Has the Euro changed the Business Cycle?*

Zeno Enders
University of Bonn

Philip Jung
University of Mannheim

Gernot J. Müller
University of Bonn

February 2009
- *Preliminary version* -

Abstract

In this paper we analyze European business cycles before and under EMU. Across the two periods we find 1) a significant fall in real exchange rate volatility, 2) significant changes in cross-country correlations, and 3) the volatility of domestic aggregates largely unaltered. We develop and calibrate a two-country business cycle model to capture defining characteristics of the German economy and an aggregate of six European countries. The model is able to replicate many key features of the data, both prior to and under EMU. Counterfactual experiments suggest that the absence of non-fundamental exchange rate volatility under EMU goes a long way in accounting for the observed changes.

Keywords: European business cycles, Euro, Optimum Currency Area, EMU, Monetary Policy, Exchange rate regime
JEL-Codes: F41, F42, E32

*We thank Jörg Breitung for helpful discussions. The usual disclaimer applies. Please address correspondence to zeno.enders@uni-bonn.de, p.jung@vwl.uni-mannheim.de or gernot.mueller@uni-bonn.de.

1 Introduction

In January 1999 eleven European countries adopted the euro as a common currency and delegated monetary policy to the European Central Bank in order to create the European Monetary Union (EMU). Such a formidable experiment had been anticipated and subject to both policy debates and theoretical research for several decades.[1] Ten years after its actual inception it is possible to take up the question whether the euro has changed the European business cycle and, if so, why?

To answer this question we focus on a sample of nine European countries—Belgium, France, Finland, Germany, Netherlands, Ireland, Italy, Spain and Portugal—and study the properties of macroeconomic aggregates at business cycle frequency. Specifically, we compute the volatility of output and its components as well as those of unemployment and inflation. We also measure cross-country correlations for these variables and, in addition, the volatility of the real exchange rate and the trade balance. We distinguish the period 1985–1996 and the period 1999–2007 and refer to these periods as the 'PreEMU' and the 'EMU' sample, respectively. Comparing results for both samples, three findings emerge. First, we document a significant and strong decline in real exchange rate volatility. Second, there are significant changes in the cross-country correlation of macroeconomic aggregates: while output, consumption and investment correlations increase, the correlation of government spending falls considerably. Third, the volatility of macroeconomic aggregates is largely unaltered across the two periods.

As far as business cycles are concerned, our findings suggest that the experiences of European economies in adopting the euro *mirrors* those documented for the period when the Bretton-Woods-system had been abandoned in favor of a system of floating exchange rates. In an influential study, Mussa (1986) documented a dramatic rise in real exchange rate volatility in OECD countries in the period after 1973. Baxter and Stockman (1989) provide a more comprehensive analysis of the data and find, in addition, evidence suggesting a decline in the cross-country correlation of economic activity, but an increase the correlation of government consumption after the demise of the Bretton-Woods system. Finally, they document that macroeconomic variables display quite similar volatilities under and after the Bretton-Woods system of fixed exchange rates.

Focusing on the recent European experience, we attempt to identify the causes underlying the documented changes. Conceptually, it is helpful to distinguish three candidate explanations. First, sources of business cycle fluctuations may have changed. Specifically, under a less than fully pegged exchange rate the foreign exchange market may be a genuine source business cycle fluctuations, see, for instance, Flood and Rose (1995) for evidence and Jeanne and Rose (2002) for a theoretical analysis.

[1] The academic literature developed a large body of work around the theory of Optimum Currency Areas (OCA theory). Key contribution include Mundell (1961), McKinnon (1963) and Kenen (1969), Corsetti (2008) provides a modern treatment. In 1970 a group of policy makers drafted a roadmap for the adoption of a common European currency known as the Werner report.

Second, to the extent that nominal rigidities characterize actual economies, the exchange rate regime matters for the propagation of business cycles within and across countries—as argued by Friedman (1953) among others. Third, the conduct of economic policy may have changed systematically under EMU. This not only holds for monetary policy, but also for fiscal policy which *de jure* has been subjected to the Stability and Growth pact.

We assess these possibilities within an calibrated two-country model. The model is sufficiently detailed in order to account for the defining characteristics of the European economy. Hence, our model features a non-Walrasian labor market along the lines of Mortensen and Pissarides (1994). Our two-country structure draws on Chari et al. (2002), but also distinguishes between the production of traded and non-traded goods as in Stockman and Tesar (1995). We assume that price setting in each sector is constrained by the Calvo mechanism and maintain the assumption that prices are sticky in the buyer's currency. Duarte (2003) shows that this assumption helps to account for the observations by Mussa and Baxter-Stockmann.[2] The characterization of households' and firms' behavior is standard and the model is closed by assuming that policy makers' behavior can be captured by estimated feedback rules.

We calibrate the model to match key features of European data. Specifically, we focus on data for Germany and an aggregate of the above mentioned European countries less Belgium and the Netherlands (EA6), since the latter two maintained a strict de-facto peg to the deutsche mark during the PreEMU period. Relying on standard procedures we estimate shocks processes for technology shocks as well as shocks which originate in the foreign exchange market. Following Kollmann (2002) we refer to these shocks as 'UIP shocks', for they drive a wedge in the uncovered interest rate parity condition. We estimate feedback rules for monetary and fiscal policy and use the regression residuals to specify the policy shocks in the model. In the spirit of Clarida et al. (1998), we allow monetary policy in EA6 to respond to German interest rates, while German monetary policy is assumed to be conducted independently during the PreEMU period.

We simulate the model under two scenarios: PreEMU and EMU. While UIP shocks are assumed to occur as estimated under the PreEMU scenario, we assume that they are absent under EMU, given that UIP shocks are meant to capture noise in the foreign exchange market. Technology shocks are assumed to be determined by the same process under both scenarios. Policy rules, in contrast, are assumed to be different under both scenarios corresponding to our estimates. All the other deep parameters of the model are assumed to be constant. We assess the performance of the model in replicating key features of the data under both scenarios and, importantly, the documented changes across periods. We find that the model performs well on both counts.

[2]Monacelli (2003) introduces an distinct import goods sector where prices are determined inflexibly. This limits exchange rate pass-through—a feature which turns out to be crucial for his model to successfully account for the observations by Mussa and Baxter-Stockman.

On these grounds we use the model to perform counterfactual experiments which allow us to identify the causes of the observed changes. We find that the disappearance of UIP shocks under EMU goes a long way in accounting for the first two observations: the decline in real exchange volatility and the increase in the cross-country correlation of macroeconomic aggregates other than government spending. The decreased correlation of government spending can be explained by changes in the shock structure of the estimated fiscal policy rules, rather than changes in the systematic conduct of fiscal policy. The common monetary policy under EMU and the lack of exchange rate flexibility seem not to have induced lack of stabilization—reflected in either higher output volatility or lower cross-country correlations. If anything, monetary policy under EMU appears to have lead to increased stability as a result of more muted monetary policy shocks.[3]

The remainder of the paper is organized as follows. Section 2 provides a detailed analysis of the data. Section 3 outlines the model structure. In section 4 we discuss the calibration of the model and assess its performance in accounting for key features of the data, both prior to and under EMU. Section 5 preforms counterfactual experiments to understand changes in European business cycles. Section 6 concludes.

2 Properties of the data

In this section we summarize properties of macroeconomic times series for output and its components as well as those of the unemployment rate, inflation, the trade balance and the real exchange rate. Our sample includes nine European countries, all of which introduced the euro in January 1999: Belgium, France, Finland, Germany, Ireland, Italy, Netherlands, Spain and Portugal (EA9).[4] As a control group we include seven countries which did not adopt the euro; four European countries: Norway, Sweden, Switzerland, and the UK as well as three non-European countries: Canada, Japan, and the US.

We consider quarterly data for two periods. First, our PreEMU sample comprises data from 1985 until 1996. The starting point of sample is motivated by the observation that business cycle fluctuations became more moderate from 1984 onwards, see Stock and Watson (2005) for evidence on the G7 countries. We also exclude 1984 since the Solow residuals display some unusual outliers in that year. In order to take a possible anticipation of the introduction of the euro into account, we chose the end date two years before the actual creation of EMU. Our EMU sample runs from 1999 to 2007. We apply the HP-filter with a smoothing parameter of 1600 to all series in order to isolate business cycle fluctuations.[5]

[3]Collard and Dellas (2002), Kollmann (2004) and Faia (2007) provide related analyses. In contrast to the present paper, these studies are less concerned with actual changes in European business cycles due to the Euro and in identifying its underlying causes.

[4]We lack data for Austria and Luxembourg.

[5]To filter the data, we use the longest time series available, i.e. 1970Q1–2007Q4. A detailed description of the data sources and the aggregation method is provided in the appendix.

Identifying a 'Euro-effect' on European business cycles across the two samples is complicated by the rich variety of exchange rate arrangements in the decades prior to the introduction of the euro. During our sample period 1985–1996, the European Monetary System was subjected to considerable turbulence and the width of the targeted bands was increased to $\pm 15\%$ after the 1992 crisis. In addition, capital controls had been in place up to 1990 or later for some countries. Hence, for a set of countries there was considerable exchange rate flexibility and therefore monetary control. To keep things manageable and yet to isolate the effect of fixing exchange rates, we distinguish among those countries which successfully limited exchange rate variability vis-à-vis Germany already in the PreEMU period (Belgium, Netherlands) and the remaining countries where exchange rate volatility relative to Deutsche Mark was higher. We refer to the latter group as EA6: Finland, France, Ireland, Italy, Portugal and Spain.[6] When studying changes in cross-country correlations, we consider the aggregate of the EA9 countries as the counterpart of each of the non-EMU countries. For each member of the EA6 group we use the aggregate of the remaining eight EMU-countries. For Belgium, Netherlands, and Germany, instead, we only consider EA6 as a counterpart, because it is only with respect to these countries that a significant change in the exchange rate regime occurred as a result of the introduction of the euro.

In figure 1 we display the standard deviations of the variables of interest before and under EMU for all nine EMU countries in our sample as well as for the seven non-EMU countries. Standard deviations are computed in percent per quarter and, except for those of output, are scaled by the standard deviation of output. In each panel, the standard deviation for the period prior to EMU is plotted against the horizontal axis; the standard deviation for the EMU period is plotted against the vertical axis. A point on the $45°$ line indicates that for a particular country no change in the standard deviation can be observed. Points above the $45°$ line indicate an increase in volatility, while points below the $45°$ line indicate a reduction in volatility. EMU countries are represented by solid points, while those of the control group are represented by circles.

The upper left panel displays the standard deviation of output. There is a tendency for a decline in volatility, but this seems to be the case for EMU as well as for non-EMU countries. Except for the real exchange rate the other panels suggest no systematic change across periods. It thus appears that the volatility of those variables changed in the same way as output. The reduction of the volatility of the real exchange rate (relative to that of output) is quite pronounced for the euro countries, while no systematic change can be observed for non-EMU countries.

Figure 2 displays the cross-country correlation for output and its components, the unemployment rate

[6] In the appendix we plot monthly percentage change of the nominal exchange rate in these eight countries. Fluctuations in the exchange rates of Belgium and the Netherlands were much more limited than those of the EA6 group. The variance of the percentage changes of the quarterly Guilders/Mark rate over the sample was 0.03, while the Belgian Franc/Mark rate was more volatile with a variance of 0.49 due to the very short period of larger movements in 1993. We decided to classify France not as a peg because the exchange rate volatility is almost twice as large as the one of Belgium.

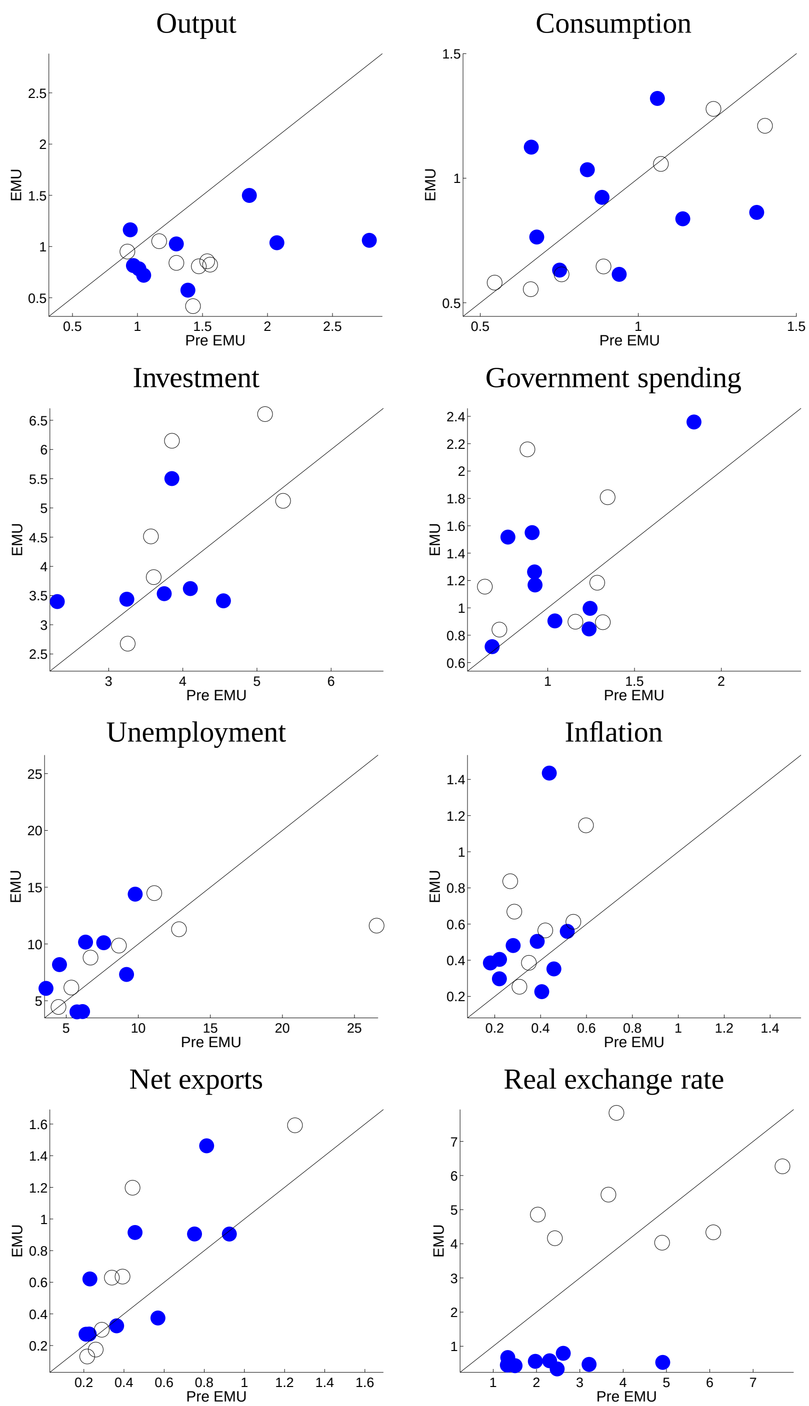

Figure 1: Standard deviation of macroeconomic time-series before and under EMU. Notes: solid points represent EMU countries, circles represent non-EMU countries; standard deviations are scaled by standard deviation of output; statistics computed on quarterly HP-filtered data for period 1984–1996 and 1999–2007.

