Business Cycle Synchronization in Europe – The Role of Price and Wage Rigidities*

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Abstract

The role of the transmission of economic fluctuations between countries for their respective economic performance has been analyzed extensively in different theoretical and econometric frameworks. This paper contributes to this literature by presenting a model in the framework of the rapidly evolving New Open Economy Macroeconomics literature. I assess the transmission properties of technology shocks and provide some interesting insights into the sources of economic synchronization tendencies. In contrast to earlier studies, the transmission of asynchronous shocks across borders appears to be actually relevant for national business cycles. The model shows a relatively strong impact of asynchronous shocks on trade partners and therefore reveals a possibly important source of economic synchronization.

Keywords: Open Economy Macroeconomics; Business Cycles; International Transmission.

JEL class: E32, F36, F41, F42

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1 Introduction

In the advent of the European Monetary Union and its eastward enlargement, business cycle transmission between the European economies has drawn considerable interest in macroeconomic research. This is of course due to the fact that, as, among others, Bayoumi and Eichengreen (1993) have noted, a synchronous behavior of business cycles is a vital prerequisite for an efficient monetary policy. With transmission being a possible source of business cycle synchronization (see e.g. Frankel and Rose, 1998), the impact and channels of transmission on business cycles’ parallels have been extensively discussed in recent literature.

From an empirical perspective, there seems to be a broad consensus that the members of the EMU show significant similarities concerning their aggregate cyclical behavior. This tendency towards a so called “European Business Cycle” has been shown in a series of papers by Artis et al. (1997, 1998, 1999). Further empirical evidence has been presented by, among others, Dueker and Wesche (2001) and Lumsdaine and Prasad (2003).

However, even if one agrees upon the existence of a common European business cycle, the causes for the cyclical similarities remain unclear. In general, two major sources of synchronization have been discussed in international business cycle models: common shocks and the transmission of country specific shocks. Some authors (see, among others, Anderson et al., 1999 or Laxton and Prasad, 2000) stress the importance of trade linkages for the synchronization of international business cycles. However, e.g. Dellas (1986) and Canova and Marrinan (1998) were able to show that realistic output fluctuations cannot be reproduced via the transmission mechanism alone. Instead, the presence of a common exogenous shock appears to be necessary to quantitatively match the data gathered in empirical studies. This is in line with a recent study of mine (Fichtner, 2003) that shows that transmission of economic fluctuations over the trade channel appears to be of minor importance for the synchronization of national business cycles in Europe.

Yet, these findings are derived under the assumption of flexible prices and wages and are thus to be taken with caution, as the endogenous shock propagation of real business cycle models is generally to be assessed rather low. This has been a widely discussed shortcoming of models in the RBC tradition, as is documented for example by Backus et al. (1995) and Baxter (1995).

The present paper therefore relies on a model in the NOEM framework to incorporate a wider array of interdependencies and richer dynamics into the analysis of business
cycle synchronization across countries. I use a DSGE model of three countries similar to
the one proposed by Ghironi (2000). His model is extended by using Kollmann’s (2001)
richer structure to model each country’s internal economic conditions. The model thus
features the elements characterizing the models in the tradition of Obstfeld and Rogoff’s
(1995) seminal Redux paper such as nominal rigidities and imperfect competition.

The introduction of nominal rigidities does, as I am able to show, indeed strengthen
the transmission of shocks across countries. Thus, the trade channel appears to be
underestimated in previous works due to the missing dynamics of nominal rigidities and
market imperfections. In the NOEM framework presented here, trade does undoubtedly
lead to a strong synchronization of economic fluctuations.¹

The paper is structured as follows: Section 2 outlines the model’s structure and basic
assumptions and describes the optimization behavior of agents. Section 3 describes
the derivation of the model’s steady state, section 4 presents the model’s log-linearized
dynamic behavior. Section 5 presents some first insights into the dynamic properties
of the model and the impact of technology shocks. Section 6 concludes and gives an
outlook on future enhancements of the paper.

