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ABSTRACT

Has the Euro changed the Business Cycle?*

In contrast to the notion that the exchange-rate regime is non-neutral, there is little evidence that EMU has systematically changed the European business cycle. In fact, we find the volatility of macroeconomic variables largely unchanged before and after the introduction of the euro. Exceptions are a strong decline in real exchange rate volatility and a considerable increase in cross-country correlations. To account for this finding, we develop a two-country business cycle model which is able to replicate key features of European data. In particular, the model correctly predicts a limited effect of EMU on standard business cycles statistics. However, further analysis reveals that the euro has changed the nature of the cycle through its impact on the transmission mechanism. Cross-country spillovers have become relatively more, domestic shocks relatively less important in accounting for economic fluctuations under EMU. This explains why there is little change in unconditional volatilities.

JEL Classification: E32, F41 and F42
Keywords: cross-country spillovers, EMU, euro, European business cycles, exchange rate regime, monetary policy and optimum currency area

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1 Introduction

In January 1999 eleven European countries adopted the euro as a common currency and delegated monetary policy to the European Central Bank. Theory suggests that the creation of the European Monetary Union (EMU) may alter European business cycles profoundly. Most importantly, the lack of exchange rate flexibility impairs macroeconomic adjustment in the face of asymmetric shocks if prices are sticky (Friedman 1953). This is the maintained hypothesis of the theory of optimum currency areas which balances foregone stabilization under a common currency with gains in transparency and lower transaction costs (Mundell 1961, McKinnon 1963, and Kenen 1969).

Yet a number of recent time-series studies find it difficult to identify a "euro effect" in European business cycles. Examples include Canova et al. (2007), Del Negro and Otrok (2008), Giannone et al. (2009), and Canova et al. (2012).[1] Taking up the issue within a two-country business cycle model, we are able to resolve the apparent conflict between the received wisdom suggesting a euro effect and the lack of evidence thereof.[2] Specifically, we find that cross-country spillovers of country-specific shocks increase strongly within a currency union, that is, countries become more exposed to economic fluctuations originating in other countries of the union. At the same time, the effects of domestic shocks on the economy become relatively less important, such that the unconditional volatility of macroeconomic aggregates remains fairly unchanged.

Central to our analysis is a carefully calibrated model of the euro area which is able to capture the key features of European business cycles before and after the introduction of the euro. Our analysis proceeds in two steps. First, we compute a number of business cycle statistics on the basis of samples which contain quarterly data for nine European countries for the period up to 1996 (PreEMU sample) and for the period since 1999 (EMU sample). As a control group we also consider time-series data for non EMU-countries. Comparing results for both samples, we find 1) the volatility of macroeconomic variables largely unchanged, except for 2) a significant decline in real exchange rate volatility; and 3) a significant increase in the cross-country correlation of output and other macroeconomic aggregates. Importantly, we observe an increased comovement outside EMU only if we include data after 2007.

These findings are subject to the caveat that longer-term developments triggered by the euro may not yet be manifest in the data.[3] It is reassuring, however, that our findings mirror those for the period

[1] Gerlach and Hoffmann (2008), in contrast, report significant changes in various measures of business cycle co-movement. Artis and Zhang (1997) perform an early analysis of the implications of the European exchange rate mechanism for business cycles correlations.

[2] In contrast to related studies by Collard and Dellas (2002), Kollmann (2004), and Faia (2007) our focus is on the ability of a two-country business cycle model to account for European business cycles before and under EMU. Moreover, we aim at isolating the euro effect in historical time-series data. Our approach is thus similar to Kollmann (2005), who explores the ability of a business cycle model to account for business cycle statistics pertaining to the period before and after the end of the Bretton-Woods system. Relative to his model, our model features a number of additional frictions and is thus able to capture better the international co-movement of economic aggregates.

[3] For instance, the euro may, by stimulating trade integration at the inter- and intraindustry level, affect the extent of

when the Bretton-Woods system has 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 correlations of economic activity. Importantly, they also find that macroeconomic time series display quite similar volatilities under and after the Bretton-Woods system of fixed exchange rates (see also Flood and Rose 1995).[4]

In a second step, we develop a two-country general equilibrium model that allows us to isolate the role of specific factors, such as changes in policy, the exchange rate regime, and the exogenous shock structure in accounting for this outcome. The two-country structure draws on Chari et al. (2002), but also distinguishes between the production of traded and non-traded goods in order to better capture the comovement of macroeconomic aggregates across countries (Stockman and Tesar 1995). As unemployment fluctuations are a major concern regarding business cycle fluctuations in Europe, our model features a non-Walrasian labor market along the lines of Mortensen and Pissarides (1994). We assume that price setting is constrained by the Calvo mechanism and that prices are sticky in the buyer's currency. All model features are fairly standard. To our knowledge, however, no attempt has been made to calibrate such a model to specific characteristics of European economies before and after the introduction of the euro.

To calibrate the two-country model we use data up to 2007 for Germany and an aggregate of the remaining EMU countries. We disregard post-2007 data in this step of the analysis, as the model is not meant to provide a full-fledged account of the global financial crisis. We distinguish a PreEMU and an EMU scenario by allowing fiscal and monetary policy rules to differ according to our own estimates. We also estimate time-invariant exogenous processes for technology in traded and non-traded goods sectors, and shocks that drive a wedge in the uncovered interest rate parity condition (Kollmann 2002). These shocks are meant to capture volatility which emerges in the foreign exchange market unrelated to changes in fundamentals. Hence, we assume them to occur only under the PreEMU scenario. Overall, we find that the model is able to capture important aspects of the data both for the PreEMU sample and the EMU sample. Moreover, we show that the model also accounts for key features of post-2007 data regarding the international comovement of business cycles.

A number of interesting findings emerge from analyzing the transmission mechanism implied by the calibrated model. First, the absence of non-fundamental exchange rate shocks under EMU allows us to match quantitatively the decline in real exchange rate volatility. This is noteworthy, as our

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specialization across countries and hence business cycle synchronization in the long-run, see Krugman (1993).

[4]Duarte (2003) and Monacelli (2004) have stressed the potential role of of limited exchange rate pass-through to account for the observations by Mussa and Baxter-Stockman. Note that this explanation has potentially important policy implications: if pass-through is limited, exchange rates fail to operate as automatic stabilizers thereby undermining the case for flexible exchange rates (Devereux and Engel 2003 and Corsetti 2008).

estimation of shock processes is carried out independently to the simulations of the model. Second, the exchange rate regime has a strong impact on the transmission of shocks across countries. Relative to PreEMU, cross-country spillovers of country-specific shocks increase substantially under EMU, while their effect on domestic variables declines – reflecting a common monetary stance (and a muted real exchange rate response). This change in the transmission mechanism implies two offsetting effects on the volatility of macroeconomic aggregates and is thus difficult to detect in standard business cycle statistics. Finally, the model predicts strong international comovement in response to a common shock only if exchange rates are flexible. To the extent that the sample period 2007–2011 is dominated by the global financial crisis – arguably a common shock – the model thus provides an account for why international comovement increased strongly outside EMU, but little within EMU during that period.

The remainder of the paper is organized as follows. Section 2 analyzes properties of the data. Section 3 outlines the model structure. Section 4 discusses the calibration of the model and its performance in accounting for key features of the data. Section 5 performs counterfactual experiments. Section 6 concludes.

2 Properties of the data

In this section we summarize properties of times series for output and its components as well as those for the unemployment rate, inflation, 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). As a control group we consider 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 to 1996. The starting point of the sample is motivated by the observation that business cycle fluctuations became more moderate from the mid-1980s onwards, see Stock and Watson (2005) for evidence on the G7 countries. 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.[5] Regarding the EMU sample starting in 1999, we distinguish a subsample which ends 2007Q4 (the pre-crisis EMU sample) from the full EMU sample until 2011Q3. In all instances, we apply the HP-filter with a smoothing parameter of 1600 in order to isolate business cycle fluctuations.[6]

Identifying a euro effect on European business cycles across the two samples is complicated by the

[5] Results are not sensitive to extending the PreEMU sample up to 1999.

[6] In applying the filter we consider data from 1970Q1 where available. A detailed description of the data sources and the aggregation method is provided in the appendix.

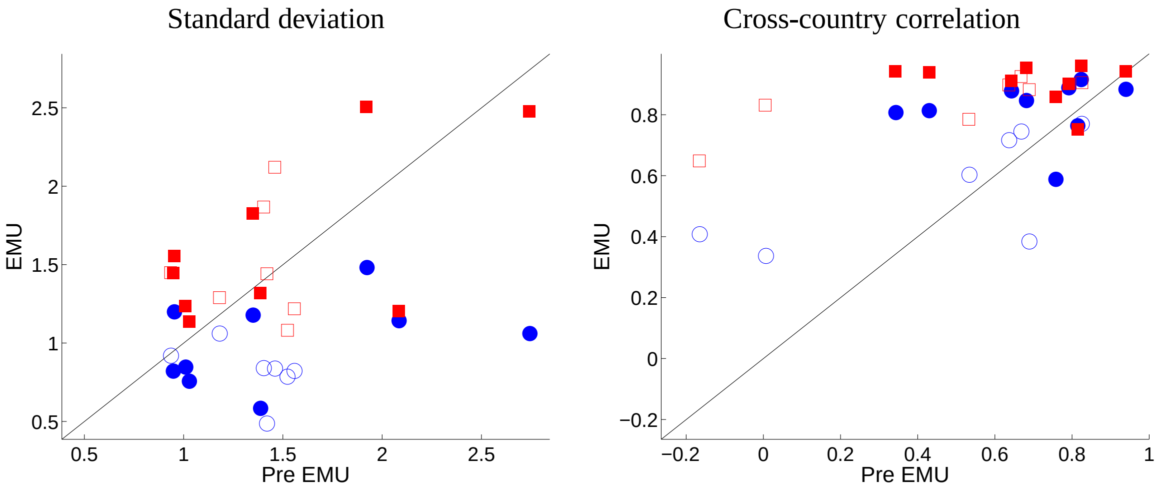

Figure 1: Output fluctuations before and under EMU. Notes: solid circles and solid squares represent EMU countries for PreEMU (1985Q1–1996Q4) vs. pre-crisis EMU sample (1999Q1–2007Q4) and PreEMU vs. full EMU sample (1999Q1–2011Q3), respectively; transparent circles and transparent squares represent non-EMU countries for PreEMU vs. pre-crisis EMU sample and PreEMU vs. full EMU sample, respectively; statistics pertain to HP-filtered data.

rich variety of exchange rate arrangements in the decades prior to the introduction of the euro. While exchange rates were not fully flexible during our sample period 1985–1996, the European Monetary System was subject to considerable turbulence and the width of the targeted bands was increased to ±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.[7]

Figure 1 displays the standard deviation and cross-country correlation of output before and under EMU, in the left and right panel, respectively. Correlations are computed with respect to the aggregate of the remaining countries.[8] In each panel, the statistic for the period prior to EMU is plotted against the horizontal axis; the statistic for the EMU period is plotted against the vertical axis. An item on the 45° line indicates that for a particular country no change in the statistic can be observed. Items above the 45° line denote an increase, while items below the 45° line indicate a reduction. Statistics

[7] In the appendix we plot monthly percentage changes of the nominal exchange rate for all countries.

[8] 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. For non-EMU countries we consider the aggregate of the remaining non-EMU countries as the corresponding counterpart.

