconomic Imbalances?”, *CEPR Discussion Paper No. 1498*, Centre for Economic Policy Research, October.
- Chadha, B. and E. Prasad (1996), “Real Exchange Rate Fluctuations and the Business Cycle: Evidence from Japan”, *IMF Working Paper*, No. 96/132, November.
- Clarida, R. and J. Gali (1994), “Sources of Real Exchange-rate Fluctuations: How Important are Nominal Shocks?”, *Carnegie-Rochester Conference Series on Public Policy*, Vol. 41, pp. 1-56.
- Clark, P. and R. MacDonald (1998), “Exchange Rates and Economic Fundamentals: A Methodological Comparison of BEERs and FEERs”, *IMF Working Paper*, No. 98/67, May.
- Clostermann, J. and W. Friedmann (1998), “What Drives the Real-Effective D-Mark Exchange Rate?”, *Konjunkturpolitik*, Vol. 44, pp. 207-230.
- Deutsche Bundesbank (2001), *Monthly Report*, November 2001.
- Dornbusch, R. (1976), “Expectations and Exchange Rate Dynamics”, *Journal of Political Economy*, Vol. 84, No. 6, pp. 1161-1176.
- Duval, R. (2002), “What Do We Know about Long Run Equilibrium Real Exchange Rates? PPPs vs Macroeconomic Approaches”, *Australian Economic Papers*, Vol. 41, No. 4, pp. 382-403, December.
- European Central Bank (2002), “Economic Fundamentals and the Exchange Rate of the Euro”, *Monthly Bulletin*, pp. 41-53, January.
- Farrant, K. and G. Peersman (2005), “Accounting for the Source of Exchange Rate Movements: New Evidence”, *Bank of England Working Paper*, No. 269, Bank of England.

- Faust, J. (1998), "The Robustness of Identified VAR Conclusions About Money", *Carnegie-Rochester Conference Series in Public Policy*, Vol. 49, pp. 207-44.
- Fischer, C. and K. Sauernheimer (2002), "A History of the D-Mark's Real External Value", *Australian Economic Papers*, Vol. 41, No. 4, pp. 480-498, December.
- Fisher, L.A. and H-S. Huh (2002), "Real Exchange Rates, Trade Balances and Nominal Shocks: Evidence for the G-7", *Journal of International Money and Finance*, Vol. 21, pp. 497-518.
- Funke, M. (2000), "Macroeconomic Shocks in Euroland vs. the UK: Supply, Demand, or Nominal?", Hamburg University Department of Economics, mimeo, July 2000, Hamburg, Germany.
- Goldstein, M. and M.S. Khan (1985), "Income and Price Effects in Foreign Trade", in R.W. Jones and P.B. Kenen (eds.), *Handbook of International Economics*, Vol. 2, Elsevier, Amsterdam, pp. 1041-1105.
- Johansen, S. (1988), "Statistical Analysis of Cointegration vectors," *Journal of Economic Dynamics and Control*, Vol. 12, No. 2-3, pp. 231-254.
- Johansen, S. and K. Juselius (1990), "Maximum Likelihood Estimation and Inference on Cointegration – With applications to the Demand for Money", *Oxford Bulletin of Economics and Statistics*, Vol. 52, pp. 169-210.
- MacKinnon, J.G., A. Haug and L. Michelis, "Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration", *Journal of Applied Econometrics*, Vol. 14, No. 5, 1999, pp. 563-577.
- Mundell, R. (1961), "A Theory of Optimum Currency Areas", *American Economic Review*, Vol. 51, No. 4, pp. 657-65, September.
- Obstfeld, M. (1985), "Floating Exchange Rates: Experience and Prospects", *Brookings Papers on Economic Activity*, Vol. 2, pp. 369-456.
- Obstfeld, M. and K. Rogoff (1996), *Foundations of International Macroeconomics*, MIT Press.
- OECD (2001), "Tracking the Euro", *Economics Department Working Papers*, No. 298, OECD, Paris.
- Rogoff, K. (1996), "The Purchasing Power Parity Puzzle", *Journal of Economic Literature*, Vol. 34, No. 2, June, pp. 647-668.
- Sachverstaendigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (SVR) (2004), "Jahresgutachten 2004".
- Stein, J.L. (1994), "The Natural Real Exchange Rate of the Dollar and Determinants of Capital Flows", in J. Williamson (ed.), *Estimating Equilibrium Exchange Rates*, Institute for International Economics, Washington, D.C.
- Stein, J.L. (2002), "The Equilibrium Real Exchange Rate of the Euro: An Evaluation of Research", *ifo Studien Zeitschrift fuer empirische Wirtschaftsforschung*, Vol. 48, No.3, pp. 349-381.
- Uhlig, H. (1999), "What are the Effects of Monetary Policy: Results from an Agnostic Identification Approach", *Tilburg University Working Paper*, No. 9928.
- Wurzel, E. (2005), "Why Germany Needs Structural Reform", *CES-ifo Forum* 4/2005, pp. 28-32.