2 The Model

The model follows in its structural definition the model presented by Ghironi (2000),
i.e. the world economy consists of two regions: Europe and the U.S. (or, presumably,
the rest of the world). While the U.S. consist of one single economy (country 1), the
European region is formed by two different countries (2 and 3).

Each of the three countries produces a single final good and a continuum of inter-
mediate goods indexed by $z$. The final good is produced from domestic and imported
intermediate goods and is sold in a perfectly competitive environment. In contrast, the
intermediate goods are produced using exclusively domestic production factors and are
sold under monopolistic competition. Note that the U.S. produces the full range of in-
termediate goods $z \in [0, 1]$, whereas the European countries each produce only a given
fraction ($a$ and $1 - a$, respectively) of the intermediate goods such that country 2 pro-
duces $z \in [1, 1 + a]$ and country 3 produces $z \in (1 + a, 2)$.² The number of households
responds to this relative size.³

¹ In this preliminary version of the paper, the application to economic conditions in Europe is rather
incomplete. Future revisions will present a more thorough comparison to empirical observations.
² Production factors are assumed to be immobile between the European economies.
³ I will use $a_1^l = 1, a_2^l = a, a_3^l = 1 - a$ or $a_1^h = 0, a_2^h = a_3^h = 1, a_2^l = a_3^l = 1 + a, a_2^h = 2$ in different
2.1 Final goods

The final good in country $i$ is produced from intermediate goods by $a_i$ firms according to the production function

$$Y_{1t}^i = \left\{ \left(1 - b\right) \frac{1}{\theta} \cdot \int_0^1 y_{1t}^{1,1}(z)^{(\theta-1)/\theta} \, dz + b \frac{1}{\theta} \cdot \left[ \int_1^{1+\alpha} y_{1t}^{2,1}(z)^{(\theta-1)/\theta} \, dz + \int_{1+a}^2 y_{1t}^{3,1}(z)^{(\theta-1)/\theta} \, dz \right] \right\}^{\frac{\theta}{\theta-1}}, \quad (2.1)$$

where $b$ is the weight of imported goods in the production of country $1$’s final good. An analogous expression is formed for the two European countries:

$$Y_{2t}^i = \left\{ b \frac{1}{\theta} \cdot \int_0^1 y_{2t}^{1,2}(z)^{(\theta-1)/\theta} \, dz + \left(1 - b\right) \frac{1}{\theta} \cdot \left[ \int_1^{1+\alpha} y_{2t}^{2,2}(z)^{(\theta-1)/\theta} \, dz + \int_{1+a}^2 y_{2t}^{3,2}(z)^{(\theta-1)/\theta} \, dz \right] \right\}^{\frac{\theta}{\theta-1}}, \quad (2.2)$$

$$Y_{3t}^i = \left\{ b \frac{1}{\theta} \cdot \int_0^1 y_{3t}^{1,3}(z)^{(\theta-1)/\theta} \, dz + \left(1 - b\right) \frac{1}{\theta} \cdot \left[ \int_1^{1+\alpha} y_{3t}^{2,3}(z)^{(\theta-1)/\theta} \, dz + \int_{1+a}^2 y_{3t}^{3,3}(z)^{(\theta-1)/\theta} \, dz \right] \right\}^{\frac{\theta}{\theta-1}}, \quad (2.3)$$

Again, $b$ denotes the fraction of imported (i.e., US) intermediate goods in the production of the final good. Aggregate production of the respective country is $\tilde{Y}_i^t = a_i \cdot Y_i^t$.

Note that the final good is not tradable. This implies that the respective countries consumer price index $P_{1t}^i$ is given by the price of the final good, which is in turn due to perfect competition determined by the minimal expenditure required to produce one unit of $Y_i^t$:

$$P_{1t}^i = \min_{y_{1t}^{1,i}(z)} \left\{ \int_0^1 e_t^{1,i} p_{1t}^i(z) y_{1t}^{1,i}(z) \, dz + \int_1^{1+\alpha} e_t^{2,i} p_{1t}^2(z) y_{1t}^{2,i}(z) \, dz + \int_{1+a}^2 e_t^{3,i} p_{1t}^3(z) y_{1t}^{3,i}(z) \, dz \right\} \quad \text{s.t. } Y_i^t = 1,$$

Contexts to avoid cluttering the notation.
where $e^{i,j}_t$ denotes the price of one unit of country $j$’s currency in terms of country $i$’s currency and $p^j_t(z)$ the price of good $z$ produced in country $j$ in the producing country’s currency.