Table 1: Cyclical properties of time series before EMU and from EMU until crisis and today

	Germany/EA6			EMU Avg			Non-EMU Avg		
	PreEMU	EMU		PreEMU	EMU		PreEMU	EMU	
		-'07	-'11		-'07	-'11		-'07	-'11
Volatility									
Std. Dev. Y	1.35	1.18	1.83	1.22	0.93*	1.50	1.13	0.85	1.52
Std C/Std Y	0.70	0.58	0.34**	0.92	0.81	0.61**	0.89	0.73**	0.70**
Std I/Std Y	2.20	2.95*	2.62	2.92	3.21	2.98	3.56	4.31	3.80
Std GS/Std Y	0.99	0.76	0.52*	1.02	0.88	0.62**	1.11	1.08	0.68*
Std UE/Std Y	8.91	6.60*	3.80**	6.84	7.52	5.58	7.64	8.67	7.48
Std Infl/Std Y	0.21	0.24	0.16	0.28	0.41	0.26	0.36	0.45	0.36
Trade									
Std RX/Std Y	2.38	0.27**	0.15**	2.71	0.46**	0.27**	5.03	4.88	3.05*
Std NX/Std Y	0.22	0.24	0.17	0.38	0.43	0.28*	0.26	0.27	0.18*
Cross-Country									
Corr. Y Y*	0.43	0.81*	0.94**	0.66	0.85*	0.94*	0.53	0.62	0.90**
Corr. C C*	0.34	0.68	0.51	0.56	0.76**	0.70	0.38	0.25	0.73**
Corr. I I*	0.53	0.83*	0.91**	0.64	0.84**	0.92**	0.28	0.75**	0.90**
Corr. GS GS*	0.34	-0.12*	0.24	0.38	-0.09**	0.26	-0.23	0.45**	0.47**
Corr. UE UE*	0.71	0.86	0.66	0.71	0.75	0.69	0.68	0.72	0.87*
Corr. Infl Infl*	0.52	0.49	0.65	0.52	0.50	0.64**	0.36	0.46	0.64*

Notes: statistics are computed for time series after applying HP-filter. PreEMU, -'07, and -'11 periods cover 1985Q1–1996Q4, 1999Q1–2007Q4, and 1999Q1–2011Q3, respectively.

for EMU countries are represented by solid circles (pre-crisis EMU sample) and squares (full EMU sample), while those pertaining to countries in the control group are represented by transparent circles (pre-crisis EMU sample) and squares (full EMU sample).

Two observations stand out. First, relative to the pre-EMU sample, output volatility has been declining somewhat prior to the crisis. Yet this observation applies not only to EMU countries, but also to the control group. Contrasting the full EMU sample with the pre-EMU sample, instead, we find output volatility increased somewhat. Second, regarding cross-country correlations, we observe an increased comovement relative to the pre-EMU sample period. However, while this increase can be observed for the pre-crisis period in case of EMU countries, it can only be observed for the full sample in case of non-EMU countries.

Table 1 provides a more comprehensive assessment of a possible euro effect on European business cycles for three groups of countries. In the left panel, we report standard deviations and correlations for Germany relative to EA6 which we use for a quantitative analysis of our two-country model below. In the middle and right panel, we report averages over all EA9 countries and averages of the non-EMU countries. In each instance, we compare business cycle statistics for the PreEMU and EMU samples, distinguishing in the latter case between the full sample and a sample which excludes the global financial crisis. We use a non-linear Wald test to evaluate whether changes are significant,

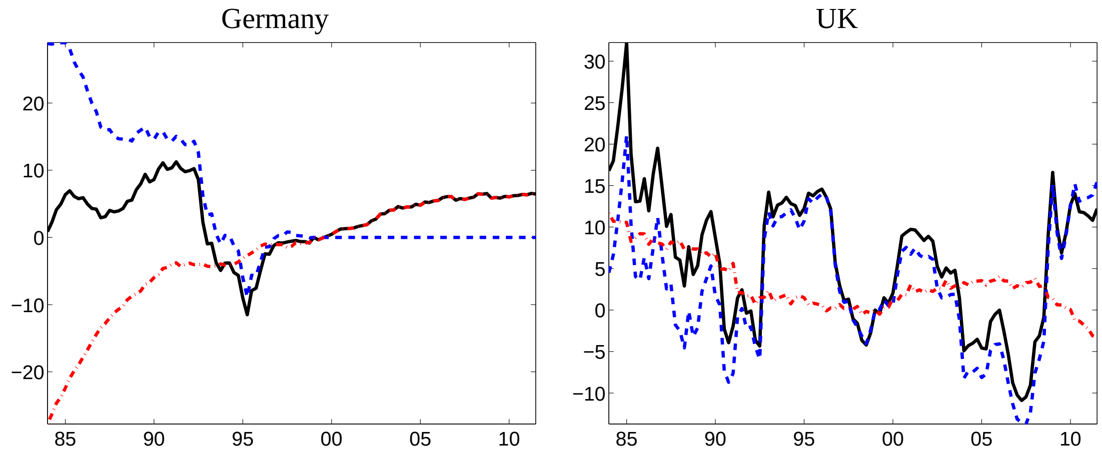

Figure 2: Real exchange rate (solid line), nominal exchange rate (dashed line), and price ratio (dashed-dotted line) 1985–2011. Notes: the real exchange rate is measured as the (log of) the price ratio times the nominal exchange rate, where the price ratio is given by CPI^*/CPI. Variables are defined against EA6 for Germany and against the remaining Non-EMU countries for the UK.

with one or two asterisks indicating significance at the 5% or 1% level.[9]

In terms of macroeconomic volatility there is little systematic change across the two sample periods – in line with the evidence provided in figure 1. Output volatility increases or falls in the EMU sample, depending on whether observations for the crisis are included in the sample. The same holds for non-EMU countries. The upper panel of table 1 also reports the volatility of various other macroeconomic time series relative to output. Again, it is difficult to observe systematic changes between the PreEMU and the EMU sample. An exception is the decline of the relative volatility of consumption and government spending, which can be observed for non-EMU countries as well.

The second panel of table 1 reports the volatility of the real exchange rate and the trade balance. It turns out that while there is no systematic change in the volatility of trade flows due to EMU, the volatility of the real exchange rate declines strongly. In fact, for our sample we find a decline by a factor of about 10-20, depending on whether we include observations for the crisis. We thus confirm for EMU the finding that the exchange rate regime is a key determinant of real exchange rate volatility. 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. Figure 2 decomposes movements in the real exchange rate into movements of the nominal exchange rate and the ratio of price levels. It contrasts results for Germany and the UK: as real exchange rates move quite closely with nominal rates, much of its volatility disappears after 1999 in Germany.[10]

In the bottom panel of table 1, we report cross-country correlations. In line with the evidence provided

[9] Details are provided the appendix.

[10] For other EMU countries a similar pattern can be observed. Results are available on request.

in figure 1, we find a significant increase of output correlations: under EMU it materializes prior to the crisis, outside the EMU it materializes only during the crisis. We also find a systematic increase in the comovement of consumption and investment. Note, however, that the cross-country correlation of investment increases for non-EMU countries as well. The cross-country correlation of government spending falls for EMU countries but increases across non-EMU countries. Also the average change in the cross-country correlation of inflation is positive and significant.

Note that our findings mirror the observations reported by Baxter and Stockman (1989) regarding a possible change of business cycles 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 increase in real exchange rate volatility – but show 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]

3 The model

In order to provide a structural account of the data before and under EMU, in this section we put forward our two-country business cycle model. The good market structure draws on earlier work by Chari et al. (2002), among others. Important 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' by means of an asterisk. The relative size of the home country, i.e., its population divided by the population of the foreign country, is denoted by n.

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

[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.

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 χV_t a resource loss arising from labor market frictions discussed below, the constraint of the final good firms can be stated as follows

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

where $\sigma \equiv (1+\varsigma)^{-1}$ measures the trade price elasticity of substitution, $\epsilon \equiv (1+\varepsilon)^{-1}$ denotes the elasticity of substitution between intermediate goods of the same type, and $\eta = (1+\varrho)^{-1}$ measures the elasticity of substitution between tradeable and non-tradeable goods. The parameters υ and ω are the weights of traded and imported goods in final and traded goods, respectively. Expenditure minimization implies that the price of final goods is given by

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

where

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

We discuss below how prices of varieties, $P_{k,t}(j)$, are determined. The index k is used to denote traded domestically produced, imported, or non-traded intermediate goods. Expenditure 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

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

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

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

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

3.2 Intermediate goods firms

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

$$
Y_{k,t}(j) = Z_{k,t} K_{k,t}(j)^{\theta} L_{k,t}(j)^{1-\theta}, \qquad (7)
$$

where $Z_{k,t}$ denotes technology in sector $k \in \{A, N\}$. $K_{k,t}(j)$ and $L_{k,t}(j)$ measure the amount of capital and labor employed by firm j in sector k, respectively. Capital and labor inputs are not firm specific and can be adjusted freely in each period. Cost minimization implies $L_{k,t}(j)/K_{k,t}(j) = \theta^{-1}(1-\theta)R_{k,t}/P_{L,t}$, where $P_{L,t}$ and $R_{k,t}$ denote the price of labor and capital, respectively—note that only the latter is sector specific. Marginal costs are given by

$$MC_{k,t} = \frac{P_{L,t}^{1-\theta} R_{k,t}^{\theta}}{Z_{k,t}\theta^{\theta}(1-\theta)^{1-\theta}}. \tag{8}$$

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 $1-\xi_k$. 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' decision 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 that it sets its price $P_{N,t}(j)$, given the opportunity to readjust, in order to maximize the expected discounted value of net profits:

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

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

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

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

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

subject to the demand function (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. Aggregate labor and capital services employed in the intermediate goods sector are given by

$$L_{k,t} = \int_0^1 L_{k,t}(j)dj, \qquad K_{k,t} = \int_0^1 K_{k,t}(j)dj. \tag{12}$$

3.3 Households

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

$$E_0 \sum_{t=0}^{\infty} \beta_t \left(\frac{C_t^{1-\gamma} - 1}{1-\gamma} - \vartheta \frac{H_t^{1+\mu}(1-U_t)}{1+\mu} \right) \tag{13}$$
$$\beta_0 = 1, \;\; \beta_{t+1} = \beta(C_t)\beta_t, \;\; \beta(C_t) = (1 + \psi C_t)^{-1},$$

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.[12] The parameter $\psi > 0$ determines the value of the discount factor in steady state. U_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

$$K_{k,t+1} \;\; = \;\; (1-\delta)K_{k,t} + \digamma(X_{k,t}, X_{k,t-1}), \text{ with } \digamma = \left[1 - \frac{\kappa}{2} \left(\frac{X_{k,t}}{X_{k,t-1}} - 1 \right)^2 \right] X_{k,t}, \tag{14}$$

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 therefore given by

$$\begin{aligned} & W_t H_t(1-U_t) + R_{A,t}K_{A,t} + R_{N,t}K_{N,t} + \Upsilon_t - P_{F,t}(C_t + T_t + X_t) \\ = \;\; & R_t^{-1}\Theta_{t+1} + R_t^{*-1}S_t\Theta_{t+1}^*/n - \Theta_t - S_t\Theta_t^*/n \end{aligned} \tag{15}$$

where R_t and R_t^* denote domestic and foreign gross nominal interest rates and W_t is the wage rate. T_t measures lump-sum taxes and Υ_t denotes intermediate and labor market firms' profits discussed below. Households maximize (13) subject to (14) and (15). Combining the first order conditions for domestic and foreign bond holdings gives rise to the uncovered interest rate parity (UIP) condition: $R_t = R_t^* E_t \Delta S_{t+1}$. Empirically, failure of UIP has been widely documented. We therefore assume, following Kollmann (2005), that there are disturbances (UIP shocks) to this condition:

$$R_t = R_t^* E_t \Delta S_{t+1} \varepsilon_t^{UIP}, \tag{16}$$

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

where ε_t^{UIP} follows an exogenous process specified below. We assume that UIP shocks originate in the foreign exchange market, giving rise to non-fundamental exchange rate volatility as documented, for instance, in Flood and Rose (1995). Under an alternative interpretation, UIP shocks generate departures from the UIP condition which reflect frictions absent from our model, as, for instance, costly portfolio adjustment suggested by Bacchetta and van Wincoop (2010).