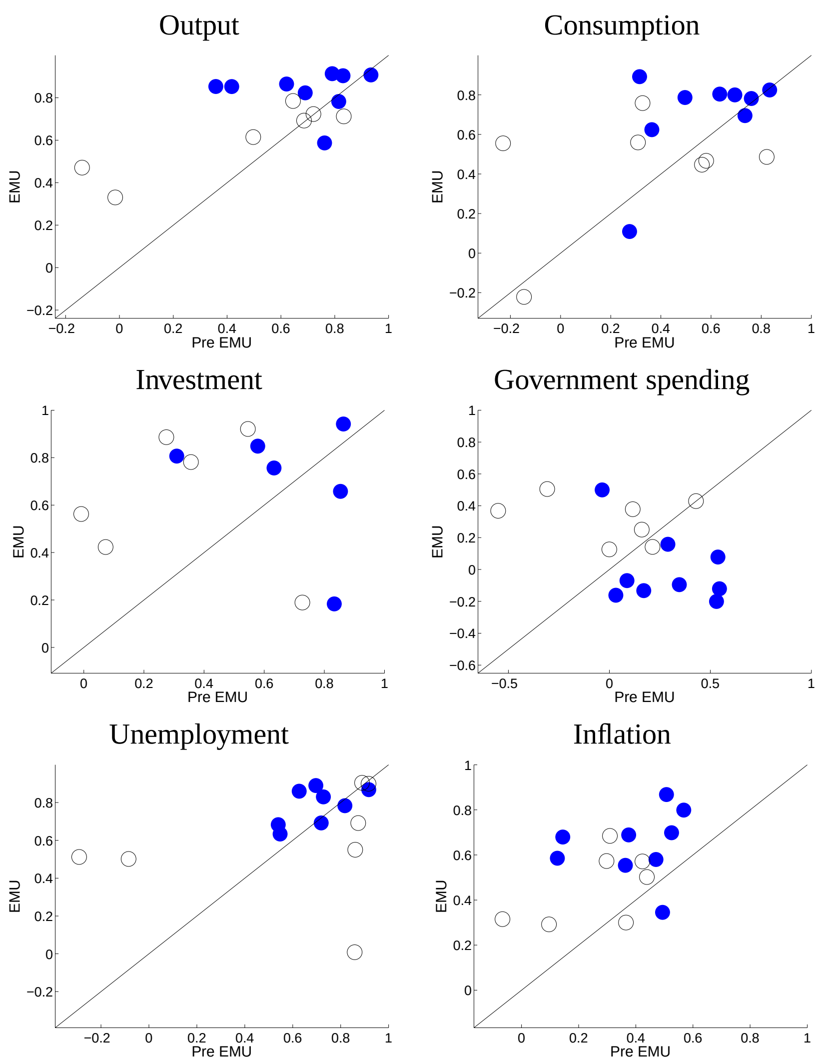

Figure 2: Cross-country correlations of macroeconomic time-series. Notes: see figure 1; for each country the cross-country correlation in computed considering the aggregate as defined in the text as the other country.

Table 1: Cyclical properties of time series before and under EMU

	Germany/EA6		EMU Avg		Non-EMU Avg	
	PreEMU	EMU	PreEMU	EMU	PreEMU	EMU
Volatility GE						
Std. Dev. Y	1.30	1.03	1.20	0.87**	1.10	0.87*
Std C/Std Y	0.68	0.76	0.93	0.84	0.87	0.70***
Std I/Std Y	2.31	3.40***	3.01	3.48**	3.63	4.45*
Std GS/Std Y	1.04	0.90	1.02	0.95	1.14	1.03
Std UE/Std Y	9.18	7.32	6.96	7.37	7.76	8.51
Std Infl/Std Y	0.22	0.30	0.33	0.48*	0.36	0.46
Trade						
Std RX/Std Y	2.48	0.34***	2.74	0.48***	5.22	4.92
Std NX/Std Y	0.23	0.27	0.38	0.45	0.26	0.27
Cross-Country						
Corr. Y Y^*	0.42	0.85**	0.66	0.86**	0.54	0.62
Corr. C C^*	0.36	0.62	0.60	0.72*	0.41	0.32
Corr. I I^*	0.58	0.85***	0.67	0.85***	0.27	0.74***
Corr. GS GS^*	0.35	-0.10**	0.38	-0.07***	-0.27	0.42***
Corr. UE UE^*	0.73	0.83	0.71	0.77	0.67	0.72
Corr. Infl $Infl^*$	0.49	0.35	0.43	0.61***	0.37	0.49

Notes: statistics are computed for time series for after applying HP-filter. PreEMU and EMU periods cover 1985–1996 and 1999–2007, respectively.

and inflation in the PreEMU and the EMU sample for all countries in our sample. Again, we use the horizontal axis to measure the correlation before EMU and the vertical axis for the correlation under EMU. According to this measure, it appears that the co-movement of macroeconomic aggregates increased somewhat under EMU. A remarkable exception is government spending, where cross-country correlations declined markedly under EMU.

Table 1 summarizes the evidence for three groups of countries. We report standard deviations and correlations for Germany relative to EA6 (left panel). The values for standard deviations for EMU and non-EMU countries in the middle panel are averages over all EA9 countries using long-run PPP GDP as weights.[7] We use a non-linear Wald test to evaluate whether changes are significant and use an asterisk to indicate significance at the 10% level, two asterisks for the 5% level, and three for the

[7] Concerning the correlations, first pairwise correlations for all countries relative to all other countries of the above mentioned group of foreign countries are calculated. Averages are then calculated using the sum of long-run PPP GDP of both parts of each pair as weights. We also calculate the standard deviations for the EA6 aggregate. The numbers are reported in table 4, where we compare them with the model simulations.

1% level.[8]

The most dramatic change across the two sample periods is the reduction in the volatility of real exchange rates. In fact, for our sample we find a decline by a factor of about 6-7. We thus confirm for EMU the well know finding that the exchange rate regime is a key determinant of real exchange rate behavior. In an influential study, Mussa (1986) documented that the variability of real exchange rates increased systematically in the period after 1973 relative to the Bretton-Woods period.[9] Regarding the cross-country correlations we find a significant increase in the correlation of output in Germany and output in EA6 and a significant decline in the cross-country correlation of government spending. Also the average change in the cross-country correlation of inflation is positive and significant.[10] A third finding is that there seems to be no systematic change in overall volatility. While the standard deviation of output falls (significantly for the EMU average), we also observe a significant decline for our sample of non-EMU countries across the two sample periods.

Our findings thus mirrors the finding reported by Baxter and Stockman (1989) as regards a possible change in business cycle statistics after the breakdown of the Bretton-Woods system of fixed exchange rates. They find little change in the volatility of macro aggregates—except for a strong decline in real exchange rate volatility, but document that the cross-country correlation of economic activity was higher under the Bretton-Woods system of fixed exchange rates. They also document a considerable increase in the correlation of government consumption in the post-Bretton-Woods period.[11]

Given that the change in real exchange rate volatility is certainly the most striking change which can be related to the introduction of the euro, we follow Mussa (1986) and decompose movements in the real exchange rate into movements of the nominal exchange rate and the ratio of price levels. Figure 2 plots the results for Germany, the EA6-countries, and the UK. For all euro countries it

---

[8] The test statistic of the Wald test is

$$W = [r(b) - q]' \{R(b)\hat{V}R'(b)\}^{-1}[r(b) - q] \sim \chi^2(1),$$

with b being a vector of variances of the variables needed for the specific statistic. The function $r(b)$ maps these variances into the statistic of interest, for example $Std(C_{PreEMU})/Std(Y_{PreEMU}) - Std(C_{EMU})/Std(Y_{EMU})$. The derivative $R(b)$ is defined as $\partial r(b)/\partial b'$. Finally, $\hat{V}$ is the estimated variance-covariance matrix of b, i.e. the variances and covariances of the included variances. We estimate $\hat{V}$ employing the Newey-West adjustment for autocorrelation and heteroscedasticity using a lag length of $T^{1/4}$, with T being the sample length.

[9] Mussa's study relies mostly on plots of the real exchange rate. He finds: "the size of the observed difference in the short-term variability of real exchange rates under floating rather than fixed exchange rates is generally so large that measures of statistical significance are irrelevant. The consistent observation of these large differences, without exception, across a broad array of cases is fatal to the hypothesis of nominal exchange rate neutrality." (p. 123).

[10] The finding concerning output correlations is somewhat fragile. Specifically, we also find an (insignificant) increase in the output correlation of non-EMU countries with EA9, see the appendix. Moreover, Canova et al. (2007) fail to detect the emergence of a specific EMU cycle. Their data, however, ends in 2003. Regarding inflation, our findings square well with Gerlach and Hoffmann (2008), who find a significant decline in relative volatility of inflation, GDP, and consumption for EMU countries.

[11] Kollmann (2005), in contrast, focusing on an aggregate of Germany, France and Italy, on the one hand and the US on the other, finds that the cross-country correlations of real macro aggregates and the price level were markedly higher in the post-Bretton-Woods era relative to the Bretton-Woods period.

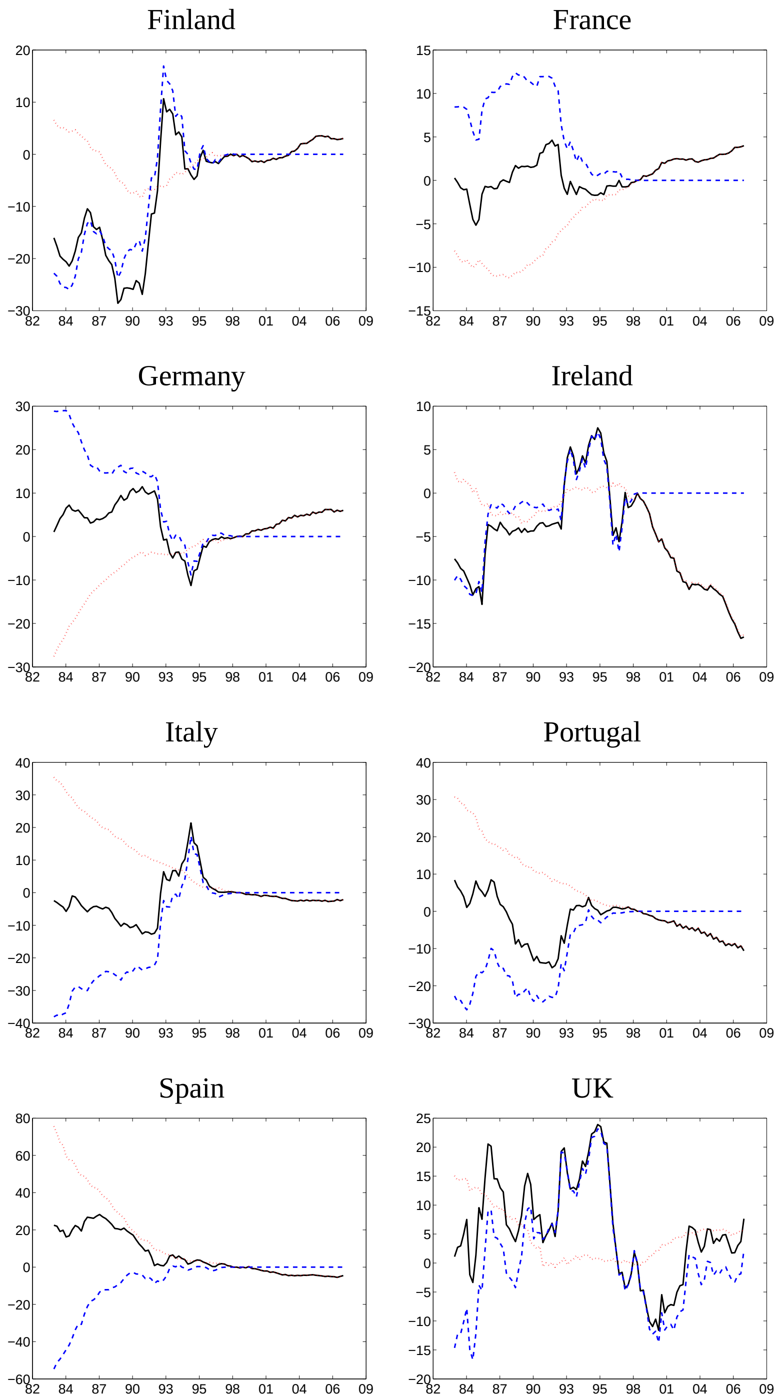

Figure 3: Real exchange rates (solid line), nominal exchange rates (dashed line), and price ratio (dashed-dotted line). Notes: Variables are defined relative to remaining European countries (see main text for country selection) weighted by time-varying tradeshares (4 quarters rolling window). The price ratio CPI/CPI^{*}.

becomes apparent that real exchange rates move quite closely with nominal rates and, hence, much of the volatility vanishes after 1999. The exception is Ireland, which experienced very limited real exchange rate movements also before EMU (note the small scale of the y-axis).

3 The model

In the following we propose a two-country business cycle model which is meant to capture the defining features of the European economy. As a crucial test for the model, we assess its ability to account for key features of the data before and under EMU. Our good market structure draws on earlier work by Chari et al. (2002), among others. Key differences concern price setting behavior where we rely on the Calvo scheme and the fact that we consider a non-traded goods sector as in Stockman and Tesar (1995) and labor market frictions along the lines of Mortensen and Pissarides (1994).

In the following we give a formal exposition of the model, discussing in turn the problems of the final goods firm, intermediate goods firms, the labor market firm and the representative household. We close the model with feedback rules characterizing monetary and fiscal policy. As both countries have isomorphic structures, we focus on the domestic economy, i.e. on the 'home' country. When necessary we refer to foreign variables by means of a star superscript.