## WORKING PAPERS

*The full series of Economics Department Working Papers can be consulted at [www.oecd.org/eco/Working\\_Papers/](http://www.oecd.org/eco/Working_Papers/)*

- 522. *Short-term pain for long-term gain: the impact of structural reform on fiscal outcomes in EMU*  
(November 2006) Paul van den Noord and Boris Cournède
- 521. *Interactions between monetary and fiscal policy: How monetary conditions affect fiscal consolidation*  
(November 2006) Rudiger Ahrend, Pietro Catte and Robert Price
- 520. *Restoring fiscal sustainability in the Euro Area: raise taxes or curb spending?*  
(October 2006) Boris Cournède and Frédéric Gonand
- 519. *Should Measures of Fiscal Stance be Adjusted for Terms of Trade Effects*  
(October 2006) David Turner
- 518. *Monetary policy and inflation expectations in Latin America: Long-run effects and volatility spillovers*  
(October 2006) Luiz de Mello and Diego Moccero
- 517. *Social safety nets and structural adjustment*  
(September 2006) Paul van den Noord, Nathalie Girouard and Christophe André
- 516. *Adapting the Icelandic education system to a changing environment*  
(September 2006) Hannes Suppanz
- 515. *Forecasting monthly GDP for Canada*  
(September 2006) Annabelle Mourougane
- 514. *Finland's housing market: reducing risks and improving policies*  
(September 2006) Laura Vartia
- 513. *The Danish housing market: Less subsidy and more flexibility*  
(September 2006) Espen Erlandsen, Jens Lundsgaard and Felix Huefner
- 512. *Labour market reform in Germany: How to improve effectiveness*  
(September 2006) Eckhard Wurzel
- 511. *Removing obstacles to employment for women in Ireland*  
(September 2006) Boris Cournède
- 510. *Assessing Russia's non-fuel trade elasticities: Does the Russian economy react "normally" to exchange rate movements?*  
(September 2006) Christian Gianella and Corinne Chanteloup
- 509. *Regulation, competition and productivity convergence*  
(September 2006) Paul Conway, Donato De Rosa, Giuseppe Nicoletti and Faye Steiner
- 508. *Improving education achievement and attainment in Luxembourg to compete in the labour market*  
(September 2006) David Carey and Ekkehard Ernst
- 507. *Raising economic performance by fostering product market competition in Germany*  
(August 2006) Andrés Fuentes, Eckhard Wurzel and Andreas Reindl
- 506. *Regulation of financial systems and economic growth*  
(August 2006) Alain de Serres, Shuji Kobayakawa, Torsten Sløk and Laura Vartia

505. *Enhancing Portugal's human capital*  
(August 2006) Bénédicte Larre and Stéphanie Guichard
504. *Improving labour market performance in France*  
*Améliorer la performance du marché du travail en France*  
(July 2006) Stéphanie Jamet
503. *Wage setting in Finland: Increasing flexibility in centralised wage agreements*  
(July 2006) Åsa Johansson
502. *Taxation, business environment and FDI location in OECD countries*  
(July 2006) Dana Hajkova, Giuseppe Nicoletti, Laura Vartia and Kwang-Yeol Yoo
501. *The political economy of structural reform: Empirical evidence from OECD countries*  
(July 2006) Jens Høj, Vincenzo Galasso, Giuseppe Nicoletti and Thai-Thanh Dang
500. *Labour market performance, income inequality and poverty in OECD countries*  
(July 2006) Jean-Marc Burniaux, Flavio Padrini and Nicola Brandt
499. *Improving Public-Spending Efficiency in Czech Regions and Municipalities*  
(July 2006) Philip Hemmings
498. *Policies to Promote Innovation in the Czech Republic*  
(July 2006) Alessandro Goglio
497. *Getting Education Right for Long-Term Growth in the Czech Republic*  
(July 2006) Alessandro Goglio
496. *Assessing the 2005 Czech Proposals for Pension Reform*  
(July 2006) Philip Hemmings and Edward Whitehouse
495. *Poland's Education and Training: Boosting and Adapting Human Capital*  
(July 2006) Paul O'Brien and Wojciech Paczynski
494. *The Rates and Revenue of Bank Transaction Taxes*  
(July 2006) Jorge Baca-Campodónico, Luiz de Mello and Andrei Kirilenko
493. *Nothing Ventured, Nothing Gained: The Long-Run Fiscal Reward of Structural Reforms*  
(July 2006) Peter Hoeller and Claude Giorno
492. *Ireland's Housing Boom: What has Driven It and Have Prices Overshot?*  
(June 2006) Dave Rae and Paul van den Noord
491. *Boosting Competition in Ireland*  
(June 2006) Dave Rae, Line Vogt and Michael Wise
490. *Factors Behind Low Long-Term Interest Rates*  
(June 2006) Rudiger Ahrend, Pietro Catte and Robert Price
489. *The Fiscal Challenge in Portugal*  
(June 2006) Stéphanie Guichard and Willi Leibfritz
488. *Are House Prices Nearing a Peak? A Probit Analysis for 17 OECD Countries*  
(June 2006) Paul van den Noord
487. *Maintaining Switzerland's Top Innovation Capacity*  
(June 2006) Florence Jaumotte