3.4 Labor market firms

Total demand for labor by intermediate good firms is given by $L_t = L_{A,t} + L_{N,t}$. It is provided by perfectly competitive labor market firms. Specifically, each firm is a match between a single worker and a single firm, which produces a "labor good" according to a linear production function in hours worked.[13] We consider a symmetric equilibrium where all matches provide the same amount of labor. The final labor market good is then the aggregates of matches of individual workers: $L_t = (1-U_t)H_t$. We assume a standard homogenous matching function that relates the number of matches M_t to the number of vacancies V_t and unemployed U_t:

$$M_t = sV_t^{\Psi}U_t^{1-\Psi}, \tag{17}$$

$$\frac{M_t}{V_t} \equiv \pi_{f,t} = s\left(\frac{V_t}{U_t}\right)^{\Psi-1}, \tag{18}$$

$$\frac{M_t}{U_t} \equiv \pi_{ue,t} = s\left(\frac{V_t}{U_t}\right)^{\Psi}, \tag{19}$$

where Ψ measures the matching elasticity, and s 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. Real profits of a single firm J_t and the surplus of the match from the workers' perspective V_t are given by

$$J_t = \frac{P_{L,t}H_t - W_tH_t}{P_{F,t}} + E_t(1-f)\rho_{t,t+1}J_{t+1}, \tag{20}$$

$$V_t = \frac{W_tH_t - b_t}{P_{F,t}} - \frac{\vartheta}{U_{C,t}}\frac{H_t^{1+\mu}}{1+\mu} + E_t\rho_{t,t+1}(1-f-\pi_{ue,t})V_{t+1}, \tag{21}$$

where f 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, determines the amount of vacancies posted, and is described below. We draw on Hall and Milgrom (2008) and Jung and Kuester (2011) and assume that the threat point of the worker in the bargaining process is not given by the value of being unemployed (standard Nash-bargaining), but by the cost of delaying bargaining for one period. This allows us to use the static bargaining solution given by

[13] This setup ensures that, if we fix the unemployment rate at a constant level and shut down the labor market friction, our model delivers the standard neoclassical labor market outcome.

$$\frac{\vartheta H_t^{\mu}}{U_{C_t}} = \frac{P_{L,t}}{P_{F,t}} \tag{22}$$

for hours worked, delivering an efficient choice of hours worked identical to the one obtained in the neoclassical limiting case. Our labor market friction manifests itself in the following wage setting equation

$$W_t = \Omega P_{L,t} + (1-\Omega)\left[\frac{P_{L,t}}{1+\mu} + \widetilde{b}\overline{W}\right]. \tag{23}$$

Here, Ω denotes the bargaining power of the worker. Our setup implies that wages are a convex combination of productivity and the outside option. The latter is given by the saved amount of leisure and an abstract strike value $b_t = \widetilde{b}\overline{W}H_t$, where $\widetilde{b} \in [0,1]$ expresses the outside option in percentage terms of the average (steady state) wage per hour $\overline{W}$, see Jung and Kuester (2011).[14] Note that, by setting $\widetilde{b} = 0$, we can reproduce cyclical properties of a Walrasian labor market where wages (almost) perfectly comove with productivity and movements in the unemployment rate are essentially shut down. The free entry condition ensures that on average firms make no profits when posting a new vacancy:

$$\chi = \pi_{f,t} E_t \rho_{t,t+1} J_{t+1}, \tag{24}$$

where χ are real vacancy posting costs expressed in terms of the consumption good and are accounted for in the total resource constraint of the economy. Finally, the implied law of motion for the unemployment rate U_t is given by:

$$U_{t+1} = U_t(1 - f - \pi_{ue,t}) + f. \tag{25}$$

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). Regarding international asset markets, we assume that only domestic currency bonds are traded in equilibrium. 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 $Y_{N,t} \equiv \left(\int_0^1 Y_{N,t}(j)^{-\varepsilon} dj\right)^{\frac{1}{\varepsilon}}$. Substituting for

[14] Note that we fix $\overline{W}$ to the steady-state value, but allow the outside option to comove positively with hours worked. This enables us to reproduce a version of the static Nash-bargaining equation with hours worked. The main difference to the standard Nash-solution is the absence of a term $\chi\frac{V}{U}$, which turns out to be small and negligible given our calibration strategy but complicates the derivation. For our purpose it is enough to assume this mild form of wage rigidity supposing that the outside option does not move one-to-one with the business cycle. In the present context, we interpret $\widetilde{b}$ as an abstract outside option that will be set to match the amount of unemployment volatility observed in the data; it may either be interpreted as unemployment benefits or as the cost of delaying/striking for one period. This allows us to sidestep on the debate between Hagedorn and Manovskii (2008) and Shimer (2005) and to use this parameter to align the model and the data with respect to matching observed unemployment volatilities.

$Y_{A,t}(j) = A_t(j) + A_t^*(j)/n$ and $Y_{N,t}(j) = N_t(j)$ in both expressions, using the demand functions given by (4)-(6), gives the aggregate relationships

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

The aggregate production function is given by

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

where $\zeta_{k,t} \equiv \int_0^1 \left(\frac{P_{k,t}(j)}{P_{k,t}} \right)^{-\epsilon} dj$ provides a measure for price dispersion at the level of intermediate goods in each sector. As a measure for real GDP we define

$$Y_t \equiv C_t + X_t + G_t + \chi V_t + \frac{S_t P_{A,t}^*}{P_{F,t}} A_t^*/n - \frac{P_{B,t}}{P_{F,t}} B_t, \tag{28}$$

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

$$A_t^* = \upsilon \left(\frac{P_{A,t}^*}{P_{T,t}^*} \right)^{-\sigma} \left(\frac{P_{T,t}^*}{P_{F,t}^*} \right)^{-\eta} \omega F_t^*, \quad B_t = \upsilon \left(\frac{P_{B,t}}{P_{T,t}^*} \right)^{-\sigma} \left(\frac{P_{T,t}}{P_{F,t}} \right)^{-\eta} (1-\omega) F_t. \tag{29}$$

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

$$RX_t \equiv \frac{S_t P_{F,t}^*}{P_{F,t}}, \quad NX_t \equiv \frac{S_t P_{A,t}^* A_t^*/n - P_{B,t} B_t}{P_{F,t} Y_t}. \tag{30}$$

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 and its own past value:

$$\log G_t = (1-\rho_g) \log G + \rho_g \log G_{t-1} + \phi \log \left(Y_{t-1}/Y_{t-2} \right) + \varepsilon_{g,t}, \tag{31}$$

where variables without time-subscripts refer to steady-state values and $\varepsilon_{g,t}$ denotes i.i.d. government spending shocks. We assume that lump-sum taxes adjust to balance the government budget in each period: $G_t = T_t$. Note that while this rule is fairly simple, it strikes us as a convenient way to capture a possible change in the endogenous conduct of fiscal policy. We consider a response to lagged rather than current output growth because of decision and implementation lags, see Blanchard and Perotti (2002).[15] Monetary policy is characterized by an interest rate feedback rule of the following type

$$\log R_t = \rho \log R_{t-1} + (1-\rho) E_t \left[\varpi + \varphi_\pi \log \Pi_{t-1,4} + \varphi_y \log \left(Y_t / Y_{t-1}\right) + \varphi_r \log R_t^*\right] + \varepsilon_{r,t}, \quad (32)$$

where $\Pi_{t,i} \equiv P_{F,t+i}/P_{F,t}$ 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. 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).

4 Model simulation

We use a first-order approximation to the equilibrium conditions around a deterministic steady state to study the properties of the model numerically. The following subsection provides the rationale for the parameter values used in the simulation of the model. The empirical performance of the model is analyzed afterwards.

4.1 Calibration

We calibrate our two-country model to capture key features of the German economy relative to EA6 – for the PreEMU and the EMU scenario. To pin down parameter values, we rely on estimates of earlier studies, but also on new estimates. For this purpose we use data up to 2007 only. 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.

Preferences and Technologies The first set of parameters is displayed in table 2; we assume identical values under PreEMU and EMU because these parameters are arguably 'deep' enough to be invariant with respect to changes in the policy regime. In the upper (lower) panel, we report the values of those parameters which are identical (different) across countries. In the right column of the table, we report target values or sources which serve to pin down the parameter values shown in the left column.[16]

[15] 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).

[16] In general equilibrium, calibration targets typically depend on values of several parameters; nevertheless it is possible to pin down specific parameter values by focusing on one particular target value. Unless stated otherwise, we draw on the OECD Economic Outlook database to compute target statistics.

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)	
Utility weight of work	ϑ	36.9	Hours worked steady state	0.30
Risk aversion	γ	1.00	Balanced growth	
Trade price elasticity	σ	0.90	Heathcote and Perri (2002)	
Non-traded price elast.	η	0.44	Stockman and Tesar (1995)	
Elast. of discount factor	ψ	.014	K/Y	12.00
Depreciation rate	δ	.015	I/Y	0.186
Adjustment costs	κ	1.50	std(I_t)/std(Y_t)	Table 4
Price elasticity	ϵ	6.00	Markup	0.20
Capital share	θ	0.34	Labor share	0.66
Government share	G/Y	0.21	Government spending share	0.21
Country size home	n	0.49	GDP Germany vs. EA6	
Separation rate	f	.045	Jung and Kuhn (2010)	
Bargain parameter	Ω	0.50	Shimer (2005)	
Matching elasticity	Ψ	0.50	Petrongolo and Pissarides (2001)	

Asymmetric parameters		Germany	EA6	Calibration target / source	Germany	EA6
Outside option	$\widetilde{b}$	0.65	0.65	std(U_t)/std(Y_t)	Table 4	
Vacancy posting	χ	0.05	0.06	Unemployment steady state	0.075	0.096
Matching constant	s	0.55	0.42	Normalization V/U	1.000	1.000
Weight traded goods	υ	0.38	0.35	Production manuf./services	0.621	0.537
Weight domestic goods	ω	0.85	0.90	Import & exp. share Germany	0.053	0.067
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

Notes: Parameters remain unchanged across simulations, see main text for discussion of target values. Price durations are measured in quarters. Variables without time subscript refer to steady-state values.

One period in the model corresponds to one quarter. We set $\mu = 2$, implying a Frisch wage elasticity of labor supply of 0.5, see Domeij and Flodén (2006). We set ϑ such that hours worked in steady state are 0.3. Furthermore, we assume that $\gamma = 1$, consistent with balanced growth. Regarding trade price elasticities, we set $\sigma = 0.9$, which corresponds to the estimate reported in Heathcote and Perri (2002). Following Stockman and Tesar (1995) we set $\eta = 0.44$. We target a steady-state quarterly capital-to-output share of 12 and an average investment-to-output ratio of 0.186 to pin down the elasticity of the discount factor ψ and the depreciation rate δ, respectively. Capital adjustment costs (κ) are set to match the volatility of investment, reported in table 4 below (average value across countries and scenarios). We determine ϵ such that the average markup is 20 percent, see Rotemberg and Woodford (1993). We set θ to match average wage shares of two thirds for Germany and EA6.[17] The observation that government spending accounts for 21 percent of GDP on average allows us to pin down the steady state share of government spending accordingly. The relative size of the domestic economy n is set to reflect the ratio of German output to EA6 output. Regarding labor markets, we set $f = 0.045$ in line with estimates for firing/separation rates for Germany at quarterly frequency, see

[17] Data for the capital-to-output ratio and the wage share are obtained from the AMECO database of the European Commission.

Jung and Kuhn (2010). Following Shimer (2005) and Petrongolo and Pissarides (2001), respectively, we set the bargaining parameter Ω and the matching elasticity Ψ to one half.

Next, we turn to parameters which are allowed to take different values in Germany and EA6 in order to capture important heterogeneities in the labor market. First, we determine the outside option by targeting the unemployment volatility reported in table 4 below (average value across countries and scenarios).[18] To pin down vacancy posting costs, we target the average unemployment rate, which is 7.5% for Germany and 9.6% for EA6. Finally, we normalize the number of posted vacancies to pin down values for s.

A last set of parameters is set to determine the weight of traded and non-traded goods and the extent of price rigidities. In both respects, we allow for asymmetries as they are likely to impact fundamentally on intra-European business cycles. The weight of traded goods in total output υ is determined by the average ratio of output in the manufacturing sector relative to services. This ratio is 0.62 for Germany and 0.54 for the EA6 aggregate.[19] Given the parameter υ, the shares of imports and exports in steady state are governed by ω. For the period 1985–2007, we find that German imports from EA6 average at 5.32 percent of GDP, while exports to EA6 average at 6.67 percent.[20] We pin down price rigidities on the basis of the frequency of price changes reported in Dhyne et al. (2006). For the traded and non-traded goods sector, we consider data for non-energy industrial goods and services, respectively. Price durations are highest within the non-traded goods sector in Germany and lowest in the traded goods sector in EA6. The Calvo parameters ξ_T and ξ_N are set to match average price durations.[21]

Policy rules The behavior of fiscal and monetary policy is characterized by the feedback rules (31) and (32), which are allowed to differ under the PreEMU and EMU scenario according to our estimates. First, regarding the monetary policy rule, drawing on Clarida et al. (1998), we employ a two-stage least squares approach, using four lags of CPI-inflation, the short-term interest rate, the oil price, and output growth as instruments in the first step of the procedure. We estimate two different rules for Germany and EA6 for PreEMU and a common monetary policy rule for EMU. While we restrict the parameter φ_r to be zero for Germany, we estimate it for EA6. Results are reported in the first panel of table 3. For Germany we find considerable interest rate smoothing and a fairly strong

[18]Our model does not suffer from a lack of volatility of unemployment, stressed by Shimer (2005), because of sluggish real-wage adjustment which in turn induces profits to fluctuate strongly over the cycle. For details see, among others, Hagedorn and Manovskii (2008) and Hall and Milgrom (2008).