3.1 Final good firms

Final goods, F_t, which are not traded across countries, are composites of intermediate goods produced by a continuum of monopolistic competitive firms in both countries. We use $j \in [0,1]$ to index intermediate good firms as well as their products and prices. Final goods firms purchase domestically produced intermediate goods, $A_t(j)$, imported intermediate goods, $B_t(j)$ and domestically produced non-traded goods, $N_t(j)$. Taking their domestic currency prices $P_{A,t}(j)$, $P_{B,t}(j)$ and $P_{N,t}(j)$ as given, final good firms operate under perfect competition. A representative final good firm minimizes expenditures in order to meet the demand for final goods subject to an aggregation technology. Letting C_t, X_t and G_t denote consumption, investment and government spending, respectively and κV_t a resource loss arising from labor market frictions discussed below, the constraints of the final good firms can be stated as follows

$$\begin{aligned} F_t &= C_t + X_t + G_t + \kappa V_t \\ &= \left\{ \begin{array}{c} \upsilon^{\varrho+1} \left[\omega^{\varsigma+1} \left(\int_0^1 A_t(j)^{-\varepsilon} dj \right)^{\frac{\varsigma}{\varepsilon}} + (1-\omega)^{\varsigma+1} \left(\int_0^1 B_t(j)^{-\varepsilon} dj \right)^{\frac{\varsigma}{\varepsilon}} \right]^{\frac{\varrho}{\varsigma}} \\ + (1-\upsilon)^{\varrho+1} \left(\int_0^1 N_t(j)^{-\varepsilon} dj \right)^{\frac{\varrho}{\varepsilon}} \end{array} \right\}^{-\frac{1}{\varrho}}, \end{aligned} \quad (1)$$

where $\sigma \equiv (1+\varsigma)^{-1}$ measures the trade price elasticity of substitution, $\epsilon \equiv (1+\varepsilon)^{-1}$ denotes the elasticity of substitution between the two intermediate goods of the same type and $\eta = (1+\varrho)^{-1}$

measures the elasticity of substitution between tradeable and non-tradeable goods. The parameters ν and ω are the weights of traded and imported goods in final and traded goods, respectively.
Expenditure minimization implies that the price final goods is given by:

$$P_{F,t} = \left[\upsilon {P_{T,t}}^{1-\eta} + (1-\upsilon)\, {P_{Nt}}^{1-\eta}\right]^{\frac{1}{1-\eta}},\ \text{with}\ P_{T,t} = \left[\omega {P_{A,t}}^{1-\sigma} + (1-\omega)\, {P_{B,t}}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \quad (2)$$

where

$$P_{U,t} = \left(\int_0^1 P_{U,t}(j)^{1-\epsilon} dj\right)^{\frac{1}{1-\epsilon}} \text{ for } U \in A, B, N. \quad (3)$$

We discuss below how prices of intermediate goods, $P_{U,t}(j)$, are determined. The index U is used to denote traded domestically produced, imported, or non-traded intermediate goods. Expenditures minimization by final good firms at home and abroad gives rise to demand for domestically produced intermediate goods of the tradeable type, $A_t(j)$, and $A_t^*(j)$, respectively

$$A_t(j) = \upsilon \left(\frac{P_{A,t}(j)}{P_{A,t}}\right)^{-\epsilon} \left(\frac{P_{A,t}}{P_{T,t}}\right)^{-\sigma} \left(\frac{P_{T,t}}{P_{F,t}}\right)^{-\eta} (1-\omega)F_t \quad (4)$$

$$A_t^*(j) = \upsilon \left(\frac{P^*_{A,t}(j)}{P^*_{A,t}}\right)^{-\epsilon} \left(\frac{P^*_{A,t}}{P^*_{T,t}}\right)^{-\sigma} \left(\frac{P^*_{T,t}}{P^*_{F,t}}\right)^{-\eta} \omega F_t^*. \quad (5)$$

For non-traded goods, $N_t(j)$, we have

$$N_t(j) = (1-\upsilon) \left(\frac{P_{N,t}(j)}{P_{N,t}}\right)^{-\epsilon} \left(\frac{P_{N,t}}{P_{F,t}}\right)^{-\eta} F_t. \quad (6)$$

3.2 Intermediate goods firms

The production of intermediate goods is governed by the following production function

$$Y_{Ut}(j) = Z_{U,t} K_{U,t}(j)^{\theta} L_{U,t}(j)^{1-\theta}, \quad (7)$$

where $Z_{U,t}$ denotes technology in sector $U \in \{A, N\}$. $K_{U,t}(j)$ and $L_{U,t}(j)$ measure the amount of capital and labor employed by firm j, respectively. Capital and labor inputs are not firm specific and can be adjusted freely in each period such that marginal costs for each firm within each sector are given by

$$MC_{U,t} = \frac{P_{L,t} L_{U,t}}{(1-\theta) Y_{U,t}} = \frac{R_{U,t} K_{U,t}}{\theta Y_{U,t}}, \quad (8)$$

where $P_{L,t}$ and $R_{U,t}$ denote the price of labor and capital, respectively—note that only the latter is sector specific.
We assume that price setting is constrained exogenously by a discrete time version of the mechanism suggested by Calvo (1983). Each firm has the opportunity to change its price with a given probability $1-\xi_U$. With respect to firms which produce traded intermediate goods, we assume that prices are set

in buyer's currency. As a result, intermediate goods producers' problems differ depending on whether they produce traded or non-traded goods.

Consider first the problem of a generic firm in the non-traded goods sector. We assume it sets its prices $P_{N,t}(j)$ in order to maximize the expected discounted value of net profits:

$$\max \sum_{k=0}^{\infty} (\xi_N)^k E_t \rho_{t,t+k} N_{t,t+k}(j) \left[P_{N,t}(j) - MC_{N,t+k} \right] / P_{F,t+k}. \tag{9}$$

subject to demand functions defined by (6), the production function (7), and marginal costs (8). $N_{t,t+k}(j)$ denotes demand in period $t + k$ given that prices have been last adjusted in period t. $\rho_{t,t+k}$ is the pricing kernel used to discount profits. As firms are owned by households, we assume that $\rho_{t,t+k} = \frac{\beta_{t+k} U_{C,t+1}}{\beta_t U_{C,t}}$, where β_t and $U_{C,t}$ denote discount factor and marginal utility of households, respectively. We discuss the household problem in detail below.

Traded good firms set possibly different prices for the domestic and foreign market. We assume that the frequency of price adjustment is determined by the destination market, not by the origin of the product.Domestic prices $P_{A,t}(j)$ are set in order to maximize the expected discounted value of net profits

$$\max \sum_{k=0}^{\infty} (\xi_A)^k E_t \rho_{t,t+k} A_{t,t+k}(j) \left[P_{A,t}(j) - MC_{A,t+k} \right] / P_{F,t+k}, \tag{10}$$

subject to demand functions defined by (4), the production function (7), and marginal costs (8). Foreign prices $P^*_{A,t}(j)$ are set to maximize the following expression

$$\max \sum_{k=0}^{\infty} (\xi_A^*)^k E_t \rho_{t,t+k} A^*_{t,t+k}(j) \left[S_{t+k} P^*_{A,t}(j) - MC_{A,t+k} \right] / P_{F,t+k}, \tag{11}$$

subject to demand functions defined by (5), the production function (7), and marginal costs (8). ξ_A^* measures the probability that a price remains in effect in the foreign market and S_t is the nominal exchange rate.

3.3 Labor market firms

We introduce a non-Walrasian labor market by assuming that intermediate goods firms purchase labor services from labor market firms. Aggregate demand for the labor good is given by $L_t = L_{A,t} + L_{N,t}$. We view a labor market firm as a match between a single worker and a single firm that produce the labor good according to a homogeneous production function:

$$l_{i,t} = H_{i,t}. \tag{12}$$

The perfectly competitive labor good sector aggregates the production of the continuum of matches of individual workers to the final labor market good: $L_t = \int_0^{1-O_t} l_t(i) di = (1 - O_t) H_t$ where O_t

denotes the measure of workers that are currently unemployed. We consider a symmetric equilibrium where all matches provide the same amount of labor and therefore drop the i subscript from now on. Real profits of a single firm Λ_t and the surplus of the match from the workers perspective $V_{eu,t}$ are given by

$$\Lambda_t = \frac{P_{L,t}H_t - W_tH_t}{P_{F,t}} + E(1-\lambda)\rho_{t,t+1}\Lambda_{t+1} \quad (13)$$

$$V_{eu,t} = \frac{W_tH_t(1-\tau_t) - b}{P_{F,t}} - \frac{\vartheta}{\frac{\partial U}{\partial C_t}}\frac{H_t^{1+\mu}}{1+\mu} + E\rho_{t,t+1}(1-\lambda-\pi_{ue,t})V_{eu,t+1} \quad (14)$$

where λ is the exogenous destruction rate of the match. Note that in a bargaining model productivity and wages do not equalize. The wedge, i.e. profits of the firm, determine the amount of vacancies posted, and is described below. We draw on Hall and Milgrom (2008) and Jung and Kuester (2008) by assuming that the threat point of the worker in the bargaining process is not given by the value of being unemployed (Nash-bargaining), but by the cost of delaying the bargaining for one period. This allows us to use the static bargaining solution given by

$$\frac{\vartheta H_t^{\mu}}{\frac{\partial U}{\partial C_t}} = \frac{P_{L,t}}{P_{F,t}}(1-\tau_t) \quad (15)$$

for hours worked and

$$W_t = \Omega P_{L,t} + (1-\Omega)\left[\frac{P_{L,t}}{1+\mu} + \widetilde{b}\overline{W}\right] \quad (16)$$

for wages. It is common in these types of models that wages are a convex combination of productivity and the outside option given by the saved amount of leisure and an abstract strike value $\widetilde{b}$ (expressed in percentage of average hourly wages $\overline{W}$) that would be delivered to the worker by her union in case the bargaining breaks down (which never occurs in equilibrium and is therefore unobserved), see Jung and Kuester (2008) for a discussion. We use this value as a mechanism to resolve the Shimer-puzzle without relaying on strong assumptions about the value of unemployment benefits as in Hagedorn and Manovskii (2008).[12] Note that, by setting $\widetilde{b} = 0$, we can reproduce cyclical properties of a Walrasian labor market where wages perfectly co-move with productivity.

To close the labor market we assume a standard homogenous matching function:

$$M_t = V_t^{\Psi}O_t^{1-\Psi} \quad (17)$$

$$\frac{M_t}{V_t} \equiv \pi_{f,t} = s_1\left(\frac{V_t}{O_t}\right)^{\Psi-1} \quad (18)$$

$$\frac{M_t}{O_t} \equiv \pi_{ue,t} = s_2\left(\frac{V_t}{O_t}\right)^{\Psi}, \quad (19)$$

[12] The standard Nash-bargaining solution would deliver a similar wage equation if market tightness does not enter too strongly, but would require us to interpret b as unemployment benefits. In the present context, we interpret this value as an abstract entity that will be *set* to match the amount of unemployment volatility observed in the data. We therefore take an agnostic view on the debate between Hagedorn and Manovskii (2008) and Shimer (2005) and use this parameter to align the model and the data.

where M_t is the number of matches, V_t is the number of vacancies posted, Ψ measures the matching elasticity, and s_i is a scaling constant. $\pi_{f,t}$ denotes the probability of finding a worker from the firms' perspective, $\pi_{ue,t}$ is the probability of finding a job from the workers' perspective. The free entry condition insures that on average firms make no profits when posting a new vacancy:

$$\kappa = \pi_{f,t} E \rho_{t,t+1} \Pi_{t+1}. \tag{20}$$

Here κ are real posting cost denoted in terms of the consumption good. Finally the law of motion for the unemployment rate O_t is given by:

$$O_{t+1} = O_t(1 - \lambda - \pi_{ue}) + \lambda. \tag{21}$$

3.4 Households

A representative household allocates consumption expenditures on final goods, C_t, and supplies labor, H_t. Preferences are given by

$$\begin{aligned} & E_0 \sum_{t=0}^{\infty} \beta_t \left(\frac{C_t^{1-\gamma} - 1}{1-\gamma} - \vartheta \frac{H_t^{1+\mu}(1 - O_t)}{1+\mu} \right) \\ & \beta_0 = 1, \;\; \beta_{t+1} = \beta(C_t)\beta_t, \;\; \beta(C_t) = (1 + \psi C_t)^{-1}, \end{aligned} \tag{22}$$

where the function $\beta(C_t)$ ensures that the discount factor β_t increases in response to a rise in average consumption. This effect is not internalized by the household.[13] The parameter $\psi > 0$ determines the value of the discount factor in steady state. O_t denotes the measure of workers that are unemployed. Labor and capital are internationally immobile; households in each country own the capital stock: $K_{A,t}$ and $K_{N,t}$ are employed in the production of intermediate traded goods and non-traded goods, respectively. As in Christiano et al. (2005), we assume that it is costly to adjust the rate of investment. Specifically, we assume for the law of motion for capital in each sector

$$K_{U,t+1} \;\; = \;\; (1-\delta)K_{U,t} + F(X_{U,t}, X_{U,t-1}), \text{ with } F = \left[1 - \frac{\kappa}{2} \left(\frac{X_{U,t}}{X_{U,t-1}} - 1 \right)^2 \right] X_{U,t}, \tag{23}$$

where $\kappa \geq 0$ measures the extent of adjustment costs. Total investment expenditures are given by $X_t = X_{A,t} + X_{N,t}$.

As regards international financial markets, we only allow for trade in riskless bonds, Θ_t and Θ_t^* denominated in domestic and foreign currency, respectively. The budget constraint of the domestic household is given by

$$\begin{aligned} & (1-\tau_t)(W_t H_t (1 - O_t) + R_{A,t} K_{A,t} + R_{N,t} K_{N,t} + \Upsilon_t) + T_t - P_{F,t}(C_t + X_t) \\ = \;\; & R_t^{-1} \Theta_{t+1} + R_t^{*-1} S_t \Theta_{t+1}^* - \Theta_t - S_t \Theta_t^* \end{aligned} \tag{24}$$

[13]The assumption of an endogenous discount factors induces stationarity of the model in around a deterministic steady state, see Schmitt-Grohé and Uribe (2003) for more details.

where R_t and R_t^* denote domestic and foreign gross nominal interest rates. T_t measures transfers from the government and Υ_t denotes intermediate and labor market firms' profits. Households maximize (22) subject to (23) and (24).

Combining the first order conditions for domestic and foreign bond holdings gives rise to the uncovered interest rate parity condition: $R_{1t} = R_{2t} E_t \Delta S_{t+1}$. We assume, following Kollmann (2005), that there are disturbances to this condition in the following way

$$R_{1t} = R_{2t} E_t \Delta S_{t+1} \varepsilon_t^{UIP}, \tag{25}$$

where ε_t^{UIP} follows an exogenous process specified below. Assuming that such shocks characterize foreign exchange markets provides a convenient way to account for non-fundamental exchange rate volatility as documented, for instance, in Flood and Rose (1995).[14]

3.5 Market clearing, aggregation and definitions

In equilibrium firms and households maximize profits or utility for given initial conditions and government policies (specified below). In each sector, markets clear at the level of intermediate goods. As in Galí and Monacelli (2005), we define an index for aggregate output in each sector $Y_{A,t} \equiv \left(\int_0^1 Y_{A,t}(j)^{-\varepsilon} dj\right)^{\frac{1}{\varepsilon}}$ and $Y_{N,t} \equiv \left(\int_0^1 Y_{N,t}(j)^{-\varepsilon} dj\right)^{\frac{1}{\varepsilon}}$.[15] Substituting for $Y_{A,t}(j) = A_t(j) + A_t^*(j)$ and $Y_{N,t}(j) = N_t(j)$ in both expressions using the demand functions given by (4)-(6) gives the aggregate relationships

$$\begin{aligned} Y_{A,t} &= \upsilon \left[\left(\frac{P_{A,t}}{P_{T,t}}\right)^{-\sigma} \left(\frac{P_{T,t}}{P_{F,t}}\right)^{-\eta} (1-\omega) F_t + \left(\frac{P_{A,t}^*}{P_{T,t}^*}\right)^{-\sigma} \left(\frac{P_{T,t}^*}{P_{F,t}^*}\right)^{-\eta} \omega F_t^* \right] \\ Y_{N,t} &= (1-\upsilon) \left(\frac{P_{N,t}}{P_{F,t}}\right)^{-\eta} F_t. \end{aligned} \tag{26}$$

From the definition of marginal costs (8), we can write an intermediate good firms' production function as $Y_{U,t}(j) = K_{U,t}(j) R_{U,t} (\theta MC_{U,t})^{-1}$. Aggregation over firms gives $\int_0^1 Y_{U,t}(j) dj = K_t R_{U,t} (\theta MC_{U,t})^{-1}$ or, using again (8), we have for each sector

$$\zeta_{U,t} Y_{U,t} = Z_{U,t} K_{U,t}^{\theta} H_{U,t}^{1-\theta}, \tag{27}$$

where $\zeta_{U,t} \equiv \int_0^1 \frac{Y_{it}^U(j)}{Y_{it}^U} dj = \int_0^1 \left(\frac{P_{it}^U(j)}{P_{it}^U}\right)^{-\epsilon} dj$ provides a measure for output and price dispersion at the level of intermediate goods in each sector.