The price index is thus given by

$$
P^1_t = \left\{ (1 - b) \int_0^1 p^1_t(z)^{1-\theta} \, dz + b \int_1^{1+a} \left( e^{1,1}_t p^1_t(z) \right)^{1-\theta} \, dz + \int_1^{2} \left( e^{2,1}_t p^1_t(z) \right)^{1-\theta} \, dz \right\}^{1/1-\theta},
$$

$$
P^2_t = \left\{ b \int_0^1 \left( e^{1,2}_t p^1_t(z) \right)^{1-\theta} \, dz + (1 - b) \int_1^{1+a} \left( e^{2,2}_t p^2_t(z) \right)^{1-\theta} \, dz + \int_1^{2} \left( e^{2,2}_t p^3_t(z) \right)^{1-\theta} \, dz \right\}^{1/1-\theta},
$$

$$
P^3_t = \left\{ b \int_0^1 \left( e^{1,3}_t p^1_t(z) \right)^{1-\theta} \, dz + (1 - b) \int_1^{1+a} \left( e^{2,3}_t p^2_t(z) \right)^{1-\theta} \, dz + \int_1^{2} \left( e^{2,3}_t p^3_t(z) \right)^{1-\theta} \, dz \right\}^{1/1-\theta}.
$$

(2.4)

Note that using $e^{i,j}_t = 1/e^{j,i}_t = e^{k,j}_t/e^{i,k}_t$ in these equations shows that consumption based PPP holds within Europe, i.e. $P^2_t = e^{3,2}_t \cdot P^3_t$, but not across the Atlantic Ocean ($P^1_t \neq e^{2,1}_t \cdot P^2_t$).

Aggregate demand curves are given by

$$
y^{i,j}_t(z) = b^{i,j} \cdot \left( \frac{e^{i,j}_t p^1_t(z)}{P^3_t} \right)^{-\theta} y^j_t,
$$

(2.5)

where

$$
b^{1,1} = (1 - b), \quad b^{1,2} = b \cdot a, \quad b^{1,3} = b \cdot (1 - a),
$$

$$
b^{2,1} = b, \quad b^{2,2} = (1 - b) \cdot a, \quad b^{2,3} = (1 - b) \cdot (1 - a),
$$

$$
b^{3,1} = b, \quad b^{3,2} = (1 - b) \cdot a, \quad b^{3,3} = (1 - b) \cdot (1 - a),
$$

(2.6)

has been defined for notational clarity.

### 2.2 Intermediate goods

The production function of the firm producing intermediate good $z$ in country $i$ is

$$
y^{i,S}_t(z) = Z^i_t \cdot K^i_t(z) \alpha L^i_t(z)^{1-\alpha},
$$

(2.7)

where $Z^i_t$ is a country specific productivity parameter, $K^i_t(z)$ is the physical capital stock used by firm $z$ at date $t$ and $L^i_t(z)$ is an index of different types of labor $h$ used by the
firm,
\[
L_t^i(z) = \left( \int_0^1 l_t^i(h, z)^{(\gamma - 1)/\gamma} \, dh \right)^{\gamma/(\gamma - 1)}.
\] (2.8)

Cost minimization implies
\[
l_t^i(h, z) = L_t^i(z) \left( \frac{w_t^i(h)}{W_t^i} \right)^{-\gamma}
\] (2.9)

where \(w_t^i(h)\) is the nominal wage for type \(h\) labor and \(W_t^i\) is an aggregate wage index
\[
W_t^i = \left\{ \int_0^1 w_t^i(h)^{1-\gamma} \, dh \right\}^{1/(1-\gamma)}.
\] (2.10)

Further, it is
\[
L_t^i(z) = \frac{1 - \alpha}{\alpha} \cdot \frac{R_t^i}{W_t^i} \cdot K_t^i(z),
\] (2.11)

where \(R_t^i\) denotes the nominal rental rate for capital.