[19]Source: STAN database of the OECD.

[20]In the medium to long term the import-to-GDP ratio is likely to depend on the nominal exchange rate regime. In fact, following Rose (2000), the importance of the exchange rate regime for trade has been discussed by a number of authors. During our sample period, a considerable increase in openness can be observed. We therefore experimented with different degrees of openness: the quantitative implications for business cycle dynamics turned out to be negligible. In what follows we therefore assume constant values for υ and ω.

[21]Aggregation follows Baharad and Eden (2004). 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.

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

		PreEMU		EMU	
		Germany	**EA6**	**Germany**	**EA6**
Monetary policy					
Smoothing	ρ_r	0.75	0.64	0.71	
Inflation	φ_π	2.06	0.92	1.31	
Output growth	φ_y	0.25	0.10	0.23	
German interest rate	φ_{i_G}	—	0.74	—	
Variance of innovations (10^{-6})		1.18	2.01	5.90	
Government spending					
Smoothing	ρ_g	0.59	0.99	0.53	0.84
Output growth	ϕ	-0.32	-0.06	0.06	-0.01
Variance of innovations (10^{-4})		1.55	0.15	0.78	0.05
UIP process					
AR(1)-coeff UIP shock	ρ^{UIP}	0.35		—	
UIP shock variance (10^{-4})	$\sigma^2_{\nu UIP}$	1.90		—	
Technology process		**Germany**	**EA6**	**USA**	**Common**
AR(1)-coefficient					
Tradables	ρ^c_T	0.94	0.82	0.77	0.91
Non-tradables	ρ^c_N	0.97	0.85	0.93	—
Variance of innovations (10^{-4})					
Tradables		1.61	0.63	0.87	0.37
Non-tradables		0.42	0.35	0.13	—

Notes: parameter values for monetary and fiscal policy for PreEMU and pre-crisis EMU scenario, see main text for discussion.

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. Second, regarding fiscal policy, we allow for a change in the parameters governing the rule (31) under EMU relative to PreEMU and estimate them for both sample periods by OLS.[22] Results are reported in the second panel of table 3 for both sample periods. We find quite persistent processes for government spending for both sample periods, notably for EA6. According to our estimates, fiscal policy has been conducted more countercyclically under PreEMU.[23]

Forcing processes In estimating the process of UIP shocks we follow Kollmann (2005). Rewriting (16) in logs without expectations provides a measure for the realized deviations from UIP:

$$\ln(\hat{\varepsilon}_t^{UIP}) \equiv \ln(R_t) - \ln(R_t^*) - \ln(\Delta S_{t+1}).$$

[22]A linear trend is included in the estimation. Note that our specification excludes a contemporaneous response of government spending to output. We thus employ an identification assumption which is frequently made in the VAR literature on fiscal policy transmission, see Blanchard and Perotti (2002).

[23]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.

In order to extract the expected ex-ante component, ε_t^{UIP}, we regress $\ln(\hat{\varepsilon}_t^{UIP})$ 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 EA6. Next, we estimate an AR(1) process on the fitted values. Results are reported in the third panel of table 3. We find that predictable deviations from the uncovered interest rate parity are fairly short-lived, compared to Kollmann's estimate of $\rho^{UIP} = 0.5$ for the US.

We assume UIP shocks to occur only under PreEMU because there is no currency trade under EMU, as a result of which non-fundamental exchange rate volatility could arise. Of course, allowing for UIP shocks in the PreEMU scenario thus raises, all else equal, the volatility of nominal and – in the presence of nominal rigidities – real exchange rates. We stress, however, that our analysis is disciplined by the estimates of the shock process obtained independently of the model. Moreover, UIP shocks enter the decision problem of households and thus impact – subject to the cross-equation restrictions implied by the equilibrium conditions – the business cycle statistics of the model which we use to assess its performance.[24]

Regarding the technology process governing intermediate goods production, we assume that deviations from steady state follow an AR(1) process specific to each country and each sector. In addition, we allow for a common factor in the technology of the traded-goods sector. Specifically, we assume the following law of motion

$$Z_{T,t}^c = \tilde{Z}_{T,t}^c + \Gamma_t \text{ and } Z_{N,t}^c = \tilde{Z}_{N,t}^c, \text{ with}$$
$$\tilde{Z}_{k,t}^c = \rho_k^c \tilde{Z}_{k,t-1}^c + \varepsilon_{k,t}^c \text{ and } \Gamma_t = \rho_\tau \Gamma_{t-1} + \varepsilon_t,$$

where T denotes the traded-goods sector, while k represents both the traded and the non-traded goods sectors. Γ_t is the common factor, and c indicates the country or area (i.e., $c \in \{\ ,*, US\}$). As in Gregory and Head (1999), we extract the common factor using a Kalman filter. In order to control for the rest of the world when estimating the process for the common factor, we include sector-specific US Solow residuals in the estimation. We use data for the industrial sector where available (otherwise we employ data for the manufacturing sector) as a proxy for the traded goods sector, and the service sector for the non-traded goods sector.[25] Results are reported in the last panel of table 3.

4.2 Model performance

We assess the ability of the calibrated model to account for European business cycles. Specifically, we confront the model predictions for the PreEMU and the EMU scenario with key features of the data

[24] Lubik and Schorfheide (2005) pursue an alternative strategy, as they add an error term to the measurement equation. This term represents exchange rate changes in addition to what is accounted for by fundamentals. Hence, it does not impact the equilibrium outcome, but captures model misspecification.

[25] We linearly detrend the log series and drop observations for Germany at the time of the reunification.

for Germany and EA6. In case of the EMU scenario we focus on data up to 2007, as the model is not meant to provide a full-fledged account of the global financial crisis. Nevertheless, below we show in section 5.2 that the model can indeed account for a key aspect of post-2007 data which concerns the international comovement of business cycles.

In order to appreciate the model performance recall that under PreEMU both countries are characterized by distinct monetary policy rules, while under EMU we assume a common monetary policy. Moreover, all shock processes – including the process for UIP shocks – have not been specified in order to target specific model predictions, but have been estimated independently of the model. Table 4 reports the model predictions and corresponding moments of the data.[26] In the left panel we list the moments for Germany and EA6. The first and the second column replicate the values for the PreEMU and EMU period shown in table 1 as well as the corresponding moments for EA6. In the right panel we report the corresponding statistics for the model.

In the upper two panels we focus on the volatility of macroeconomic variables. In terms of absolute volatility, measured by the standard deviation of output, the model fails to predict actual output volatility somewhat. This is perhaps unsurprising given that we consider only a limited number of shocks. In accordance with the data, the model predicts a decline in output volatility, but the predicted delince is more moderate. In terms of relative volatilities the model performs quite well, with volatilities of consumption and government spending somewhat overpredicted for Germany and underpredicted for EA6. Note that average values for the volatilities of investment and unemployment have served as a calibration target and cannot be used to evaluate the model. Yet the model correctly predicts the change in volatility for both variables.[27]

In the third panel we focus on the volatility of the real exchange rate and the trade balance for Germany relative to its trading partners (EA6). We find that the model captures rather well the volatility of the exchange rate, the absolute level both under the PreEMU and under the (pre-crisis) EMU scenario, and hence the substantial decline of volatility. It amounts to almost 80 percent according to the model, while in the data we find a decline by almost 90 percent. To a large extent this result is driven by UIP shocks which are absent under EMU.[28] If we consider a model version without UIP shocks, the decline of real exchange rate volatility amounts to 30 percent only – reflecting the difficulty of standard business cycle models to account for real exchange rate volatility (see Lubik and Schorfheide 2005). This difficulty can be overcome if one is ready to assume a high degree of risk aversion and a

[26]Tables 2 and 3 summarize the parameter values used in the simulations. In each case we draw from the assumed distribution of shocks and generate time series of 52 observations (and an additional 60 observations to initialize the model), 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 500 simulations.

[27]The extent of labor market frictions is crucial for the model to match actual unemployment fluctuations, but also affects the propagation of shocks more generally. Considering a version of the model which approximates a Walrasian labor market, we find that output volatility declines by about 20 percent. Results are available on request.

[28]Table A-2 in the appendix provides a business cycle variance decomposition.

Table 4: Model performance

	Data			Model		
	PreEMU	**EMU (-'07)**	**Δ**	**PreEMU**	**EMU**	**Δ**
Germany/Home						
Std Y * 100	1.35	1.18	-0.17	1.00	0.97	-0.03
Std C/Std Y	0.70	0.58	-0.12	0.98	0.96	-0.02
Std I/Std Y	2.20	2.95	0.75	2.52	2.56	0.04
Std G/Std Y	0.99	0.76	-0.23	1.31	0.94	-0.37
Std U/Std Y	8.91	6.60	-2.31	9.14	8.90	-0.24
Std π/ Std Y	0.21	0.24	0.03	0.06	0.16	0.10
EA6/Foreign						
Std Y * 100	1.19	0.78	-0.41	0.65	0.62	-0.03
Std C/Std Y	1.00	0.95	-0.05	0.89	0.87	-0.02
Std I/Std Y	3.27	3.39	0.12	2.78	2.77	-0.00
Std G/Std Y	1.06	0.87	-0.29	0.74	0.43	-0.31
Std U/Std Y	5.22	6.18	0.96	4.82	4.98	0.16
Std π/ Std Y	0.31	0.51	0.20	0.20	0.31	0.10
Trade						
Std RX/Std Y	2.38	0.27	-2.11	2.16	0.50	-1.66
Std NX/Std Y	0.22	0.24	0.02	0.14	0.04	-0.10
Cross-country						
Corr Y Y^*	0.43	0.81	0.38	0.28	0.58	0.30
Corr C C^*	0.34	0.68	0.34	0.23	0.69	0.46
Corr I I^*	0.53	0.83	0.30	0.30	0.35	0.05
Corr G G^*	0.34	-0.12	-0.46	0.00	0.01	0.00
Corr U U^*	0.71	0.86	0.15	0.42	0.50	0.09
Corr $\pi\pi^*$	0.52	0.49	-0.03	0.13	0.18	0.05

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.

large contribution of monetary policy shocks to business cycle fluctuations (Chari et al. 2002). In our setup, however, the contribution of monetary policy shocks is pinned down by the monetary policy rules which are estimated independently of the model.[29] Finally, regarding the third panel, we note that the model is less successful in predicting the (change in the) volatility of the trade balance.

Instead, the performance of the model in predicting cross-country correlations, shown in the lowest panel, is quite strong. While the model does not fully predict the size of the correlation, it correctly predicts the sign and the approximate size of the change of the correlation, except for inflation. In this regard our assumption of a large non-traded goods sector plays an important role in aligning theory

[29] If we adopt the preference specification of Chari et al. (2002), while maintaining the assumptions about the (estimated) shocks processes, we still obtain a decline of exchange rate volatility by 30 percent only, although the volatility is generally higher. Results are available on request.

and evidence.[30]

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 (prior to the crisis): 1) the volatility of macroeconomic variables is largely unchanged across the two sample periods; 2) an exception is the the real exchange rate whose volatility is substantially reduced under EMU; 3) there is considerable increase in the cross-country comovement, except for government spending.

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, we turn to the underlying transmission mechanism which drives our results. We focus first on how the exchange rate regime alters the effects of country-specific shocks. In a second step, we turn to common shocks and the role of the exchange rate regime for international comovement in the context of the crisis.