Market clearing on factor markets requires

$$L_{U,t} = \int_0^1 L_{U,t}(j) dj, \qquad K_{U,t} = \int_0^1 K_{U,t}(j) dj, \tag{28}$$

[14] Bacchetta and van Wincoop (2008) for example attribute deviations from UIP to infrequent foreign currency portfolio decisions, which can arise due to relatively small fees for managing foreign exchange positions.

[15] Similarly, defining $A_t^* \equiv \left(\int_0^1 A_t^*(j)^{-\varepsilon} dj\right)^{\frac{1}{\varepsilon}}$ provides a measure for total exports.

for all U and the asset market clears by Walras' law.

We define as a measure for real GDP

$$Y_t \equiv C_t + X_t + G_t + \kappa V_t + \frac{S_t P^*_{A,t}}{P_{F,t}} A^*_t - \frac{P_{B,t}}{P_{F,t}} B_t, \tag{29}$$

where exports and imports are defined as $A^*_t \equiv \left(\int_0^1 A^*_t(j)^{-\varepsilon} dj\right)^{\frac{1}{\varepsilon}}$ and $B_t \equiv \left(\int_0^1 B_t(j)^{-\varepsilon} dj\right)^{\frac{1}{\varepsilon}}$, respectively. Using (5) and the corresponding domestic counterpart to substitute for $A^*_t(j)$ and $B_t(j)$ gives in aggregate terms

$$A^*_t = \upsilon \left(\frac{P^*_{A,t}}{P^*_{T,t}}\right)^{-\sigma} \left(\frac{P^*_{T,t}}{P^*_{F,t}}\right)^{-\eta} \omega F^*_t, \quad B_t = \upsilon \left(\frac{P_{B,t}}{P^*_{T,t}}\right)^{-\sigma} \left(\frac{P_{T,t}}{P_{F,t}}\right)^{-\eta} (1-\omega) F_t. \tag{30}$$

Finally, we define the real exchange rate and the trade balance as follows

$$RX_t \equiv \frac{S_t P^*_{F,t}}{P_{F,t}}, \quad NX_t \equiv \frac{S_t P^*_{A,t} A^*_t - P_{B,t} B_t}{P_{F,t} Y_t}. \tag{31}$$

3.6 Government policies

We close the model by specifying feedback rules characterizing monetary and fiscal policies. Regarding the latter, we assume that government spending reacts to lagged output growth (due to lags in the implementation of budget adjustments) and its own past value:

$$G_t = (1-\rho_g) G + \rho_g G_{t-1} + \phi \frac{G}{Y} (Y_{t-1} - Y_{t-2}) + \varepsilon_{g,t}, \tag{32}$$

where variables without time-subscript refer to steady state values; $\varepsilon_{g,t}$ denotes i.i.d. government spending shocks. Note that while this rule is fairly simple, it strikes us as a convenient approach to capture a possible change in the endogenous conduct of fiscal policy in Europe. We consider a response to lagged rather than current output growth for reasons discussed in the calibration section.[16]

Monetary policy is characterized by an interest rate feedback rule of the following type

$$\log(R_t) = \rho \log(R_{t-1}) + (1-\rho) E_t \left[\varpi + \varphi_\pi \Pi_{t-1,4} + \frac{\varphi_y}{Y}(Y_t - Y_{t-1}) + \varphi_r \log(R^*_t)\right] + \varepsilon_{r,t} \tag{33}$$

where $\Pi_{t,i} \equiv P_{F,t+i}/P_{F,t} = \prod_{j=t}^{i} \Pi_{t,j}$ such that $\Pi_{t-1,4}$ denotes four quarter cumulated future inflation (of final goods). $\varepsilon_{R,t}$ is an i.i.d. shock to monetary policy. The coefficients φ_π, φ_y and φ_r determine how interest rates are adjusted in response to expected inflation, output growth and foreign interest rates. They may take different values in home and abroad. Furthermore, we allow innovations to government spending and the interest rate to be correlated across countries as we discuss below. Note that monetary policy rules of this type have been shown to provide a good description of monetary policy in Europe, see, for instance, Clarida et al. (1998).

[16] We leave more sophisticated specifications—notably by considering debt—for future research (recall that in the present version of the model Ricardian equivalence holds and the time path of taxes/government debt is irrelevant for the allocation for any given stream of government spending).

4 Model simulation

To solve the model, we derive the first order conditions of households and firms. We use a first-order approximation to these equilibrium conditions around a deterministic steady state to study the properties of the model numerically. Before discussing the results, the following subsection provides the rationale for our parameter choices.

4.1 Calibration

We calibrate our two-country model so as to capture key features of the German economy relative to EA6. To do so we rely mainly on our own estimates as well as on previous studies which have established values for key parameters. We distinguish three sets of parameters: 1) parameters characterizing preferences and technologies; 2) parameters capturing the behavior of monetary and fiscal policy and 3) parameters governing the exogenous shock processes. We discuss each group in turn.

Preferences and Technology The first set of parameter values is displayed in table 2. Those parameters are unchanged across various simulations of the model under the presumption that these parameters are sufficiently 'deep' so as to be invariant with respect to changes in the policy regime. Our parameter choice is as follows. We set $\mu = 2$, implying a Frisch wage elasticity of labor supply of 0.5, see Domeij and Flodén (2006). Furthermore, we assume that $\gamma = 1$, consistent with balanced growth, and set θ, which determines the capital share in production, to 0.30 for all sectors. The depreciation rate is $\delta = 0.015$, resulting from an average investment to output ratio of 0.186 for Germany observed in our sample period.[17] Capital adjustment costs κ are set to 2, allowing us to match an average of the volatilities of investment relative to output for Germany and EA6, reported in table 4 below.

Regarding trade price elasticities, we assume $\sigma = 0.9$ which corresponds to the estimate reported in Heathcote and Perri (2002). Following Stockman and Tesar (1995) we set $\eta = 0.44$. We pin down price rigidities on the basis of the frequency of price changes reported in Dhyne et al. (2006). Specifically, we calculate the corresponding values for ξ_T and ξ_N in Germany and EA6. For the tradable sector, data for non-energy industrial goods is used, while the non-tradable sector is calibrated using the numbers for services. Our aggregation follows Baharad and Eden (2004).[18] As often found in the literature, prices in the non-tradable sector are less frequently changed than in the tradable sector.

[17] If not stated differently, data used stem from the Economic Outlook in OECD (2008a).

[18] We assume that price durations for domestically produced traded intermediate goods and for imports are the same within each country (i.e. $\xi_A^* = \xi_B$ and $\xi_A = \xi_B^*$); hence there is one value for price stickiness for each sector (ξ_T and ξ_N) in each country. The aggregation uses the mean of the time-varying trade weights used to construct the EA6 aggregate. Weights are adjusted for the fact that data for Ireland is missing.

Table 2: Parameter values of theoretical economy: structural parameters

Symmetric parameters		Value		Calibration target / source	Value	
Inverse Frisch	μ	2.00		Domeij and Flodén (2006)		
Risk aversion	γ	1.00		Balanced growth		
Capital share	θ	0.30		Wage share	0.700	
Depreciation rate	δ	.015		St. st. X/Y:	0.186	
Adjustment costs	κ	2.00		Std. Dev. X/Y	Table 4	
Price elasticity	ϵ	10.0		St. st. markup:	0.110	
Trade price elasticity	σ	0.90		Heathcote and Perri (2002)		
Non-traded price elast.	η	0.44		Stockman and Tesar (1995)		
Separation rate	λ	.045		IAB data		
Bargain parameter	Ω	0.50		Shimer (2005)		
Matching elasticity	Ψ	0.50		Shimer (2005)		
Asymmetric parameters		Germany	EA6	Calibration target / source	Values	
Price rigidities tradables	ξ_T	0.84	0.72	Price duration indust. goods:	6.173	3.569
Price rigidities non-tradables	ξ_N	0.87	0.82	Price duration services:	7.752	5.595
Unemployment-benefits	$\widetilde{b}$	0.64	0.63	Std. Dev. O/Y:	Table 4	
Matching constant	s	0.80	0.82	Normalization V/O:	1.000	1.000
Vacancy posting	κ	0.09	0.34	St. st. unemployment:	0.075	0.096
Elast. of discount factor	ψ	.015	.015	K/Y:	11.96	11.96
Weight traded goods	ν	0.38	0.36	Production Manuf./Services:	0.621	0.537
Weight domestic goods	ω	0.86	0.80	Import & exp. share Germany:	0.053	0.067

Notes: Parameters remain unchanged across simulations, see main text for discussion of target values. Price durations are measured in quarters.

The treatment of the labor market follows the recent literature on resolving the Shimer (2005) puzzle.[19] Our model period is one quarter, which typically causes some problems due to the high job-finding probability estimated for the US. However, for Germany, the average job-finding probability is around 10% per month, which allows us to interpret our job-flow equations on a quarterly frequency. To pin down vacancy posting costs, we target the average unemployment rate, which is 7.5% for Germany and 9.6% for EA6 in our sample period.[20] We use an estimate on firing/separation rates for Germany, which are roughly 4.5% on quarterly frequency (much lower than in the US), a normalization of the number of vacancy posted and a typical estimate for the matching elasticity to determine all endogenous labor market variables.[21] Note that the model has basically one free parameter that can be used to resolve the Shimer-puzzle.[22] We target unemployment volatility by adjusting the unemployment benefit level, leaving the bargaining power at an equal sharing rule. We

[19]See Jung and Kuester (2008) for details or, among many others, Costain and Reiter (2005), Hagedorn and Manovskii (2008) and Jung (2008).

[20]Note that in general equilibrium calibration targets may and typically depend on values of several parameters. Nevertheless it is possible to pin down specific parameter values by focusing on one target value at a time.

[21]See Petrongolo and Pissarides (2001) for the value of the matching elasticity and Bachmann (2005) for the firing/separation rates. The average job finding rate in equilibrium is derived from the latter.

[22]Either the outside option or the bargaining power, which are not separately identifiable in our framework as discussed above due to the particular bargaining assumption entertained.

thereby introduce the amount of wage-stickiness necessary to generate the friction which drives our endogenous propagation.[23] Note that as a result of lower unemployment volatility in EA6 relative to Germany labor market frictions turn out to be asymmetric across countries.

We furthermore target a steady-state quarterly capital to output share of 11.96, leading to an elasticity of the endogenous discount factor of $\psi = 0.0148$ in Germany and 0.0147 in EA6.[24] To pin down the weight of traded goods in total output ν, we use the average ratio of real output of the manufacturing sector to real output of services. This ratio is 0.62 for Germany and 0.54 for the EA6 aggregate, implying values for ν of 0.38 and 0.35 for Germany and EA6, respectively.[25] Given the parameter ν, the steady-state import- and export shares are governed by ω, the weight of domestically produced goods in the aggregate of traded goods in total output. For our sample (1985–2007), we find that German imports from EA6 countries average at 5.32% of GDP, while German exports to EA6 were 6.67%. The implied values for ω for Germany and EA6 are 0.89 and 0.86, respectively. Clearly, in the medium to long term the import-GDP ratio is likely to depend on the nominal exchange rate regime. Yet in what follows we abstract from these changes, since they turned out to be of second order importance for business cycle dynamics.[26]

Policy rules The behavior of fiscal and monetary policy is characterized by feedback rules (32) and (33). We estimate both rules for Germany and EA6 to pin down parameter values. First, regarding the monetary policy rule, drawing on Clarida et al. (1998), we employ a three-stage least squares approach, using four lags of German and foreign (EA6) CPI-inflation, the short-term interest rate, the oilprice, and output growth as instruments in the first step of the procedure. For the PreEMU sample (1985–1996) we estimate rules for Germany and EA6. For the EMU sample (1999–2007) we estimate a common (ECB) rule. In the former case, we estimate both rules simultaneously and allow for possible correlation of monetary policy shocks. While we restrict the parameter φ_r to be zero for Germany, we estimate it for EA6. Results are reported in the second panel of table 3. For Germany we find considerable interest rate smoothing and a fairly strong response of interest rates to inflation and economic activity, measured by output growth. For EA6, we find less strong responses to both variables, but a considerable response to German interest rates.

[23]Incidently the implied benefit level turns out to be, almost precisely, the official net replacement rate in Germany, though we neglected many potentially important determinants of the outside option like home-production and the like.

[24]The capital to output share is the average share for the period 1985–2007 reported by the annual European Commission DG ECFIN (2008) database for the euro area.

[25]The data used stems from the STAN database (OECD 2008b). Averages of yearly data, where available, were taken for 1984–2007. The weights used for aggregation are the means of the time-varying trade weights used to construct the EA6 aggregate. Weights were adjusted for the missing values for Portugal, Spain, and Ireland. Calculation of the same statistics with nominal data, where only Ireland is missing, gives almost identical values.

[26]In fact, following Rose (2000), the importance of the exchange rate regime for trade has been highlighted in a series of papers. In our context changes in import share across samples turned out to be sufficiently small so as to have an negligible effect on business cycle dynamics.

Second, we obtain parameters for the fiscal rules (32) relying on OLS. Our specification of fiscal policy whereby government spending responds only to past output growth avoids a possibly simultaneity problem.[27] We thereby implicitly adopt the identification assumption frequently employed in the empirical literature on the fiscal transmission mechanism inspired by Blanchard and Perotti (2002). We estimate different fiscal rules for both sample periods, because EMU may have induced systematic changes in the conduct of fiscal policies. Results are reported in the first panel of table 3 for both sample periods. We find quite persistent processes for government spending for both sample periods, notably for EA6. In the PreEMU period fiscal policy appears more countercyclical, suggesting that fiscal coordination under EMU, notably the Stability and Growth Pact, may have limited the flexibility of fiscal policy to a certain degree.[28]

Forcing processes In estimating the UIP shocks we follow Kollmann (2005). Rewriting (25) in logs without expectations yields

$$\ln(\hat{\varepsilon}_t^{UIP}) \equiv \ln(R_{1t}) - \ln(R_{2t}) - \ln(\Delta S_{t+1}),$$

which allows us to write

$$\ln(\varepsilon_t^{UIP}) = E_t \ln(\hat{\varepsilon}_t^{UIP})$$

up to a first-order approximation. The UIP shocks $\ln(\varepsilon_t^{UIP})$ are estimated by regressing $\ln(\hat{\varepsilon}_t^{UIP})$ on its own four lags and other variables known at time t: contemporaneous values and four lags of output, inflation, and the interest rate—each for Germany and the rest of Europe in the period 1985-1996. Finally, we assume that $\ln(\varepsilon_t^{UIP})$ follows an AR(1) process which we estimate on the fitted values. Results are reported in the third block of table 3. According these numbers, predictable deviations from the uncovered interest rate parity are rather shortlived, compared with Kollmann's estimate of $\rho^{UIP} = 0.5$ for the US.