5.1 The transmission of country-specific shocks

The calibrated model predicts only a mild decline of the volatility of macroeconomic aggregates, but a strong decline of real exchange rate volatility – in line with the evidence for EMU. Mussa (1986), Baxter and Stockman (1989), and Flood and Rose (1995) provide similar evidence for earlier episodes. This evidence apparently conflicts with the notion that – if prices are sticky – the exchange rate regime fundamentally alters the (international) transmission mechanism, a notion stressed by Friedman (1953) and maintained by OCA theory.[31]

Against this background we assess the role of the exchange rate regime in the international transmission of shocks within our calibrated model. In figures 4a and 4b we display the responses to a shock originating in the home country.[32] The dashed lines show the responses under the PreEMU, the solid lines under the EMU calibration. Horizontal axes measure time in quarters, vertical axes percentage

[30] If we consider a model version with only tradable goods $\nu = 1$ we find that the decline in the real exchange rate volatility and the increase in the correlation is considerably dampened. Results are available on request.

[31] Duarte (2003) and Monacelli (2004) attempt to account for the empirical observations of Mussa and Baxter-Stockman within sticky price models. Duarte assumes that prices are predetermined in the buyer's currency for one period such that demand is completely isolated from exchange rate changes. As a result, she finds that exchange rate volatility changes substantially across exchange rate regimes, leaving the volatility of macroeconomic variables largely unaffected. Monacelli also highlights the role of limited exchange rate pass-through, but considers a Calvo pricing scheme. Under his baseline calibration the exchange rate regime matters for the volatility of the real exchange rate, but also for the volatility of macroeconomic aggregates. Output volatility, however, is shown to remain unchanged across exchange rates regimes for high values for openness and/or trade price elasticity.

[32] To simplify the exposition we focus on domestic shocks. The effects of shocks originating in the foreign economy are not fully symmetric due to the asymmetries of the model, but generally comparable.

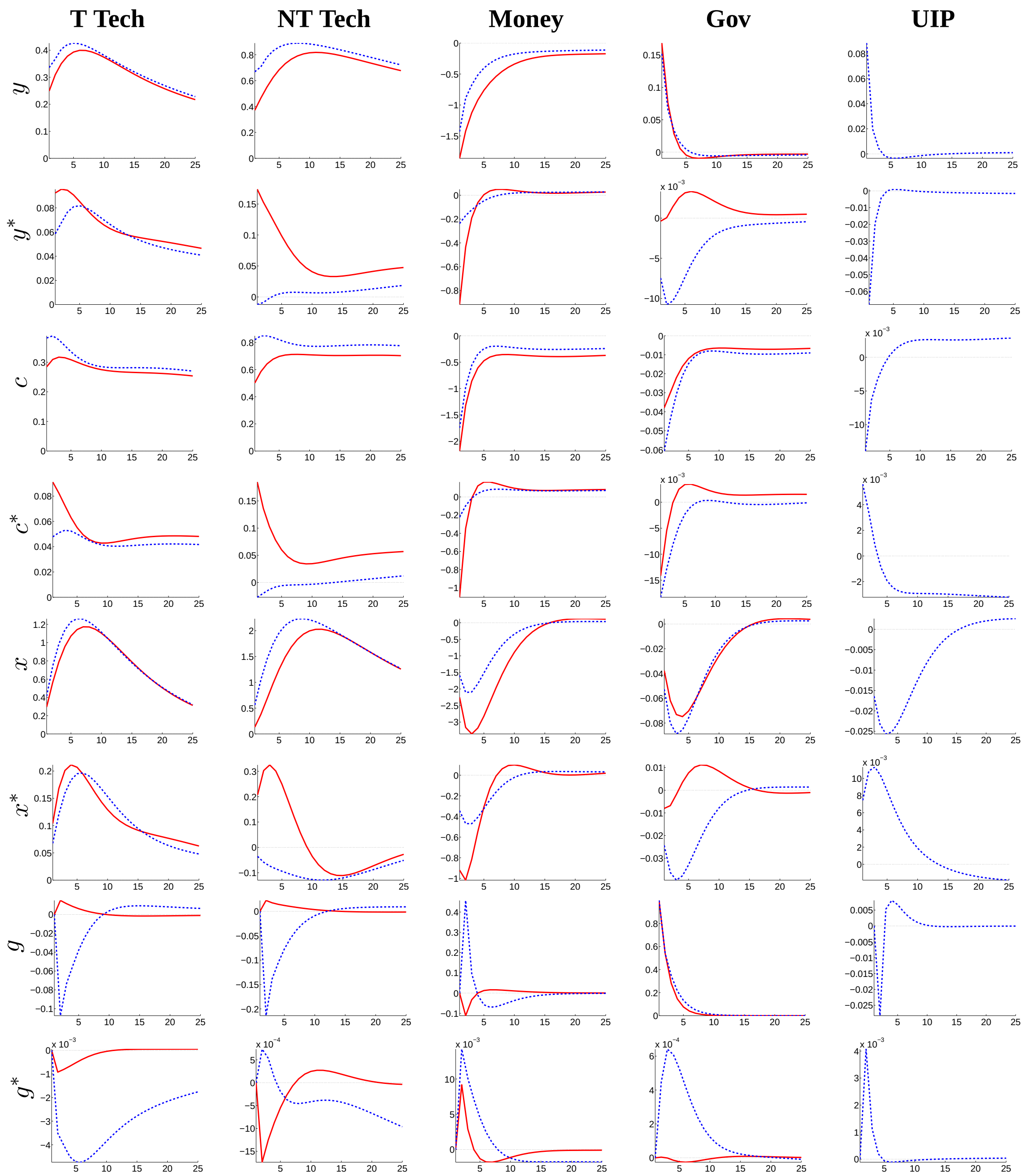

Figure 4a: Shock transmission under PreEMU (dashed) and EMU (solid) scenario.

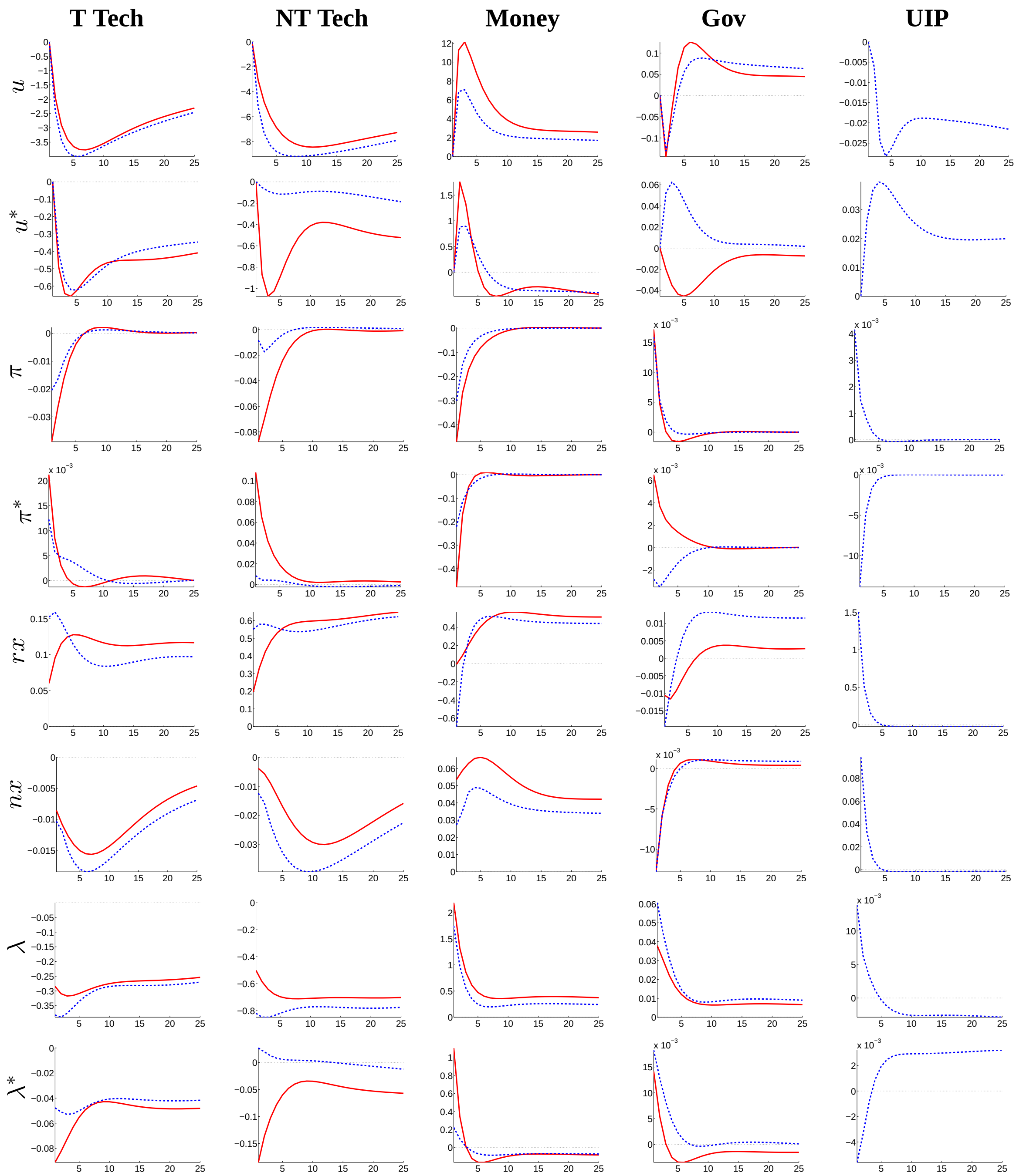

Figure 4b: Shock transmission under PreEMU (dashed) and EMU (solid) scenario.

deviation from steady state. Note that in addition to the exchange rate regime, there are also differences in the fiscal and monetary policy rules across the scenarios. It turns out, however, that whether or not countries operate a fixed exchange rate regime and thus a common monetary policy is the main cause of differences in the impulse responses.[33]

We display the responses of domestic and foreign output and its components (figure 4a) as well as those of unemployment, inflation, the real exchange rate, and the trade balance (figure 4b). In addition, we display in the lower panels of figure 4b 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 role of the exchange rate regime in the transmission mechanism.[34]

The response to a technology shock in the traded good sector is displayed in the first column: it is expansionary in both countries, irrespective of the exchange rate regime. Positive cross-country spillovers can be rationalized by the decline in long-term real rates (bottom panels of figure 4b) – consistent with increased consumption, investment and, eventually, higher output and lower unemployment in both countries. Comparing the adjustment under PreEMU and EMU, we find that domestic shocks generate larger cross-country spillovers under EMU, while their impact on domestic variables is reduced relative to PreEMU. To rationalize this observation, note that domestic shocks depreciate the real exchange rate (rx increases), but less so, at least initially, under EMU because the nominal exchange rate channel is absent and prices are sticky. As a result, demand for domestic goods increases relatively less compared to PreEMU, while demand for foreign goods increases relatively more. As a result, macroeconomic aggregates respond less to domestic technology shocks and more to foreign technology shocks. The difference in the real exchange rate response under both exchange rate regimes is consistent with our measure for long-term real interest rates. While technology shocks lower long-term real interest rates, they do less so under EMU in the domestic economy, and more so abroad. This reflects a common monetary stance (and a muted exchange rate response) under EMU, which aligns the adjustment process in both countries.

Turning to technology shocks originating in the non-tradeable goods sector, we find that EMU has a stronger bearing on the transmission mechanism. As with technology shocks in the tradeable goods sector, the domestic effects are expansionary irrespective of the exchange rate regime. Yet the sign of the effects on the foreign economy depend on the exchange rate regime. In the PreEMU scenario there are small, but negative cross-country spillover effects of a domestic shock. Under EMU, instead, spillovers are positive and sizeable. Again, this finding can be rationalized by the common monetary policy regime under which long-term real interest rates decline in both countries in response

[33] Results are available on request.

[34] 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 corresponds, in terms of deviations from steady state, to the sum of future real short-term rates up to a first order approximation of the model, see the discussion in Woodford (2003).

Table 5: Cross-country spillovers of technology shocks

	PreEMU			**EMU**		
	ALL	**TEC**	**TEC***	**ALL**	**TEC**	**TEC***
Domestic						
Std Y * 100	1.00	0.91	0.04	0.97	0.74	0.14
Std C * 100	0.97	0.91	0.03	0.93	0.70	0.15
Std I * 100	2.51	2.35	0.13	2.49	2.02	0.30
Std G * 100	1.31	0.22	0.01	0.91	0.03	0.01
Std U * 100	9.10	8.73	0.34	8.63	7.39	0.82
Std π * 100	0.06	0.03	0.00	0.15	0.09	0.02
Foreign						
Std Y * 100	0.65	0.13	0.48	0.62	0.21	0.43
Std C * 100	0.58	0.09	0.42	0.54	0.19	0.33
Std I * 100	1.80	0.31	1.45	1.72	0.49	1.37
Std G * 100	0.48	0.01	0.03	0.27	0.00	0.00
Std U * 100	3.12	0.97	2.07	3.09	1.33	2.03
Std π * 100	0.13	0.02	0.09	0.19	0.08	0.12

Notes: Standard deviation in percent. Column ‘ALL’ shows results under the assumption that all shocks occur. ‘TEC’: only domestic technology shocks; ‘TEC*’: only foreign technology shocks.

to expansionary shocks in the domestic non-tradeable goods sector.

Table 5 quantifies how EMU changes cross-country spillovers of technology shocks. It reports the standard deviations of macroeconomic variables under PreEMU (left panel) and under EMU (right panel). In both cases we report the standard deviation if either all shocks (‘ALL’), only domestic technology shocks (‘TEC’), or only foreign technology shocks (‘TEC*’) occur. Under PreEMU, domestic variables are to a large extent driven by domestic technology shocks. Reflecting increased spillovers, the importance of domestic shocks decreases under EMU, while those of foreign shocks increases considerably. Given that technology shocks are the main source of business cycle fluctuations (see table A-2 in the appendix), our results provide an explanation for the empirical observation whereby there is little change of macroeconomic volatility under EMU, while at the same time international comovement increases substantially.

The effect of EMU on the transmission of non-technology shocks is also non-negligible, although less consequential for business cycle statistics. The effects of a contractionary monetary policy shock are displayed in the third column of figure 4. An immediate effect of the shock is the increase in the domestic long-term real interest rate because of nominal rigidities. Output and its components contract, inflation declines. In the PreEMU scenario this results in a strong appreciation of the real exchange rate on impact. Under EMU the adjustment process is more symmetric, because in this case a domestic monetary policy shock corresponds to a union-wide shock.

The responses to domestic government spending shocks and UIP shocks are displayed in the fourth and fifth column of figure 4, respectively. An increase in government spending tends to increase domestic output and to lower domestic consumption and investment. The effect on foreign output is quite contained, but changes sign under EMU. UIP shocks occur only under PreEMU. They depreciate the real exchange rate and induce a strong negative comovement of macroeconomic aggregates across countries.

5.2 The transmission of a global shock

The model provides an account for why under EMU there is little change in overall volatility, but a strong increase in cross-country correlations. These are key features of the data documented in section 2 above. However, international comovement increases also strongly outside EMU once data up to 2011 are included in the sample. Within EMU the increase in comovement during that period is instead limited. Presumably, the sample period 2007–2011 is dominated by the global financial crisis. While a full-fledged analysis of the sources and the (international) transmission of the crisis are beyond the scope of the paper, the observations regarding international comovement can indeed be rationalized within the model.

To do so, we show how the exchange rate regime alters the transmission of a global shock. Specifically, we consider a common negative technology shock, that is, a simultaneous decline of productivity levels in the tradeable-goods sector in both countries. We assume that the shock is serially uncorrelated, such that an effect of the shock beyond the impact period is purely the result of endogenous shock propagation. This specification is meant to capture – albeit in a stylized manner – the global nature of the financial crisis.[35] Figure 5 displays impulse responses in home (solid line) and foreign (dashed line). The upper (lower) panels show the adjustment under flexible exchange rates (EMU).[36] Horizontal axes measure quarters, vertical axes percentage deviations from steady state.

The adjustment to the global shock differs substantially across exchange rate regimes. This reflects asymmetries across countries, as fully symmetric countries would respond identically to a global shock, irrespective of the exchange rate regime. The exchange rate regime matters in case of asymmetries, however, as monetary policy can respond to country-specific developments only under flexible exchange rates. This case is displayed in the upper panels of figure 5. Initially, a negative technology shock exerts upward pressure on prices, as marginal costs rise. The extent of this pressure depends on the structure of the economy. Specifically, prices respond more strongly in the foreign country (third panel), where they are adjusted more frequently.[37] As a result, monetary policy responds more ag-

[35] Indeed, Chari et al. (2007) show that time-varying financing frictions which distort the allocation of intermediate inputs imply an inefficiency isomorphic to an aggregate productivity shock. Nevertheless, our analysis of a negative common technology shock is an admittedly imperfect substitute for a detailed analysis of the global financial crisis. In our view, such an analysis would also feature a banking sector, as, for instance, in Kollmann et al. (2011).

[36] In case of flexible exchange rates, we assume that the monetary and fiscal policy rules in place are the same as under EMU, but one independent monetary policy rule for each country. Results for the PreEMU scenario, however, look very similar.

[37] Other asymmetries across countries matter less for the differential impact of the shock.

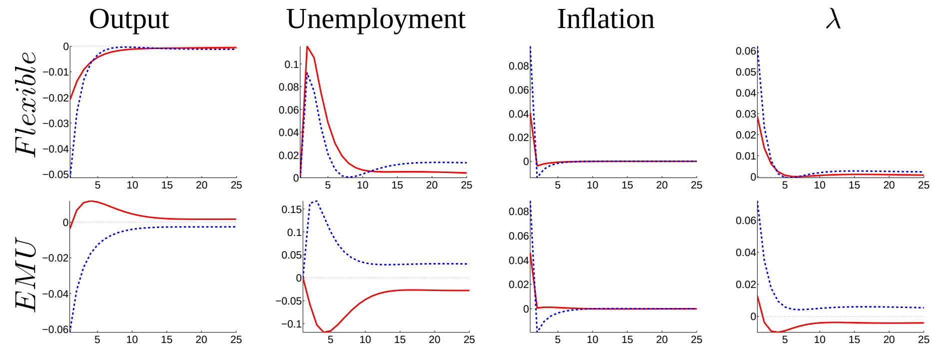

Figure 5: Effect of global, negative, and serially uncorrelated technology shock on home (solid lines) and foreign (dashed lines); upper panels show responses for counterfactual with flexible exchange rates, lower panel for EMU scenario.

gressively (right panel) and foreign experiences a sharper decline in activity. This induces a deflation in the quarters following the shock. The labor market generates further internal propagation.

In the EMU scenario (displayed in second row), monetary policy cannot respond to country-specific developments. The monetary stance will therefore be relatively expansionary in home and relatively contractionary at foreign. As a result the negative global shock is only contractionary in foreign, but has a mildly expansionary effect in home.

Overall, the model thus predicts that the exchange rate regime matters a great deal for how asymmetric countries respond to shocks. In response to a global negative technology shock we find a relatively synchronized downturn, if countries operate a flexible exchange rate regime. Under a common monetary policy (EMU), however, we find that the same shock exerts a contraction in one country, while inducing a mild expansion in the other. The model can thus account – in a stylized manner – for the increased comovement outside EMU during the crisis period, and the absence thereof within EMU. In our view, the mechanism identified here is likely to have played some role for the heterogenous macroeconomic performance in the euro area following the crisis, although we leave an analysis of a full-blown crisis scenario for future research.

6 Conclusion

Has the euro changed the European business cycle? On the one hand, changes are likely if price rigidities are non-negligible and, hence, the nominal exchange rate regime is non-neutral in the short run – the maintained hypothesis of OCA theory. On the other hand, earlier research suggests that the volatility of macroeconomic variables does not differ systematically across exchange rate regimes (Baxter and Stockman 1989, Flood and Rose 1995). Against this background, we address the question empirically and within a structural business cycle model.

In a first step, we document that changes in standard business cycle statistics related to the euro appear to be limited. Specifically, three findings emerge from analyzing European time-series data relative to a sample of non-EMU countries and comparing the periods 1985–1996 and 1999–2011. First, the volatility of macroeconomic aggregates is largely unchanged, except for – our second finding – a substantial decline in the volatility of real exchange rates. Third, the cross-country correlations of output and most macroeconomic economic time series increase after 1999. This increased comovement, however, can also be observed for countries outside EMU if we consider data after 2007.

In a second step, we develop and calibrate a two-country general equilibrium model to data for Germany and EA6 (an aggregate comprising Finland, France, Ireland, Italy, Portugal, and Spain). We find that the model performs quite well in predicting key features of the data, both for the PreEMU sample and for EMU. It also generates predictions in line with the three findings above, suggesting the following explanations. First, the absence of shocks to the nominal exchange rate accounts for most of the decline of real exchange rate volatility under EMU. The increased comovement within EMU, in turn, is due to increased cross-country spillovers of country-specific shocks. At the same time these shocks affect domestic economies less strongly under EMU.

As these changes have largely off-setting effects on the volatility of macroeconomic variables, they cannot be easily detected in unconditional time-series data. Nevertheless, these changes have potentially important implications for economic policy, as EMU member countries have become considerably more exposed to economic fluctuations originating in other member countries. Moreover, as illustrated by our last experiment, EMU induces a heterogenous adjustment to common shocks, while a more synchronized development can be observed under flexible exchange rates. To the extent that the global financial crisis represents a common shock, our finding may rationalize the observation that during the sample period 2008–2011 comovement increased strongly outside EMU, but much less so within EMU.

Appendix

A Further tables and figures

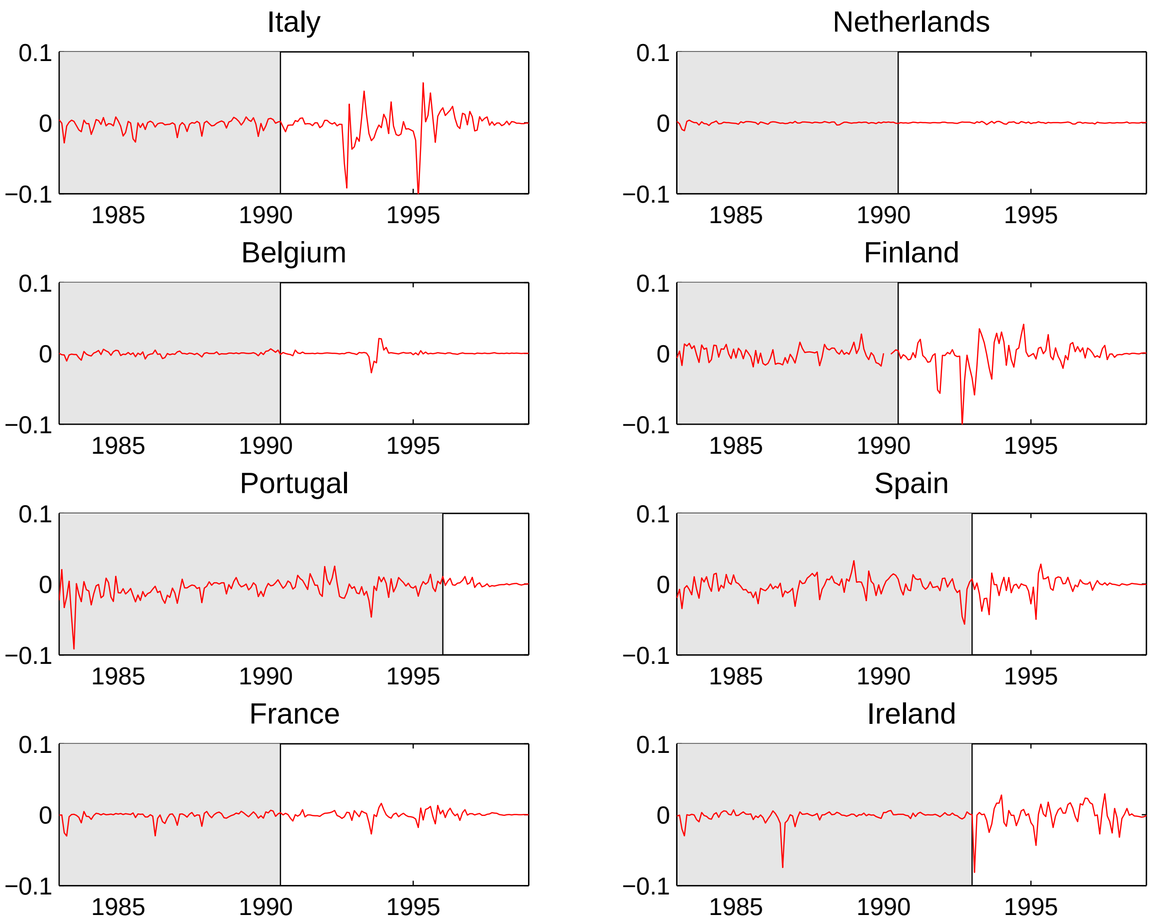

Figure A-1: Nominal exchange rate vis-à-vis Germany 1980-1998: monthly percentage change. Source: Bundesbank; gray area indicates periods with (partial) capital controls in place, see Eichengreen (1997), p. 158.