Regarding the exogenous technology process governing intermediate goods production, we assume that deviations from the steady state follow an AR(1) process. To pin down parameter values, we rely on standard procedures based on Solow residuals. We use data for the manufacturing sector sector where available (otherwise we employ data for the industrial sector) as a proxy for the traded goods sector, and the service sector for the non-traded goods sector. We estimate a SUR regression, allowing for contemporaneous correlation of the innovations both across sectors and countries. We estimate the shock process using the full sample period 1985–2007 assuming that the exogenous process of technology is stable across exchange rate regimes. Results are reported in the last block of table 3, suggesting considerable autocorrelation as well as some correlation of innovations across

[27] Note that we also include a linear trend in the regression as we do not use filtered data.

[28] Galí and Perotti (2003) fail to detect such an effect when comparing a pre-Maastricht period (1980–91) to a post-Maastricht period which ends, however, in 2002.

Table 3: Parameter values of theoretical economy: policy rules & shock processes

		PreEMU		**EMU**	
		Germany	**EA6**	**Germany**	**EA6**
Government spending					
Smoothing	ρ_g	0.60	0.99	0.58	0.87
Output growth	ϕ	-0.30	-0.07	-.003	-0.02
Var.-cov. matrix of government innov.		$\begin{bmatrix} 1.50 & 0.07 \\ 0.07 & 0.13 \end{bmatrix} * 10^{-4}$		$\begin{bmatrix} 0.71 & 0.07 \\ 0.07 & 0.43 \end{bmatrix} * 10^{-4}$	
Monetary policy					
Smoothing	ρ_r	0.88	0.67	0.62	
Inflation	φ_π	2.28	0.99	1.68	
Output growth	φ_y	0.37	0.01	0.78	
Germ. int. rate	φ_{i_G}	$--$	0.69	$--$	
Var.-cov. matrix of monetary innov.		$\begin{bmatrix} 0.88 & 0.20 \\ 0.20 & 1.80 \end{bmatrix} * 10^{-6}$		$3.77 * 10^{-6}$	
UIP process					
AR(1)-coeff UIP shock	ρ^{UIP}	0.35		-	
UIP shock variance	$\sigma^2_{\nu^{UIP}}$	$1.90*10^{-4}$		-	
Technology process		**Germany**		**EA6**	
AR(1)-coeff. techn. traded		0.95		0.93	
AR(1)-coeff. techn. non-traded		0.97		0.98	
Var.-covar. matrix of technology innovations		$\begin{bmatrix} 1.36 & 0.18 & 0.38 & 0.08 \\ 0.18 & 0.39 & 0.02 & 0.01 \\ 0.38 & 0.02 & 0.78 & 0.08 \\ 0.08 & 0.01 & 0.08 & 0.11 \end{bmatrix} * 10^{-4}$			

Notes: parameter values for monetary and fiscal policy are adjusted for PreEMU and EMU scenario according to estimated policy rules, see main text for discussion.

sectors and countries. Solow residuals in the tradable sector seem to be less autocorrelated than in the non-tradable sector, but are also subject to more volatile shocks.

4.2 Model performance

We now turn to the question whether the model is able to account for European business cycles—before and under EMU. We therefore calibrate the model to account for two scenarios. First, under 'PreEMU' both countries are characterized by distinct money policy rules as reported in the left columns of the second panel of table 3. The values for the parameters which govern the fiscal rules are also reported in the upper panel. We assume that there are shocks to technology in both sectors and countries, as well as UIP shocks and shocks to the policy functions.

Second, under 'EMU' there is a common monetary policy characterized by the parameter values reported in the right column of the second panel of table 3. We also assume different parameters for the fiscal rules according to our estimates reported in that table. In terms of shocks, we assume that the process governing technology shocks is unchanged across exchange rate regimes, but allow for changes in the data generating process of monetary and fiscal policy shocks, again in line with our estimates reported above. There are no UIP shocks under 'EMU'. Deep parameters, displayed in table 2, are assumed to be constant across calibrations.

In each case we draw from the the assumed set of shocks and generate time series of 52 observations, corresponding to the length of our PreEMU sample. After applying the HP-filter with a smoothing parameter of 1600, we compute the moments of interest and report averages over 100 simulations. We compare the model predictions for those moments which we have discussed above. The predictions for the home country are measured up against German data, the predictions for the foreign economy compared with data for EA6.

Results are reported in table 4. In the left panel, we list the empirical moments for Germany and EA6. The first and the second column replicate the values for the PreEMU and EMU period shown in table 1.[29] In a third column we report the difference between both period, i.e. we subtract the value for the PreEMU period from the value of the EMU period. In the right panel, we report the corresponding statistics obtained from simulating our model, where domestic (home) and foreign variables serve as the theoretical counterpart to the observations for Germany and EA6, respectively.

In the upper two panels, we focus on the volatility of macroeconomic aggregates as well as on the volatility of unemployment and inflation. In terms of absolute volatility as measured by the standard deviation of output, the model predicts 80 percent or more of the actual output volatility. In accordance with the data, the model predicts a decline in output volatility, but less so for EA6. Yet the actual decline in output volatility may be unrelated to the euro to the extent that it can be observed in

[29]Data for EA6 is only listed in table 4 for reasons of space.

Table 4: Model performance

	Data			Model		
	PreEMU	EMU	Δ	PreEMU	EMU	Δ
Germany/Home						
100*std(y)	1.30	1.03	-0.27	1.11	0.85	-0.26
std(c)/std(y)	0.68	0.76	0.08	0.83	0.83	0.01
std(x)/std(y)	2.31	3.40	1.09*	2.84	2.85	0.02
std(g)/std(y)	1.04	0.90	-0.14*	1.12	1.04	-0.08
std(u)/std(y)	9.18	7.32	-1.68	9.04	9.39	0.35
std(π)/std(f)	0.22	0.30	0.08	0.05	0.09	0.04
EA6/Foreign						
100*std(y)	1.07	0.70	-0.37*	0.85	0.73	-0.12
std(c)/std(y)	0.92	0.81	-0.11	0.79	0.70	-0.09
std(x)/std(y)	3.72	3.58	-0.14	2.82	3.07	0.25
std(g)/std(y)	0.72	0.59	-0.13	0.49	0.33	-0.16
std(u)/std(y)	4.87	6.07	1.20	5.30	6.02	0.72
std(π)/std(f)	0.25	0.49	0.24*	0.09	0.12	0.03
Trade						
std(rx)/std(y)	2.48	0.34	-2.14*	1.89	0.31	-1.58
std(nx)/std(y)	0.34	0.36	0.02	0.12	0.04	-0.09
Cross-country						
corr(y, y^*)	0.42	0.85	0.43*	0.52	0.76	0.25
corr(c, c^*)	0.36	0.62	0.26	0.43	0.78	0.35
corr(x, x^*)	0.58	0.85	0.27*	0.45	0.52	0.06
corr(g, g^*)	0.35	-0.10	-0.45*	0.13	0.06	-0.07
corr(u, u^*)	0.73	0.83	0.10	0.57	0.64	0.07
corr(π, π^*)	0.49	0.35	-0.14	0.44	0.20	-0.24

Notes: statistics are computed on actual (simulated) time series for Germany (home country) and EA6 (foreign country) after applying the HP-filter. First panel: standard deviations for Germany/home country; second panel: EA6/foreign country; third panel: standard deviation of real exchange rate and trade balance of Germany (home country) relative to EA6 (foreign country); lower panel cross-country correlation for variables in Germany (home country) and EA6 (foreign country). PreEMU and EMU periods cover 1985–1996 and 1999–2007, respectively. Δ-column measures difference between PreEMU and EMU period.

non-EMU countries as well.

In terms of relative volatilities, the model somewhat overpredicts the volatility of consumption in Germany and underpredicts it for EA6. The same holds for government spending. The volatility of inflation is underpredicted in both case. Qualitatively the model matches the predictions for the 12 changes in both countries except for the decline in unemployment volatility in Germany and investment volatility in EA6 which the model fails to predict. Note that the volatilities of investment and unemployment *per se* have served as a calibration target and may therefore not be used to evaluate the model's performance.[30]

In the third panel of table 4 we assess the model predictions for the volatility of the real exchange rate (rx) and the trade balance (nx) (relative to output) for Germany relative to its trading partners comprised in our EA6 aggregate. We find that predictions not only match the volatility of the real exchange rate fairly well, but also its substantial decline under EMU. It may be noteworthy to stress that while we allow for UIP shocks in an attempt to account for real exchange rate volatility, the volatility of the real exchange rate did not serve as a calibration target. Rather we where specifying the process for UIP shocks on the basis of our estimates discussed above. Below, we give a more detailed account of the exact contribution of UIP shocks to the volatility of real exchange rates. The model is somewhat less successful in predicting the volatility of the trade balance; it also incorrectly predicts a declining volatility under EMU.

In the last panel, we compare cross-country correlation of macroeconomic aggregates in Germany and EA6. The model correctly predicts a positive cross-country correlation of output and all its components. In line with the data, it also predicts an increase in correlations under EMU for these variables, except for government spending, where the model correctly predicts a decline in the cross-country correlations. Similarly, the model delivers fairly accurate prediction for the cross-country correlation of unemployment and inflation, both regarding the absolute value and the change under EMU relative to the PreEMU period.

Overall, we find that the model performs well in predicting key features of the data. Despite some shortcomings in specific dimensions, the model is able to account for three key observations regarding European business cycles before and under EMU: 1) the volatility of the real exchange rate is substantially reduced under EMU; 2) there is some increase in cross-country business cycle correlation measured by output, but less correlation of government spending; 3) the volatility of macroeconomic aggregates is largely unchanged across the two sample periods.

5 Understanding (changes in) European business cycles

Given that the model is able to replicate key features of the data, both for the PreEMU and the EMU period, it is possible to provide a structural analysis of the the observed changes in European business cycles. Conceptually, it is helpful to distinguish between changes in business cycles due to changes in shock processes and changes in propagation as they are the result of relinquishing monetary policy independence under fixed exchange rates and other policy changes related to fiscal policy.

[30]In calibrating the model, we assume that the parameters governing these moments are deep and thus constant across policy regimes. They are set so as to match the average value of the targets across both periods and countries.

Table 5: Theoretical moments: sources of fluctuations

	PreEMU					EMU			
	ALL	TEC	MON	GOV	UIP	ALL	TEC	MON	GOV
Domestic									
100*std(y)	1.11	0.91	0.33	0.21	0.12	0.85	0.71	0.31	0.13
std(c)/std(y)	0.83	0.86	0.99	0.21	0.19	0.83	0.83	0.98	0.40
std(x)/std(y)	2.84	2.89	2.42	0.35	0.48	2.85	2.91	2.36	0.56
std(g)/std(y)	1.12	0.23	0.28	5.91	0.34	1.04	0.00	0.00	6.55
std(u)/std(y)	9.04	9.60	6.99	1.14	0.29	9.39	9.93	6.90	1.14
std(π)/std(y)	0.05	0.04	0.11	0.05	0.09	0.09	0.10	0.11	0.05
Foreign									
100*std(y)	0.85	0.76	0.26	0.03	0.10	0.73	0.68	0.15	0.03
std(c)/std(y)	0.79	0.78	1.11	4.17	0.19	0.70	0.68	1.22	1.15
std(x)/std(y)	2.82	2.91	1.92	2.50	0.32	3.07	3.17	1.40	1.66
std(g)/std(y)	0.49	0.07	0.07	16.48	0.07	0.33	0.02	0.02	7.05
std(u)/std(y)	5.30	5.59	2.67	3.27	0.82	6.02	6.24	1.61	2.86
std(π)/std(y)	0.09	0.04	0.26	0.19	0.22	0.12	0.11	0.31	0.17
Trade									
std(rx)/std(y)	1.89	0.52	0.93	0.07	16.95	0.31	0.37	0.12	0.08
std(nx)/std(y)	0.12	0.04	0.04	0.08	1.11	0.04	0.04	0.04	0.09
Cross-country									
corr(y, y^*)	0.52	0.56	0.25	-0.21	-1.00	0.76	0.73	0.78	-0.40
corr(c, c^*)	0.43	0.43	0.26	0.29	-0.98	0.78	0.73	0.89	0.87
corr(x, x^*)	0.45	0.47	0.15	0.86	-0.82	0.52	0.45	0.39	-0.09
corr(g, g^*)	0.13	0.45	0.28	0.08	-0.89	0.06	0.72	0.98	0.02
corr(u, u^*)	0.57	0.59	0.19	-0.51	-0.79	0.64	0.60	0.35	-0.35
corr(π, π^*)	0.44	0.41	0.66	0.91	-1.00	0.20	-0.04	0.93	0.64

Notes: for computation of statistics see table 4. Column 'ALL' shows results under the assumption that all shocks occur. 'TEC': only technology shocks; 'MON': only monetary policy shocks; 'GOV': only government spending shocks; 'UIP': only UIP shocks.

5.1 Shock processes

In a first step, we compare the predictions of the model while allowing for only one source of shocks at a time. In the left panel of table 5, we present results for the PreEMU scenario, in the right panel we consider the EMU scenario. In each case, column 'ALL' replicates results from table 4, i.e. the case when all shocks occur as in the baseline scenarios of the calibrated model. Columns 'TEC', 'MON', 'GOV' and 'UIP' display results for a counterfactual scenario where only either technology shocks (in the traded goods and the non-traded goods sector), monetary policy shocks, government spending shocks or UIP shocks occur. Recall that we assume that there are no UIP shocks under EMU.

We find that technology shocks are by far the most important source of business cycle fluctuations, in both scenarios. With only technology shocks, output volatility is about 80 percent of what is observed if all shocks occur. Consequently, technology shocks induce volatilities close to the all-shocks scenario. Importantly, however, technology shocks induces very little real exchange rate volatility (a well known finding from standard open economy RBC models, see, for instance, Backus et al. (1995)). Also government spending fluctuations are fairly limited if only technology shocks occur (this is particularly true for Germany under the EMU scenario, as a result of the output responsiveness of government spending being virtually zero in this case).

Monetary policy shocks, in turn, account for some output volatility, but more so for inflation. In the PreEMU period they are also a non-negligible source of real exchange rate volatility. This is different under EMU, where monetary policy shocks are symmetric by construction and therefore induce very little ral exchange rate movements and high co-movement of macroeconomic aggregates across countries.

Government spending shocks are also of limited importance for output fluctuations, but the key factor driving the volatility of government spending. Their contribution to the volatility of other variables is also limited, notably for the real exchange rate. Importantly, government spending shocks induce a slightly positive cross-country correlation of government spending in the PreEMU scenario. This correlation is about zero under EMU.

Regarding UIP shocks, we note that their importance for output volatility is much smaller than those of technology shocks. Yet UIP shocks induce considerable volatility of the real exchange rate: if UIP shocks were the only source of fluctuations, the volatility of the real exchange rate would be about 17 times the volatility of output. A second noteworthy observation regarding the counterfactual UIP-shocks-only-assumption is the cross-country correlation of macroeconomic aggregates: UIP shocks induce strongly negative co-movements across-countries.