	FI		FR		GE		IR		IT		POR		SP		BE		NE	
	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU
Std. Dev. Y	2.74 (0.52)	2.48 (0.45)	1.03 (0.12)	1.14 (0.14)	1.35 (0.22)	1.83 (0.26)	1.92 (0.36)	2.50 (0.34)	0.95 (0.13)	1.45 (0.22)	2.08 (0.19)	** 1.21 (0.08)	1.38 (0.14)	1.32 (0.21)	1.01 (0.11)	1.23 (0.16)	0.95 (0.09)	** 1.55 (0.19)
Std C/Std Y	0.96 (0.08)	** 0.57 (0.03)	0.78 (0.10)	0.56 (0.06)	0.70 (0.08)	** 0.34 (0.07)	0.67 (0.10)	** 1.11 (0.08)	1.27 (0.17)	** 0.65 (0.07)	0.84 (0.13)	1.06 (0.13)	1.06 (0.12)	1.18 (0.07)	0.90 (0.15)	** 0.43 (0.07)	1.13 (0.11)	** 0.65 (0.07)
Std I/Std Y	3.72 (0.23)	** 2.35 (0.19)	3.20 (0.27)	3.24 (0.22)	2.20 (0.15)	2.62 (0.16)	3.75 (0.76)	4.98 (0.75)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	4.44 (0.77)	3.17 (0.37)	4.06 (0.60)	3.48 (0.31)
Std GS/Std Y	0.82 (0.19)	0.44 (0.10)	0.74 (0.12)	* 0.45 (0.07)	0.99 (0.18)	* 0.52 (0.08)	1.98 (0.59)	1.60 (0.26)	1.26 (0.26)	** 0.43 (0.11)	0.90 (0.16)	1.19 (0.22)	1.25 (0.17)	0.99 (0.26)	0.90 (0.18)	0.62 (0.14)	0.89 (0.18)	1.12 (0.24)
Std UE/Std Y	6.22 (0.62)	** 2.98 (0.26)	4.69 (0.60)	6.04 (0.81)	8.92 (1.04)	** 3.80 (0.79)	3.46 (0.29)	** 5.67 (0.53)	5.68 (1.08)	3.87 (0.64)	6.30 (0.70)	8.30 (0.73)	6.13 (0.51)	** 9.02 (0.87)	7.61 (0.94)	6.59 (1.14)	9.85 (1.45)	10.13 (1.54)
Std Infl/Std Y	0.13 (0.03)	0.17 (0.02)	0.24 (0.06)	0.26 (0.03)	0.21 (0.03)	0.16 (0.03)	0.21 (0.05)	0.34 (0.07)	0.32 (0.07)	* 0.16 (0.02)	0.32 (0.05)	0.32 (0.05)	0.43 (0.07)	* 0.70 (0.09)	0.32 (0.06)	0.35 (0.03)	0.30 (0.05)	* 0.17 (0.02)
Std RX/Std Y	2.33 (0.45)	** 0.24 (0.06)	1.34 (0.33)	** 0.28 (0.05)	2.38 (0.38)	** 0.15 (0.03)	1.29 (0.32)	* 0.59 (0.08)	5.02 (1.25)	** 0.26 (0.07)	1.46 (0.27)	** 0.40 (0.05)	2.63 (0.28)	** 0.44 (0.06)	1.98 (0.41)	** 0.34 (0.06)	3.18 (0.45)	** 0.38 (0.05)
Std NX/Std Y	0.24 (0.04)	0.24 (0.06)	0.22 (0.04)	0.20 (0.03)	0.22 (0.05)	0.17 (0.02)	0.73 (0.16)	0.63 (0.07)	0.59 (0.10)	** 0.21 (0.04)	0.91 (0.17)	0.84 (0.12)	0.46 (0.07)	0.43 (0.06)	0.82 (0.13)	0.95 (0.14)	0.37 (0.06)	0.28 (0.04)
Corr. Y Y*	0.34 (0.18)	** 0.94 (0.10)	0.82 (0.07)	0.96 (0.10)	0.43 (0.17)	** 0.94 (0.09)	0.76 (0.06)	0.86 (0.06)	0.68 (0.07)	* 0.95 (0.10)	0.81 (0.03)	0.75 (0.03)	0.79 (0.06)	0.90 (0.09)	0.94 (0.07)	0.94 (0.09)	0.64 (0.11)	* 0.91 (0.08)
Corr. C C*	0.29 (0.14)	0.53 (0.13)	0.63 (0.09)	* 0.86 (0.05)	0.34 (0.14)	0.51 (0.12)	0.49 (0.09)	** 0.81 (0.06)	0.70 (0.07)	0.83 (0.05)	0.64 (0.10)	0.57 (0.10)	0.82 (0.05)	0.81 (0.06)	0.71 (0.06)	0.58 (0.09)	0.47 (0.12)	0.62 (0.13)
Corr. I I*	0.60 (0.10)	* 0.87 (0.07)	0.84 (0.05)	0.97 (0.08)	0.53 (0.11)	** 0.91 (0.07)	0.67 (0.06)	0.63 (0.08)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	0.87 (0.08)	0.85 (0.05)	0.29 (0.16)	** 0.87 (0.06)
Corr. GS GS*	0.06 (0.19)	−0.07 (0.13)	0.54 (0.11)	0.20 (0.21)	0.34 (0.14)	0.24 (0.14)	−0.01 (0.20)	* 0.48 (0.14)	0.54 (0.11)	0.16 (0.17)	0.28 (0.18)	0.34 (0.16)	0.19 (0.19)	0.58 (0.09)	0.35 (0.14)	0.30 (0.15)	0.08 (0.14)	0.33 (0.15)
Corr. UE UE*	0.55 (0.16)	0.80 (0.05)	0.82 (0.07)	0.83 (0.04)	0.71 (0.10)	0.66 (0.07)	0.72 (0.11)	0.77 (0.06)	0.51 (0.13)	0.69 (0.09)	0.62 (0.05)	0.56 (0.11)	0.85 (0.07)	* 0.49 (0.13)	0.92 (0.08)	0.78 (0.06)	0.69 (0.06)	0.72 (0.08)
Corr. Infl Infl*	0.39 (0.16)	* 0.73 (0.07)	0.63 (0.08)	0.74 (0.04)	0.52 (0.09)	0.65 (0.07)	0.41 (0.09)	* 0.69 (0.06)	0.63 (0.10)	0.76 (0.06)	0.62 (0.09)	0.48 (0.11)	0.16 (0.19)	0.35 (0.10)	0.73 (0.05)	0.80 (0.07)	0.40 (0.14)	0.39 (0.07)

	CA		CH		JAP		NOR		SWE		UK		US		**Non-EMU Avg.**		**EMU Avg.**	
	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU	Pre	EMU
Std. Dev. Y	1.56 (0.16)	1.22 (0.21)	1.18 (0.23)	1.29 (0.15)	1.40 (0.16)	1.87 (0.35)	1.52 (0.18)	* 1.08 (0.13)	1.46 (0.29)	2.12 (0.39)	1.42 (0.19)	1.44 (0.32)	0.93 (0.11)	* 1.45 (0.22)	1.13 (0.09)	1.52 (0.24)	1.21 (0.11)	1.50 (0.20)
Std C/Std Y	0.76 (0.06)	0.65 (0.14)	0.54 (0.12)	0.42 (0.09)	0.72 (0.08)	** 0.46 (0.03)	1.39 (0.22)	1.22 (0.10)	1.06 (0.17)	** 0.56 (0.08)	1.24 (0.11)	** 0.75 (0.03)	0.90 (0.08)	0.78 (0.04)	0.89 (0.04)	** 0.70 (0.03)	0.92 (0.07)	** 0.61 (0.05)
Std I/Std Y	3.25 (0.31)	4.21 (0.39)	NaN (NaN)	NaN (NaN)	3.28 (0.35)	2.46 (0.30)	4.82 (0.66)	6.44 (0.55)	5.65 (0.44)	** 3.20 (0.27)	4.18 (0.50)	3.70 (0.33)	3.51 (0.36)	4.20 (0.29)	3.56 (0.19)	3.80 (0.26)	2.92 (0.14)	2.98 (0.15)
Std GS/Std Y	0.72 (0.11)	0.62 (0.13)	1.29 (0.24)	0.92 (0.12)	1.27 (0.22)	** 0.59 (0.09)	1.26 (0.18)	1.45 (0.22)	0.61 (0.14)	0.42 (0.11)	0.91 (0.14)	0.71 (0.15)	1.13 (0.23)	0.69 (0.13)	1.11 (0.16)	* 0.68 (0.10)	1.02 (0.09)	** 0.62 (0.09)
Std UE/Std Y	5.36 (0.31)	6.40 (0.50)	24.91 (2.30)	** 10.09 (1.47)	4.13 (0.39)	3.76 (0.42)	10.73 (1.12)	12.20 (1.38)	13.50 (1.74)	** 4.92 (0.86)	6.72 (0.99)	** 3.87 (0.40)	8.53 (1.19)	9.35 (0.87)	7.64 (0.73)	7.48 (0.63)	6.84 (0.53)	5.58 (0.53)
Std Infl/Std Y	0.29 (0.06)	0.51 (0.11)	0.32 (0.06)	0.26 (0.03)	0.29 (0.04)	** 0.17 (0.02)	0.26 (0.04)	** 0.60 (0.11)	0.48 (0.10)	** 0.20 (0.03)	0.59 (0.12)	0.35 (0.07)	0.34 (0.07)	0.42 (0.10)	0.36 (0.05)	0.36 (0.07)	0.28 (0.04)	0.26 (0.02)
Std RX/Std Y	2.42 (0.37)	3.81 (0.66)	6.01 (1.41)	3.48 (0.51)	7.11 (1.05)	** 3.26 (0.60)	1.96 (0.37)	* 3.49 (0.60)	3.84 (0.62)	* 2.15 (0.51)	3.86 (0.68)	3.14 (0.49)	4.84 (1.19)	2.90 (0.41)	5.04 (0.91)	* 3.05 (0.38)	2.71 (0.41)	** 0.27 (0.04)
Std NX/Std Y	0.45 (0.07)	** 0.87 (0.13)	0.29 (0.07)	0.25 (0.03)	0.24 (0.05)	0.13 (0.03)	1.21 (0.20)	1.23 (0.21)	0.42 (0.10)	0.23 (0.05)	0.34 (0.07)	0.19 (0.04)	0.21 (0.03)	** 0.11 (0.01)	0.26 (0.03)	* 0.18 (0.02)	0.38 (0.04)	* 0.28 (0.03)
Corr. Y Y*	0.83 (0.04)	0.91 (0.10)	0.53 (0.14)	0.78 (0.06)	0.00 (0.20)	** 0.83 (0.08)	−0.17 (0.22)	** 0.65 (0.09)	0.64 (0.09)	0.90 (0.10)	0.69 (0.09)	0.88 (0.10)	0.67 (0.08)	* 0.93 (0.10)	0.53 (0.08)	** 0.90 (0.09)	0.66 (0.06)	* 0.94 (0.09)
Corr. C C*	0.79 (0.06)	0.71 (0.06)	0.28 (0.24)	0.36 (0.09)	−0.13 (0.19)	** 0.62 (0.11)	−0.22 (0.18)	** 0.81 (0.07)	0.35 (0.20)	* 0.85 (0.08)	0.58 (0.12)	0.84 (0.06)	0.49 (0.09)	* 0.76 (0.07)	0.38 (0.09)	** 0.73 (0.05)	0.56 (0.05)	0.70 (0.06)
Corr. I I*	0.55 (0.14)	* 0.95 (0.11)	NaN (NaN)	NaN (NaN)	0.01 (0.23)	** 0.83 (0.07)	0.05 (0.18)	** 0.63 (0.12)	0.37 (0.14)	** 0.90 (0.08)	0.72 (0.10)	0.80 (0.06)	0.28 (0.18)	** 0.93 (0.10)	0.28 (0.16)	** 0.90 (0.08)	0.64 (0.05)	** 0.92 (0.07)
Corr. GS GS*	0.12 (0.21)	* 0.60 (0.12)	0.01 (0.17)	0.36 (0.14)	−0.52 (0.10)	** 0.28 (0.18)	0.21 (0.17)	0.26 (0.11)	0.49 (0.10)	0.26 (0.14)	0.27 (0.20)	0.08 (0.15)	−0.28 (0.16)	** 0.60 (0.10)	−0.23 (0.13)	** 0.47 (0.09)	0.38 (0.08)	0.26 (0.12)
Corr. UE UE*	0.92 (0.08)	0.93 (0.08)	0.88 (0.09)	* 0.56 (0.13)	−0.09 (0.25)	** 0.82 (0.06)	−0.29 (0.19)	** 0.68 (0.09)	0.86 (0.07)	0.73 (0.08)	0.86 (0.08)	0.67 (0.09)	0.89 (0.08)	0.93 (0.08)	0.68 (0.08)	* 0.87 (0.06)	0.71 (0.04)	0.69 (0.05)
Corr. Infl Infl*	0.30 (0.13)	** 0.68 (0.05)	0.52 (0.10)	0.73 (0.06)	0.35 (0.16)	0.51 (0.08)	−0.04 (0.14)	* 0.32 (0.07)	0.26 (0.13)	** 0.72 (0.05)	0.09 (0.10)	0.37 (0.11)	0.42 (0.15)	0.72 (0.06)	0.36 (0.11)	* 0.64 (0.03)	0.52 (0.04)	** 0.64 (0.03)