In our view, the analysis of the role of different shocks provides a plausible picture regarding the source of business cycle fluctuations. It also gives some insight into possible causes in the change in European business cycles brought about (or not) by EMU. First, a common monetary policy and the absence of idiosyncratic monetary policy shocks potentially lowered real exchange rate volatility (finding 1) and increased the cross-country correlation of business cycles (finding 2). Second, the absence of UIP shocks works in the same direction, i.e. it is a crucial factor for the decline in exchange rate volatility and an increase in cross-country correlations. The decline in the cross-country correlation of government spending (finding 2) appears to be driven by the change in the shock process determining the exogenous innovations to government spending itself. Third, all three shocks are of limited importance in accounting for overall business cycle fluctuations. This, in turn, may be explain why measures of volatility seem to be little affected by EMU (finding 3).

5.2 Transmission

We now turn to the importance of the exchange rate regime per se in accounting for the propagation of various shocks originating in the domestic economy.[31] In figures 4 and 5 we display the impulse responses under the PreEMU (dashed lines) and EMU (solid lines) calibration. We display the responses of domestic and foreign output and its components (figure 4) as well as those of unemployment, inflation, the domestic real exchange rate and the trade balance (figure 5). In addition, we display in the lower panels of figure 5 the responses of a measure for the real long term interest rate (λ). It allows us to assess the monetary policy stance and hence to account for the effect of the exchange rate regime on the transmission mechanism.[32]

The responses to technology shocks are displayed in the first (shocks in the traded goods sector) and second (non-traded goods sector) column. Both shocks are expansionary: output, consumption and investment increase both at home and abroad. The pattern of adjustment of unemployment mirrors those of output. The responses in the foreign economy are contained relative to the adjustment observed in the domestic economy.

Comparing the adjustment under the PreEMU and the EMU calibration provides important insights into the role of the exchange rate in the international transmission mechanism. Responses to technology shocks are muted under EMU in the domestic economy, but amplified abroad—an exception is inflation and the real exchange rate. This reflects difference in the monetary stance under both exchange rate regimes. While technology shocks lower long term real interest rates (lower panels of figure 5), they do less so under EMU in the domestic economy, and more so abroad. This reflects a common monetary stance under EMU which aligns the adjustment process to domestic shocks in the domestic economy and abroad.

Next, we consider the effects of a contractionary monetary policy shock (third column). Under EMU we observe a more symmetric adjustment process, since a domestic monetary policy shock corresponds to a union-wide shock in this case. An immediate effect of the shock is the increase in the domestic long-term real rate, because of nominal rigidities. Output and its components contract and inflation falls. In the PreEMU scenario this results in a strong appreciation of the real exchange rate and a fall in foreign long-term real interest rates. This is consistent with the expansion observed in the foreign economy under the PreEMU calibration.

The responses to domestic government spending shocks are displayed in the fourth column of figures 4 and 5. An increase in government spending tends to increase domestic output and to lower domestic

[31] The effects of shocks originating the in foreign economy are not fully symmetric due to the asymmetries of the model, but we omit their discussion here to economize on our exposition.

[32] Specifically, we use the lagrange multiplier on the household budget constraint as a measure for long-term real interest rates. Abstracting from endogenous changes in the discount factor, it is equal to the sum of future real short rates up to a first order approximation of the model (this follows from iterating on the Euler equation for riskless bonds)

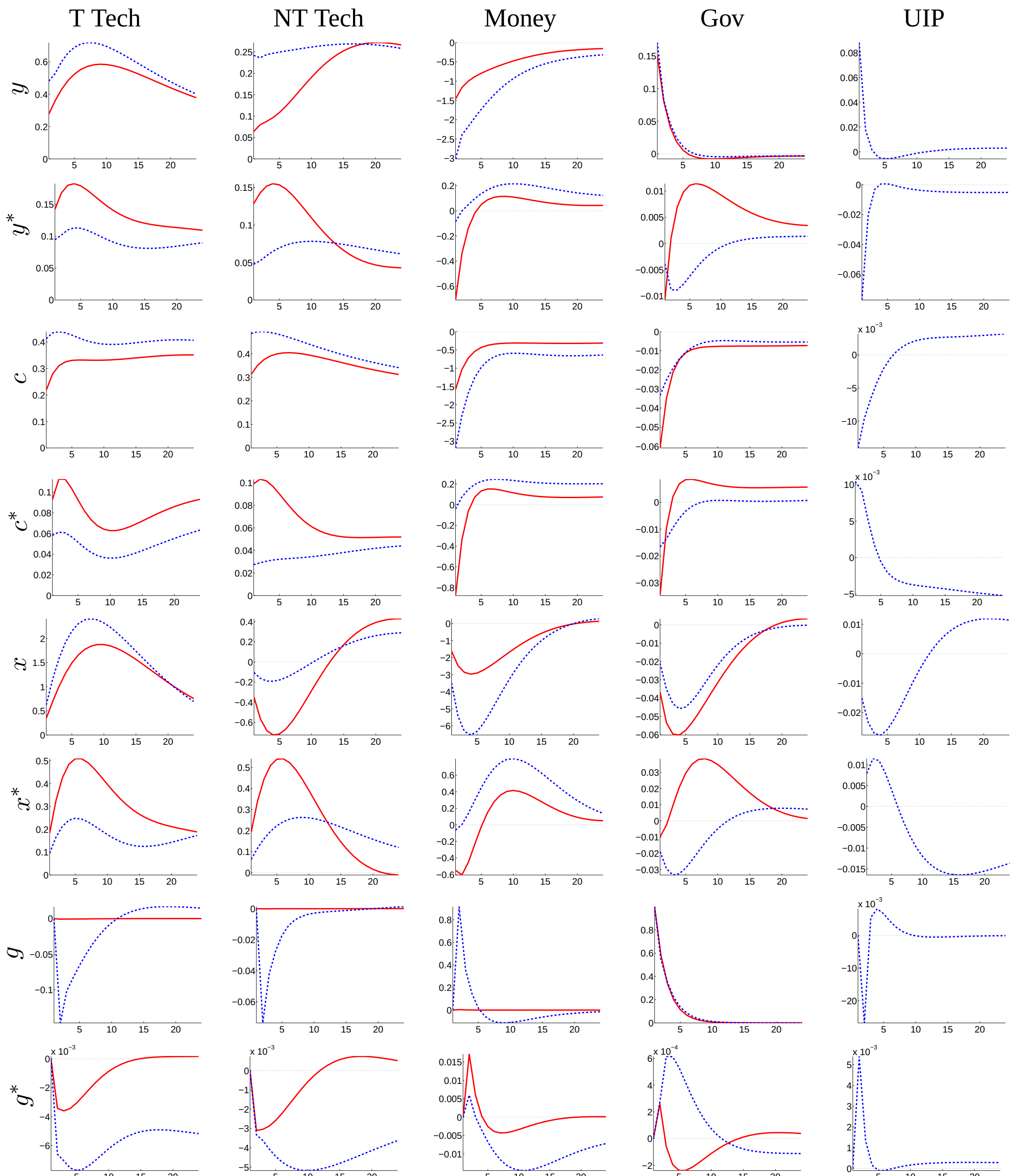

Figure 4: Shock transmission under PreEMU (dashed) and EMU (solid) scenario.

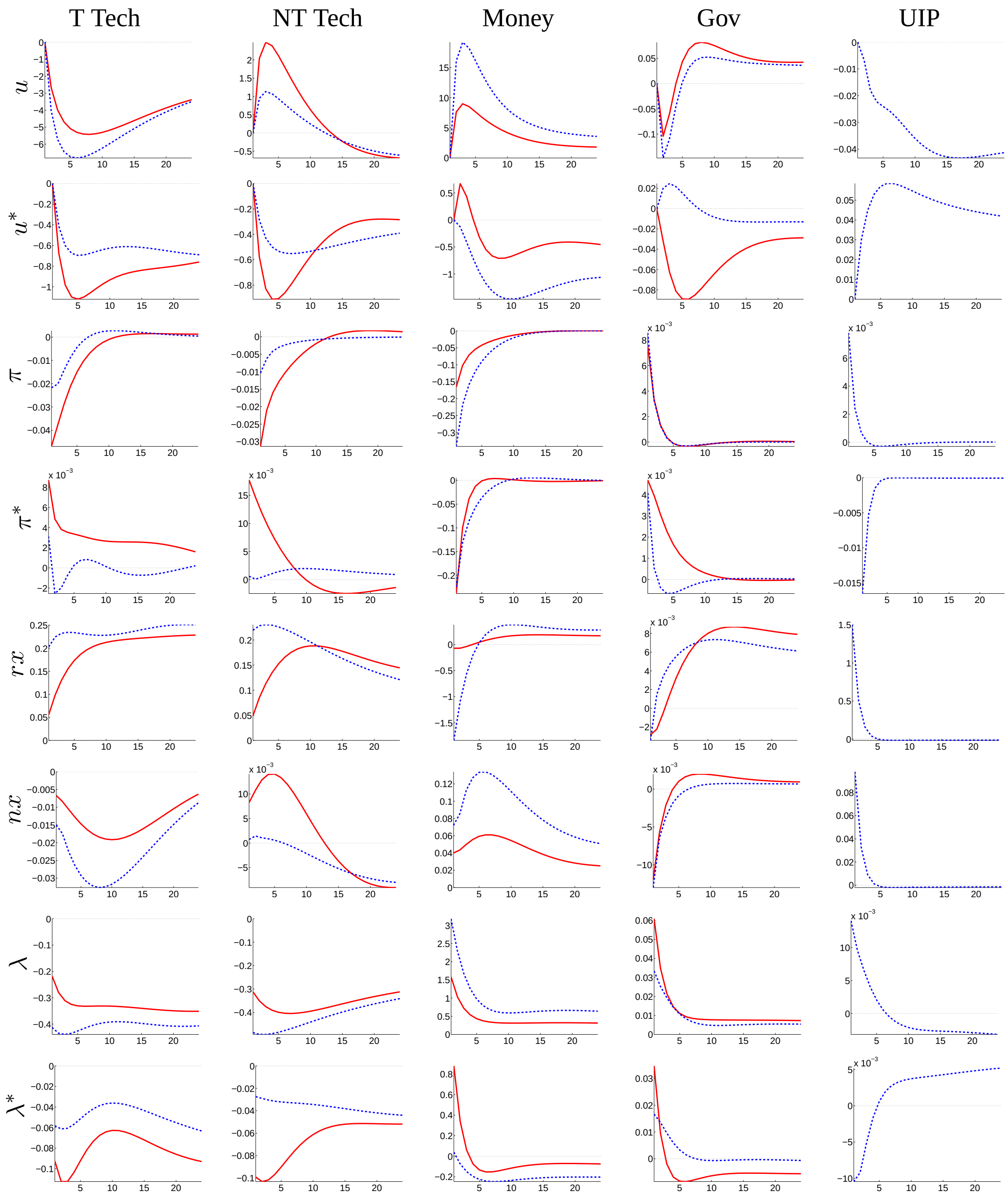

Figure 5: Shock transmission under PreEMU (dashed) and EMU (solid) scenario.

consumption and investment. The effect on foreign output (components) is quite contained.
Finally, in the fifth column we display the responses to an UIP shock under for the PreEMU calibration (there are no UIP shocks under EMU). It depreciates the real exchange rate and induces opposite responses of long-term real rates across countries. At the same time, the UIP shock also induces an almost perfectly negative co-movement of output and its components across countries.

5.3 Counterfactuals

Having analyzed the contribution of different shocks under PreEMU and EMU to business cycle fluctuations as well as the role of the exchange rate regime for the propagation of shocks, we now turn to a final assessment of the distinct quantitative contributions of the features that are different in our PreEMU and EMU calibration.
Results are reported in table 6. As a way of comparison we replicate in the left and the right column results obtained for the PreEMU and EMU calibration, respectively. In the middle columns we report the results from various counterfactual simulations which are meant to decompose the change, or put differently, to simulate a gradual transition from PreEMU to EMU by altering the features which, according our calibration, make for the difference between PreEMU and EMU.
First, we simulate the model under PreEMU except that we assume that UIP shocks are absent (second column). This experiment yields a substantial fall in real exchange rate volatility. In fact, as a result of abstracting from UIP shocks under the PreEMU calibration, real exchange volatility is almost down the level found for the EMU calibration. Other changes are rather small, except for the volatility of the trade balance, which also falls strongly and cross-country correlations which all increase mildly.
Second, we simulate the model under PreEMU without UIP shocks, but also assume that fiscal policy (i.e. rule coefficients and shock structure) is conduced as suggested by our estimates for the EMU sample. The third column of table 6 shows that this experiment induces few changes, except for government spending itself. It is now much less volatile and less correlated across countries.
Next, in addition to the previous changes to the PreEMU calibration, we also assume that monetary policy shocks happen to occur simultaneously in both counties, while drawing from the distribution of monetary policy shocks estimated for the EMU sample (fourth column). Again, the impact of this changes on most moments is contained. There is, however, a further decline in real exchange rate volatility and an increase in cross-country correlations notably for inflation and output.
Finally, we assume that monetary policy is conducted independently across countries, but the rule coefficients are assumed to take values estimated for the EMU sample. In this case real exchange rate volatility increase somewhat. This is unsurprising, given that in the PreEMU calibration monetary policy in EA6 is assumed to import German monetary condition via the specification of our interest rate rules. Assuming instead fully independent monetary policies leads to more exchange rate volatil-

Table 6: Structural decomposition of change

	PreEMU	NoUIP	EMUgov	EMUshocks	EMUrules	EMU
Domestic						
100*std(y)	1.11	1.05	1.07	1.22	0.88	0.85
std(c)/std(y)	0.83	0.84	0.81	0.85	0.86	0.83
std(x)/std(y)	2.84	2.83	2.76	2.71	2.74	2.85
std(g)/std(y)	1.12	1.20	0.79	0.70	0.99	1.04
std(u)/std(y)	9.04	9.15	8.95	8.64	9.17	9.39
std(π)/std(y)	0.05	0.05	0.05	0.07	0.07	0.09
Foreign						
100*std(y)	0.85	0.84	0.82	0.88	0.72	0.73
std(c)/std(y)	0.79	0.80	0.80	0.82	0.77	0.70
std(x)/std(y)	2.82	2.90	2.77	2.76	2.88	3.07
std(g)/std(y)	0.49	0.50	0.30	0.28	0.34	0.33
std(u)/std(y)	5.30	5.45	5.35	5.20	5.69	6.02
std(π)/std(y)	0.09	0.09	0.09	0.15	0.11	0.12
Trade						
std(rx)/std(y)	1.89	0.53	0.53	0.40	0.50	0.31
std(nx)/std(y)	0.12	0.04	0.04	0.04	0.04	0.04
Cross-country						
corr(y, y^*)	0.52	0.56	0.51	0.64	0.61	0.76
corr(c, c^*)	0.43	0.46	0.38	0.60	0.49	0.78
corr(x, x^*)	0.45	0.49	0.43	0.51	0.49	0.52
corr(g, g^*)	0.13	0.13	0.04	0.04	0.06	0.06
corr(u, u^*)	0.57	0.59	0.56	0.60	0.60	0.64
corr(π, π^*)	0.44	0.52	0.50	0.89	0.66	0.20

Notes: for computation of statistics see table 4; left and right columns replicate results for PreEMU and EMU calibration, respectively. Middle columns from left to right simulate gradual transition from PreEMU to EMU: no UIP shocks, fiscal rules/shocks as under EMU, monetary policy shocks occur symmetric (volatility as under EMU), independent monetary policy rules but with EMU coefficients.

ity and somewhat lower cross-country correlations. The volatilities of domestic and foreign variables are little affected, except for the volatility of output which falls strongly both in the domestic and the foreign economy. This is the result of the higher output coefficient estimated for the ECB rule.

Comparing the previous columns to the right column (EMU) allows us to draw conclusion as to what drives the changes in European business cycles observed between the PreEMU and the EMU sample period. Regarding the first finding, the decline in real exchange rate volatility, our results suggests that non-fundamental exchange rate volatility captured by UIP shocks can account for a large fraction of the observed decline. Monetary policy, i.e. the absence of asymmetric shocks as well as a common policy stance under EMU, played some role as well. As for our second finding, i.e.

the increase in cross-country correlations—except for government spending—the same two factors appear key: the absence of UIP shocks and the common monetary policy under EMU. The fall in the cross-country correlation of government spending, instead, is explained by the change in the fiscal rules. At the same time, the change in fiscal rules appears to be fairly inconsequential for the other moments under consideration, except for the volatility of government spending itself. Yet overall the volatility of macroeconomic aggregates in the domestic economy is fairly unchanged when moving from PreEMU to EMU (finding 3). This is likely to be the result of technology shocks being the major source of business cycle fluctuations. While the exchange rate regime has some effect on the transmission of these shocks as documented by the impulse response analysis above, the effect on second moments is quantitatively contained.

6 Conclusion

In this paper we take up the question whether the introduction of the euro changed the European business cycle. Changes are likely to come about to the extent that price rigidities are non-negligible and, hence, the nominal exchange rate regime is non-neutral in the short run. This consideration is the maintained hypothesis of OCA theory.

In a first step, we document that there are (albeit limited) changes in European business cycles which can be related to the euro. Specifically, by analyzing European time series data at business cycle frequency for the period 1984–1996 and 1999–2007 three findings emerge. First, the volatility of real exchange rates falls substantially under EMU. Second, the cross-country correlations of output and its components tend to increase, except for government spending which declines. Third, the volatility of macroeconomic aggregates is either unchanged or does not fall more than those of non-EMU countries.

In a second step, we develop and calibrate a fairly rich general equilibrium model meant to capture the defining characteristics of the European economy. We take an intra-European perspective and consider two 'countries' while abstracting from the rest of the world: Germany and EA6 (an aggregate comprising Finland, France, Ireland, Italy, Portugal and Spain). We calibrate the model to match key features of the data for both sample periods, but assume policies and shock processes to differ depending on whether we assess the PreEMU or the EMU scenario. Importantly, under EMU there is a common monetary policy for both countries and the exchange rate regime is fixed. As a result of the latter, there are no shock originating in the foreign exchange market. We find that the model performs well in predicting key features of the data, both for the PreEMU sample and for EMU. Consequently, it also correctly predicts the changes documented for the data fairly well. Given its empirical success the model is well suited to conduct counterfactual experiments which allow us to identify the causes of the change in business cycle fluctuations. We find that changes in policies, both fiscal and monetary, had a very contained effect on European cycles. Also, the fixing of the exchange rate regime *per se*, while having a considerable effect on the propagation of shocks, has little bearing on the second moments of the model.

By far the most important factor turns out to be shocks in the foreign exchange market which emerge if exchange rates are flexible. Note that we determine the importance of such shocks (UIP shocks) by focusing on a criterion which is not used to assess the model performance. Such shocks induce considerable real exchange rate volatility under PreEMU. Yet as technology shocks are the most important source of business cycle fluctuations, assuming that no UIP shocks occur under EMU leaves the volatility of key moments largely unaltered. At the same time UIP shocks induce a negative co-movement of several variables across countries. Hence, their absence under EMU also goes a long way in account for increased cross-country correlations. Finally, our analysis suggests that the decline in the cross-country correlation of government spending documented for European countries after 1999 is explained by the changes in the forcing process of government spending itself.

We conclude by noting that in this paper we attempt to provide a characterization of European business cycles through the lens of a structural model which features considerable complexity. For that reason we limit ourself to the assessment of the model's ability to replicate key features of the data, notably the change induced by the introduction of the euro. The latter raises formidable challenges and questions to be taken up in a normative analysis which we intend to pursue in future research.

Appendix

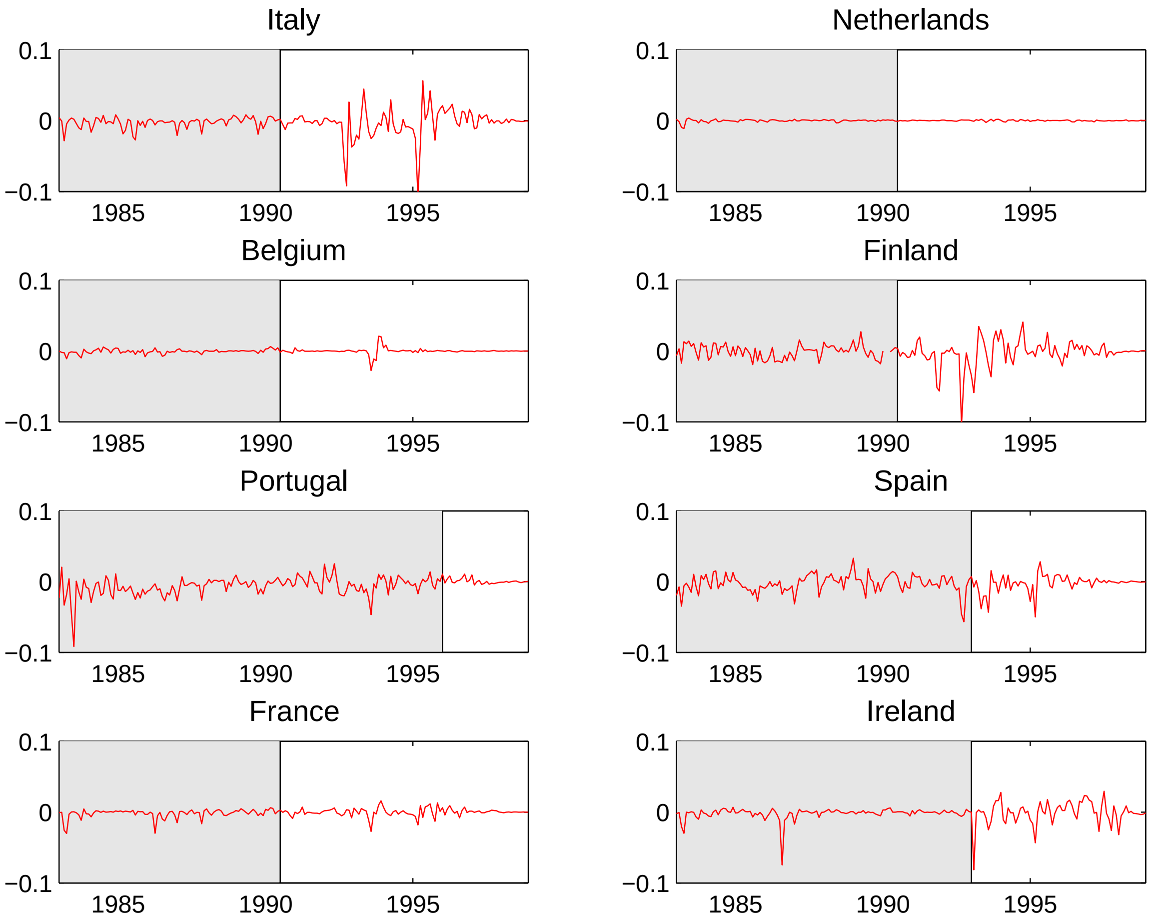

Figure 6: Nominal exchange rate vis-'a-vis Germany 1980-1998: monthly percentage change. Source: Bundesbank; gray area indicates periods with (partial) capital controls in place, see Eichengreen (1997), p. 158.

A Data sources and issues

A.1 Sources

The data used in this paper are taken from the OECD Economic Outlook 84, the Main Economic Indicators vol. 2008 release 12, Monthly Statistics of International Trade Vol. 2008 release 11, and the Quarterly National Accounts vol. 2008 release 12 databases in OECD (2008a). Where explicitly mentioned, also the STAN database in OECD (2008b) and the AMECO database in European Commission DG ECFIN (2008) were used.

	GE		IT		SP		IR		BE		FI		POR		FR		NE	
	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU
Std. Dev. Y	1.30	1.03	0.97	0.81	1.39	*** 0.57	1.86	1.50	1.01	0.78	2.78	*** 1.06	2.07	*** 1.04	1.05	* 0.72	0.94	1.16
	0.20	0.09	0.13	0.14	0.14	0.08	0.33	0.16	0.10	0.13	0.49	0.13	0.19	0.10	0.13	0.12	0.09	0.12
Std C/Std Y	0.68	0.76	1.37	** 0.86	1.06	1.32	0.66	* 1.12	0.89	0.92	0.94	** 0.61	0.84	1.03	0.75	0.63	1.14	** 0.84
	0.08	0.10	0.23	0.10	0.12	0.17	0.19	0.15	0.15	0.11	0.07	0.14	0.14	0.12	0.09	0.09	0.11	0.08
Std I/Std Y	2.31	*** 3.40	NaN	NaN	NaN	NaN	3.85	* 5.50	4.55	3.41	3.75	3.53	NaN	NaN	3.25	3.44	4.10	3.62
	0.14	0.27	NaN	NaN	NaN	NaN	0.27	0.89	0.79	0.59	0.28	0.39	NaN	NaN	0.24	0.26	0.59	0.47
Std GS/Std Y	1.04	0.90	1.24	0.85	1.24	1.00	1.84	2.36	0.93	1.17	0.77	*** 1.52	0.92	1.26	0.68	0.72	0.91	* 1.55
	0.19	0.12	0.26	0.19	0.17	0.14	0.55	0.59	0.19	0.39	0.16	0.21	0.13	0.17	0.11	0.14	0.18	0.30
Std UE/Std Y	9.18	7.32	5.75	4.02	NaN	NaN	3.59	*** 6.09	7.60	10.11	6.13	** 4.05	6.34	*** 10.16	4.53	** 8.18	9.78	** 14.39
	1.15	0.56	1.13	0.79	NaN	NaN	0.32	0.73	0.94	1.30	0.53	0.64	0.72	0.71	0.55	1.56	1.40	1.66
Std Infl/Std Y	0.22	0.30	0.40	* 0.23	0.44	*** 1.43	0.22	** 0.40	0.39	0.50	0.18	*** 0.39	0.52	0.56	0.28	* 0.48	0.46	0.35
	0.03	0.04	0.08	0.05	0.07	0.31	0.05	0.06	0.06	0.10	0.03	0.06	0.09	0.08	0.06	0.10	0.08	0.06
Std RX/Std Y	2.48	*** 0.34	4.91	*** 0.53	2.62	*** 0.79	1.34	* 0.67	1.97	*** 0.56	2.30	*** 0.57	1.50	*** 0.43	1.33	** 0.45	3.21	*** 0.47
	0.40	0.06	1.23	0.12	0.28	0.13	0.32	0.13	0.39	0.12	0.41	0.10	0.27	0.06	0.33	0.09	0.43	0.08
Std NX/Std Y	0.23	0.27	0.57	0.37	0.46	*** 0.91	0.75	0.91	0.81	** 1.46	0.23	*** 0.62	0.92	0.90	0.21	0.27	0.36	0.32
	0.05	0.03	0.09	0.08	0.07	0.16	0.16	0.16	0.12	0.30	0.04	0.07	0.17	0.14	0.04	0.05	0.05	0.04
Corr. Y Y^*	0.42	** 0.85	0.69	0.82	0.79	0.91	0.76	0.59	0.93	0.91	0.36	** 0.85	0.81	0.78	0.83	0.90	0.62	* 0.86
	0.17	0.07	0.06	0.08	0.06	0.07	0.06	0.10	0.07	0.10	0.19	0.05	0.03	0.06	0.07	0.08	0.11	0.08
Corr. C C^*	0.36	0.62	0.74	0.69	0.83	0.82	0.32	*** 0.89	0.76	0.78	0.28	0.11	0.63	0.80	0.70	0.80	0.50	** 0.79
	0.14	0.11	0.06	0.08	0.05	0.06	0.10	0.08	0.05	0.09	0.16	0.13	0.10	0.06	0.08	0.06	0.12	0.05
Corr. I I^*	0.58	*** 0.85	NaN	NaN	NaN	NaN	0.83	*** 0.18	0.85	* 0.66	0.63	0.76	NaN	NaN	0.86	0.94	0.31	*** 0.81
	0.10	0.04	NaN	NaN	NaN	NaN	0.06	0.18	0.07	0.08	0.09	0.06	NaN	NaN	0.05	0.06	0.15	0.04
Corr. GS GS^*	0.35	** −0.10	0.54	** 0.08	0.17	−0.13	−0.04	** 0.50	0.29	0.16	0.03	−0.16	0.55	*** −0.12	0.53	*** −0.20	0.09	−0.07
	0.14	0.16	0.11	0.19	0.18	0.21	0.19	0.12	0.15	0.13	0.18	0.23	0.10	0.13	0.10	0.18	0.14	0.20
Corr. UE UE^*	0.73	0.83	0.55	0.63	NaN	NaN	0.72	0.69	0.92	0.87	0.54	0.68	0.63	*** 0.86	0.82	0.78	0.70	** 0.89
	0.10	0.06	0.12	0.10	NaN	NaN	0.11	0.08	0.08	0.06	0.16	0.12	0.05	0.05	0.07	0.04	0.06	0.07
Corr. Infl $Infl^*$	0.49	0.35	0.53	0.70	0.13	*** 0.59	0.36	0.55	0.47	0.58	0.38	0.69	0.57	** 0.80	0.51	*** 0.87	0.14	*** 0.68
	0.13	0.11	0.10	0.06	0.16	0.07	0.10	0.07	0.14	0.10	0.19	0.07	0.08	0.05	0.05	0.06	0.14	0.07