Table A-1: For GE, NE, and BE: relative variables are towards EA6. Other countries: relative variables are towards (remaining) EA9. Time period: 1985Q1-2011Q3. Time-varying (4 quarters rolling window) trade shares were used as weights. All variables are expressed in logs (except Infl and NX) and HP-filtered from 1970Q1-2011Q3. Standard errors are given in small fonts. Asterisks denote 5% and 1% significant differences. Averages are weighted with long-run PPP-adjusted GDP.

Table A-2: Theoretical moments: sources of fluctuations

	PreEMU					EMU			
	ALL	**TEC**	**MON**	**GOV**	**UIP**	**ALL**	**TEC**	**MON**	**GOV**
Domestic									
Std Y * 100	1.00	0.96	0.16	0.19	0.12	0.97	0.81	0.51	0.15
Std C/Std Y	0.98	1.00	1.17	0.43	0.17	0.96	0.94	1.05	0.25
Std I/Std Y	2.52	2.61	2.00	0.81	0.43	2.56	2.71	2.28	0.63
Std G/Std Y	1.31	0.25	0.32	6.70	0.36	0.94	0.04	0.06	5.92
Std U/Std Y	9.14	9.49	5.93	1.28	0.36	8.90	9.63	7.41	1.40
Std π/ Std Y	0.06	0.04	0.21	0.10	0.05	0.16	0.12	0.23	0.10
Foreign									
Std Y * 100	0.65	0.60	0.19	0.03	0.09	0.62	0.56	0.23	0.03
Std C/Std Y	0.89	0.85	1.17	4.49	0.12	0.87	0.80	1.22	0.91
Std I/Std Y	2.78	2.89	1.83	2.57	0.24	2.77	2.95	1.50	2.35
Std G/Std Y	0.74	0.06	0.06	16.99	0.06	0.43	0.01	0.01	8.42
Std U/Std Y	4.82	4.99	3.46	7.40	0.74	4.98	5.32	2.39	2.46
Std π/ Std Y	0.20	0.16	0.46	0.23	0.21	0.31	0.27	0.50	0.31
Trade									
Std RX/Std Y	2.16	0.67	1.53	0.18	17.10	0.50	0.57	0.24	0.14
Std NX/Std Y	0.14	0.04	0.05	0.09	1.12	0.04	0.04	0.04	0.08
Cross-country									
Corr Y Y^*	0.28	0.32	0.11	-0.36	-1.00	0.58	0.53	0.87	-0.10
Corr C C^*	0.23	0.24	0.08	0.20	-0.96	0.69	0.59	0.90	0.58
Corr I I^*	0.30	0.27	0.14	0.96	-0.98	0.35	0.32	0.79	0.07
Corr G G^*	0.00	0.20	0.08	-0.00	-0.87	0.01	-0.57	-1.00	-0.00
Corr U U^*	0.42	0.41	0.20	-0.26	-0.92	0.50	0.51	0.75	-0.38
Corr $\pi\pi^*$	0.13	0.02	0.36	-0.56	-1.00	0.18	-0.55	0.94	0.49

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. UIP shocks are absent under EMU.

B Data sources and issues

B.1 Sources

Data are taken from the OECD Economic Outlook, the Main Economic Indicators, Monthly Statistics of International Trade, and the Quarterly National Accounts databases, all available from the 'SourceOECD' collection. We also use the OECD STAN database for structural analysis and the AMECO database of the European Commission DG ECFIN.

For Canada, Finland, France, Germany (Western Germany before 1991), Ireland, Italy, Norway, Japan, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States, we take the following series from the Economic Outlook: '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'. Note that government spending is defined as the sum of government investment and consumption where data on government investment is available.[38]

For the same countries we obtain the following series from the STAN database: 'Production (gross output), volumes' as well as 'Production (gross output), current prices' in 'Manufacturing' and 'Total services'; and the following series from from the AMECO database: 'Net capital stock per unit of gross domestic product at constant market prices: Capital output ratio: total economy (AKNDV)' and 'Adjusted wage share: total economy: as percentage of GDP at current factor cost (Compensation per employee as percentage of GDP at factor cost per person employed.) (ALCD2)'.

The computation of Solow residuals is based on labor inputs only (as the capital stock adjusts only very little at high frequency and data on the capital stock is not generally available). We obtain the following series from the OECD Main Economic Indicators: 'Production of total industry sa'; 'Civilian employment: industry including construction sa' (where not available—GE, FR, and IR—series for 'Production in total manufacturing sa' and 'Weekly hours worked (paid): manufacturing' or 'Employees: manufacturing sa' and 'Civilian employment: services sa'. Where available, data for (Output of) 'Services' are from the OECD Quarterly National Accounts. We only consider data up to 2006Q4, because the German labor series ends at that date. We also include a dummy at the time of the re-unification in equation for Germany.

B.2 Foreign aggregate and parameter values

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 then aggregating the weighted series. German growth rates are West-German growth rates until 1990Q4, and unified Germany's growth rates from 1991Q1 onwards. Weights are calculated as the time-varying percentage shares of trade (imports+exports) with the respective country (lagged four quarter rolling window).

The aggregated growth rates are then cumulated from the normalized base 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.

[38]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.

Concerning the values for the labor share, the capital-to-output ratio, and the price durations, the averages of the above mentioned time-varying trade weights were used as weights. These weights were adjusted for the fact that data for Ireland is missing in the case of price durations. The average capital-to-output ratio, the labor share, and government spending over GDP were calculated by aggregating the two long-run averages for Germany and EA6 using average PPP adjusted GDP weights, yielding values of 11.99, 0.66, and 0.21 respectively. We compute the average of the ratio manufacturing relative to services output using the averages of time-varying trade weights (adjusted for the missing data for Portugal, Spain, and Ireland).

B.3 Filtering

We generally apply the HP-filter with a smoothing parameter of 1600 to the time series data, before computing statistics of interest. We apply the filter from the earliest available period (1970) until the end of the samples to remove the trend. We follow the same approach to compute the output gap. Note that data used in the estimation of the Taylor rule is not filtered. Since the calculation of the UIP shocks relies on forecasts based on data available in each period, first differences were used instead of the two-sided HP-filter to remove trends.

B.4 Wald test

In section 2, we use a non-linear Wald test to evaluate whether changes in business cycle statistics are significant. The test statistic of the Wald test is given by

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

with b being a vector of variances of the original variables. The function $r(b)$ maps these variances into the statistic of interest, for example $Std(C_{EMU})/Std(Y_{EMU}) - Std(C_{PreEMU})/Std(Y_{PreEMU})$. 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.

References

Artis, M. J. and Zhang, W. (1997). International business cycles and the erm: Is there a european business cycle? *International Journal of Finance & Economics*, 2(1):1–16.

Bacchetta, P. and van Wincoop, E. (2010). Infrequent portfolio decisions: A solution to the forward discount puzzle. *American Economic Review*, 100:837–869.

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., Ciccarelli, M., and Ortega, E. (2007). Similarities and convergence in G-7 cycles. *Journal of Monetary Economics*, 54:850–878.

Canova, F., Ciccarelli, M., and Ortega, E. (2012). Do institutional changes affect business cycles? Evidence from Europe. *Journal of Economic Dynamics and Control*, 36(10):1520–1533.

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.

Chari, V. V., Kehoe, P. J., and McGrattan, E. R. (2007). Business cycle accounting. *Econometrica*, 75:781–836.

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 Economic Review*, 42:1033–1067.

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.

Del Negro, M. and Otrok, C. (2008). Dynamic factor models with time-varying parameters: measuring changes in international business cycles. Staff Reports 326, Federal Reserve Bank of New York.

Devereux, M. B. and Engel, C. (2003). Monetary policy in the open economy revisited: Price setting and exchange-rate flexibility. *Review of Economic Studies*, 70:765–783.

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 Economic 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.

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 for 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 a 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*, 18:533–572.

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

Giannone, D., Lenza, M., and Reichlin, L. (2009). Business cycles in the euro area. In Alesina, A. and Giavazzi, F., editors, *Europe and the Euro*, pages 141–167. University of Chicago Press.

Gregory, A. W. and Head, A. C. (1999). Common and country-specific fluctuations in productivity, investment and the current account. *Journal of Monetary Economics*, 44:423–451.

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*, 98(4):1653–1674.

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

Jung, P. and Kuester, K. (2011). The (un)importance of unemployment fluctuations for welfare. *Journal of Economic Dynamics and Control*, 35:1744–1768.

Jung, P. and Kuhn, M. (2010). The era of the U.S.-Europe labor market divide: What can we learn? Working paper.

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 Economic Association*, 2(2-3):289–301.

Kollmann, R. (2005). Macroeconomic effects of nominal exchange rate regimes: new insights into the role of price dynamics. *Journal of International Money and Finance*, 24:275–292.

Kollmann, R., Enders, Z., and Müller, G. (2011). Global banks and international business cycles. *European Economic Review*, 55:407–426.

Krugman, P. (1993). Lessons of Massachusetts for EMU. In Giavazzi, F. and Torres, F., editors, *The transition to Economic and Monetary Union in Europe*, pages 241–261. Cambridge University Press.

Lubik, T. and Schorfheide, F. (2005). A bayesian look at new open economy macroeconomics. In Gertler, M. and Rogoff, K., editors, *NBER Macroeconomics Annual 2005, Volume 20*, pages 313–366. MIT Press, Cambridge MA.

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

Monacelli, T. (2004). Into the Mussa puzzle: monetary policy regimes and the real exchange rate in a small open economy. *Journal of International Economics*, 62:191–217.

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.

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. *Economic Policy*, 30.

Rotemberg, J. and Woodford, M. (1993). Dynamic general equilibrium models with imperfecly comptetitive product markets. NBER Working Paper 4502.

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. *American Economic Review*, 95(1):25–49.

Stock, J. H. and Watson, M. W. (2005). Understanding changes in international business cycle dynamics. *Journal of the European Economic Association*, 3(5):968–1006.

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.

Woodford, M. (2003). *Interest & Prices*. Princeton University Press, Princeton, New Jersey.