	US		UK		JAP		CA		CH		NOR		SWE		**Non-EMU Avg.**		**EMU Avg.**	
	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	Post	Pre	Post
Std. Dev. Y	0.92	0.95	1.43	*** 0.42	1.30	*** 0.84	1.56	*** 0.82	1.17	1.05	1.47	*** 0.81	1.54	** 0.86	1.10	* 0.87	1.20	** 0.87
	0.11	0.15	0.19	0.06	0.14	0.09	0.16	0.16	0.20	0.12	0.16	0.09	0.29	0.16	0.09	0.11	0.11	0.09
Std C/Std Y	0.89	*** 0.65	1.24	1.28	0.66	0.55	0.76	0.61	0.55	0.58	1.40	1.21	1.07	1.06	0.87	*** 0.70	0.93	0.84
	0.08	0.04	0.11	0.21	0.08	0.08	0.06	0.09	0.11	0.08	0.22	0.10	0.17	0.11	0.04	0.04	0.07	0.05
Std I/Std Y	3.57	4.51	3.85	* 6.15	3.61	3.82	3.26	2.68	NaN	NaN	5.11	6.60	5.35	5.12	3.63	* 4.45	3.01	** 3.48
	0.41	0.45	0.46	1.14	0.27	0.30	0.31	0.63	NaN	NaN	0.64	1.10	0.51	0.60	0.22	0.40	0.13	0.18
Std GS/Std Y	1.16	0.90	0.88	*** 2.16	1.32	0.89	0.72	0.84	1.29	1.18	1.35	1.81	0.64	* 1.16	1.14	1.03	1.02	0.95
	0.24	0.14	0.13	0.46	0.25	0.15	0.11	0.23	0.21	0.18	0.18	0.32	0.16	0.24	0.17	0.14	0.09	0.12
Std UE/Std Y	8.66	9.86	6.69	8.80	4.46	4.45	5.36	6.16	26.54	*** 11.61	11.11	14.48	12.82	11.30	7.76	8.51	6.96	7.37
	1.17	1.05	0.98	1.88	0.49	0.49	0.31	0.65	2.56	0.88	1.19	2.75	1.70	2.65	0.72	0.78	0.62	0.75
Std Infl/Std Y	0.35	0.39	0.60	** 1.15	0.31	0.25	0.29	** 0.67	0.42	0.56	0.27	*** 0.84	0.54	0.61	0.36	0.46	0.33	* 0.48
	0.07	0.09	0.12	0.19	0.04	0.05	0.06	0.18	0.07	0.11	0.04	0.17	0.10	0.14	0.05	0.08	0.04	0.07
Std RX/Std Y	4.90	4.03	3.85	** 7.84	7.68	6.27	2.42	4.16	6.08	4.34	2.03	*** 4.86	3.66	5.44	5.22	4.92	2.74	*** 0.48
	1.19	0.80	0.68	1.39	1.22	0.95	0.37	1.10	1.35	0.28	0.38	0.80	0.58	1.35	0.95	0.66	0.41	0.07
Std NX/Std Y	0.22	** 0.13	0.34	** 0.63	0.26	0.17	0.44	*** 1.20	0.29	0.30	1.25	1.59	0.39	* 0.64	0.26	0.27	0.38	0.45
	0.03	0.02	0.07	0.12	0.06	0.02	0.07	0.25	0.06	0.05	0.16	0.28	0.09	0.11	0.03	0.03	0.04	0.05
Corr. Y Y^*	0.69	0.69	0.72	0.72	−0.02	0.33	0.83	0.71	0.50	0.61	−0.14	** 0.47	0.65	0.78	0.54	0.62	0.66	** 0.86
	0.07	0.07	0.07	0.08	0.20	0.22	0.04	0.08	0.15	0.10	0.23	0.12	0.09	0.06	0.08	0.07	0.06	0.06
Corr. C C^*	0.56	0.45	0.58	0.47	−0.15	−0.22	0.82	0.49	0.31	0.56	−0.23	*** 0.56	0.33	* 0.76	0.41	0.32	0.60	* 0.72
	0.08	0.21	0.11	0.16	0.18	0.18	0.07	0.19	0.25	0.13	0.18	0.09	0.22	0.07	0.08	0.13	0.05	0.05
Corr. I I^*	0.27	*** 0.89	0.73	** 0.19	−0.01	** 0.56	0.55	** 0.92	NaN	NaN	0.07	0.42	0.36	*** 0.78	0.27	*** 0.74	0.67	*** 0.85
	0.18	0.05	0.09	0.19	0.23	0.16	0.14	0.07	NaN	NaN	0.17	0.15	0.14	0.05	0.17	0.04	0.05	0.03
Corr. GS GS^*	−0.31	*** 0.50	0.21	0.14	−0.55	*** 0.37	0.12	0.38	−0.00	0.13	0.16	0.25	0.43	0.43	−0.27	*** 0.42	0.38	*** −0.07
	0.16	0.14	0.21	0.16	0.09	0.13	0.21	0.16	0.17	0.16	0.18	0.12	0.11	0.13	0.13	0.10	0.08	0.11
Corr. UE UE^*	0.89	0.90	0.86	*** 0.01	−0.08	* 0.50	0.92	0.90	0.87	0.69	−0.29	*** 0.51	0.86	** 0.55	0.67	0.72	0.71	0.77
	0.08	0.07	0.08	0.23	0.25	0.18	0.08	0.08	0.09	0.12	0.19	0.10	0.07	0.13	0.08	0.05	0.04	0.03
Corr. Infl $Infl^*$	0.42	0.57	0.10	0.29	0.37	0.30	0.30	* 0.57	0.44	0.50	−0.07	** 0.32	0.31	*** 0.68	0.37	0.49	0.43	*** 0.61
	0.15	0.07	0.11	0.15	0.16	0.14	0.13	0.07	0.09	0.12	0.14	0.08	0.12	0.07	0.12	0.06	0.06	0.03

Table 7: For GE, NE, and BE: relative variables are towards EA6. Other countries: relative variables are towards (remaining) EA9. Time-varying (4 quarters rolling window) tradeshares were used as weights. For all variables, first logs (except Infl and Net Exports) and then the HP-filter has been applied. Standard errors are in below coefficients. Stars denote 10%, 5%, and 1% significant difference. Standard errors are in below coefficients. Averages are weighted with long-run PPP GDP.

If needed for the respective country, the following data, where available, for Canada, Finland, France, Germany (before 1991 Western Germany), Ireland, Italy, Norway, Japan, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States was taken from the Economic Outlook:[33] ’Gross domestic product - volume - market prices’; ’Private final consumption expenditure - volume’; ’Private total fixed capital formation - volume’; ’Government final consumption expenditure - volume’; ’Government gross fixed capital formation - volume’; ’Consumer price index’; ’Unemployment rate’; ’Exchange rate’; ’Gross domestic product - volume - at 2000 PPP - USD’; ’Interest Rate, ShortTerm’; ’OECD crude oil import price - CIF - USD per barrel’; ’Total trade in value by partner countries’ for the calculation of the trade balance over GDP.

For the same countries, where available, the following data has been taken from the Main Economic Indicators: ’Production in total manufacturing sa’; ’Civilian employment: services sa’; ’Production of total industry sa’ or ’Production in total manufacturing sa’.

For the same countries, where available, the following data has been taken from the Quarterly National Accounts: (Output of) ’Services’.

For the same countries, where available, the following data has been taken from the STAN database: ’Production (gross output), volumes’ as well as ’Production (gross output), current prices’ in ’Manufacturing’ and ’Total services’.

For the euro area, the following data has been taken from the AMECO database: ’Net capital stock per unit of gross domestic product at constant market prices :- Capital output ratio: total economy’.

A.2 Foreign aggregate

In order to avoid national basis effects, we construct the rest of the world series, i.e. the ’foreign’ country for each ’home’ country considered, by first calculating quarterly growth rates and aggregating the weighted series. Euro area growth rates include West-Germany until 1990Q4, and unified Germany from 1991Q1 onwards. Weights are calculated as the time-varying percentage shares of trade (imports+exports) with the respective country in that country’s total trade with all countries in the sample. A rolling window of the first until the fourth lag is used to ensure that long-run changes in trade relationships are taken into account, while short-run shocks affecting trade do not impact the weights at the same time. The aggregated growth rates are then cumulated from the normalized base

[33]The series for UK investment (private and public) was adjusted for the unusual transfer of nuclear reactors from the British Nuclear Fuels plc to the Nuclear Decommissioning Authority in April 2005, see National Statistics (2006) for details.

year in order to transform the series into levels. Relative variables are specific to the country under consideration and the foreign-country aggregate. For example, the real exchange rate is constructed using the corresponding data on exchange rates and the CPIs of the specific country and the countries forming the foreign aggregate.

A.3 Filtering

To calculate statistics, the HP-filter with a smoothing parameter of 1600 was applied to the longest available sample (1970-2007) to remove the trend. This method was also used to calculate the output gap. Data for estimating the Taylor rule was not filtered. Since the calculation of the UIP shocks relies on forecasts based on data available at each period, first differences are used instead of the two-sided HP-filter.

References

Bacchetta, P. and van Wincoop, E. (2008). Infrequent portfolio decisions: A solution to the forward discount puzzle. mimeo.

Bachmann, R. (2005). Labour market dynamics in germany: Hirings, separations, and job-to-job transitions over the business cycle. *Humboldt University: SFB Discussion Paper 2005-45*.

Backus, D., Kehoe, P., and Kydland, F. (1995). International business cycles: Theory and evidence. In Cooley, T. F., editor, *Frontiers of Business Cycle Research*, pages 331–356. Princeton University Press, Princeton.

Baharad, E. and Eden, B. (2004). Price rigidity and price dispersion: Evidence from micro data. *Review of Economic Dynamics*, 7:613–641.

Baxter, M. and Stockman, A. C. (1989). Business cycles and the exchange-rate regime: some international evidence. *Journal of Monetary Economics*, 23:377–400.

Blanchard, O. and Perotti, R. (2002). An empirical characterization of the dynamic effects of changes in government spending and taxes on output. *Quarterly Journal of Economics*, 117(4):1329–1368.

Calvo, G. (1983). Staggered prices in a utility maximizing framework. *Journal of Monetary Economics*, 12:383–398.

Canova, F., Ciccqrelli, M., and Ortega, E. (2007). Similarities and convergence in g-7 cycles. *Journal of Monetary Economics*, 54:850/878.

Chari, V. V., Kehoe, P. J., and McGrattan, E. R. (2002). Can sticky price models generate volatile and persistent real exchange rates? *Review of Economic Studies*, 69:533–563.

Christiano, L. J., Eichenbaum, M., and Evans, C. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, 113(1):1–45.

Clarida, R., Galí, J., and Gertler, M. (1998). Monetary policy rules in practice some international evidence. *European Econmic Review*, 42:10331067.

Collard, F. and Dellas, H. (2002). Exchange rate systems and macroeconomics stability. *Journal of Monetary Economics*, 49:571–599.

Corsetti, G. (2008). A modern reconsideration of the theory of optimum currency areas. mimeo EUI.

Costain, J. and Reiter, M. (2005). Business cycles, unemployment insurance, and the calibration of matching models. *Journal of Economic Dynamics and Control, forthcoming*.

Dhyne, E., Álvarez, L. J., Bihan, H. L., Veronese, G., Dias, D., Hoffmann, J., Jonker, N., Lünnemann, P., Rumler, F., and Vilmunen, J. (2006). Price changes in the euro area and the united states: Some facts from individual consumer price data. *Journal of Ecoonomic Perspectives*, 20(2):171–192.

Domeij, D. and Flodén, M. (2006). The labor-supply elasticity and borrowing constraints: Why estimates are biased. *Review of Economic Dynamics*, 9(2):242–262.

Duarte, M. (2003). Why don't macroeconomic quantities respond to exchange rate variability? *Journal of Monetary Economics*, 50:889–913.

Eichengreen, B. (1997). *European Monetary Unification*. The MIT Press.

European Commission DG ECFIN (2008). Annual macro-economic database.

Faia, E. (2007). Financial differences and business cycle co-movements in a currency area. *JOurnal of Money, Credit, and Banking*, 39(1):151–185.

Flood, P. R. and Rose, A. K. (1995). Fixing exchange rates: A virtual quest fundamentals. *Journal of Monetary Economics*, 36:3–37.

Friedman, M. (1953). The case for flexible exchange rates. In *Essays in Positive Economics*. University of Chicago Press.

Galí, J. and Monacelli, T. (2005). Monetary policy and exchange rate volatility in small open economy. *Review of Economic Studies*, 72:707–734.

Galí, J. and Perotti, R. (2003). Fiscal policy and monetary integration in europe. *Economic Policy*, pages 534–572.

Gerlach, S. and Hoffmann, M. (2008). The impact of the euro on international stability and volatility. European Commission Economic Papers 309.

Hagedorn, M. and Manovskii, I. (2008). The cyclical behavior of equilibrium unemployment and vacancies revisited. *American Economic Review*, 98(4):1692–1706.

Hall, R. E. and Milgrom, P. R. (2008). The limited influence of unemployment on the wage bargain. *American Economic Review, forthcoming*.

Heathcote, J. and Perri, F. (2002). Financial autarky and international business cycles. *Journal of Monetary Economics*, 49:601–627.

Jeanne, O. and Rose, A. K. (2002). Noise trading and exchange rate regimes. *Quarterly Journal of Economics*, 117(2):537–569.

Jung, P. (2008). Optimal taxation and (female)-labor force participation over the cycle. *mimeo*.

Jung, P. and Kuester, K. (2008). The (un)importance of unemployment fluctuations for welfare. Working paper no. 08-31, Federal Reserve Bank of Philadelphia.

Kenen, P. (1969). The theory of optimum currency areas: an eclectic view. In Mundell, R. and Swoboda, A., editors, *Problems of the international economy*. Cambridge University Press.

Kollmann, R. (2002). Monetary policy rules in the open economy: Effects on welfare and business cylces. *Journal of Monetary Economics*, 49:989–1015.

Kollmann, R. (2004). Welfare effects of a monetary union: the role of trade openness. *Journal of the European Economics Association*, 2.

Kollmann, R. (2005). Macroeconomic effects of nominal exchange rate regimes: new insights into the role of price dynamics. *Journal of International Money and Finance*, 24:275292.

McKinnon, R. I. (1963). Optimum currency areas. *American Economic Review*, 53:717–725.

Monacelli, T. (2003). Into the mussa puzzle: monetary policy regimes and the real exchange rate in a small open economy. *Journal of International Economics*.

Mortensen, D. and Pissarides, C. (1994). Job creation and job destruction in the theory of unemployment. *Review of Economic Studies*, 61(3):397–415.

Mundell, R. (1961). A theory of optimum currency areas. *American Economic Review*, 51(4):657–665.

Mussa, M. (1986). Nominal exchange rate regimes and the behavior of real exchange rates: evidence and implications. *Carnegie-Rochester Conference Series on Public Policy*, 25:117–214.

National Statistics (2006). Business investment. Revised results - 3rd quarter 2006.

OECD (2008a). Economic Outlook 84, Main Economic Indicators vol. 2008 release 12, and Monthly Statistics of International Trade vol. 2008 release 11. SourceOECD.

OECD (2008b). STAN database for structural analysis. OECD.Stat.

Petrongolo, B. and Pissarides, C. A. (2001). Looking into the black box: A survey of the matching function. *Journal of Economic Literature*, 2001(2):390–431.

Rose, A. K. (2000). One money, one market: The effect of common currencies on trade. *Economy Policy*, 30.

Schmitt-Grohé, S. and Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, 61:163–185.

Shimer, R. (2005). The cyclical behavior of equilibrium unemployment, vacancies, and wages: Evidence and theory. *The American Economic Review*, 95(1):25–49.

Stock, J. H. and Watson, M. W. (2005). Understanding changes in interantional business cycle dynamics. *Journal of the European Economic Association*, 3(5):9681006.

Stockman, A. C. and Tesar, L. L. (1995). Tastes and technology in a two-country model of the business cycle: Explaining international comovements. *American Economic Review*, 85(1):168–185.