The producer of intermediate good \(z\) maximizes the sum of his discounted real future profits
\[
\sum_{\tau=0}^{\infty} E_t \{ \rho_t^{i, t+\tau} \cdot \Pi_t^{i, t+\tau}(z) \}.
\] (2.12)

As firms are assumed to be owned by households, weights for future profits correspond to the households’ intertemporal marginal rate of substitution, i.e.
\[
\rho_t^{i, t+\tau} = \beta^\tau \cdot \frac{\partial u_t^{i, t+\tau} / \partial C_t^{i, t+\tau}}{\partial u_t^i / \partial C_t^i}.
\] (2.13)

Note that period \(t\)’s real profits are given by
\[
\Pi_t^i(z) = \frac{p_t^i(z)}{P_t^i} \cdot y_t^{i, D}(z) - \frac{R_t^i}{P_t^i} \cdot K_t^i(z) - \frac{W_t^i}{P_t^i} \cdot L_t^i(z)
\] (2.14)

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4 See Woodford (2003), chapter 2.1.
or, due to the linear homogeneity of the production function,

\[ \Pi_i^t(z) = y_i^t(z) \left( \frac{p_i^t(z)}{P_i^t} - MC_i^t \right), \]  

where

\[ MC_i^t = \frac{1}{P_i^t} \left[ \frac{1}{Z_i^t} \cdot \left( \frac{R_i^t}{\alpha} \right) \left( \frac{W_i^t}{1 - \alpha} \right)^{1-\alpha} \right] \]  

\[ = \frac{1}{Z_i^t} \cdot \left( \frac{R_i^t}{\alpha} \right) \left( \frac{W_i^t}{1 - \alpha} \right)^{1-\alpha} \]  

are marginal cost of production in real terms.

Total demand for good \( z \) produced in country \( i \) amounts to

\[ y_{i,D}^t(z) = \sum_{j=1}^{3} b_{i,j} \left( e_{i,j}^t P_j^t \right)^{-\theta} Y_j^t \cdot p_i^t(z)^{-\theta} \equiv \Omega_i^t \cdot p_i^t(z)^{-\theta}. \]  

Prices are set as suggested by Calvo (1983). The probability of a firm being “allowed” to reoptimize its price is denoted by \((1 - \delta)\). The optimal price \( p^{*,i}_t(z) \) set in period \( t \) by the firm will therefore be

\[ p^{*,i}_t(z) = \arg \max_{\tau=0}^{\infty} \delta^\tau \cdot E_t \left\{ \rho_{t,t+\tau}^i \cdot \Pi_{t+\tau}^i(z) \right\}, \quad \text{s. t.} \quad p_{t+\tau}^i(z) = p^{*,i}_t(z) \]  

and \( y_{t+\tau}^{i,D}(z) = y_{t+\tau}^{i,S}(z) \).

The solution to the maximization problem is determined by the equation

\[ \sum_{\tau=0}^{\infty} \delta^\tau \cdot E_t \left\{ \rho_{t,t+\tau}^i \cdot \frac{\partial \Pi_{t+\tau}^i(z)}{\partial p^{*,i}_t} \right\} = 0, \]  

which yields

\[ p^{*,i}_t = \frac{\theta}{\theta - 1} \frac{\sum_{\tau=0}^{\infty} \delta^\tau \cdot E_t \left\{ \rho_{t,t+\tau}^i \cdot \Omega_{t+\tau}^i \cdot MC_{t+\tau}^i \right\}}{\sum_{\tau=0}^{\infty} \delta^\tau \cdot E_t \left\{ \rho_{t,t+\tau}^i \cdot \Omega_{t+\tau}^i \right\}}. \]
Using (2.4), the law of motion for the CPI can be derived as:

\[ P_t^{1-\theta} = \delta P_{t-1}^{1-\theta} + (1 - \delta) \cdot \left((1 - b)p_t^{*1-\theta} + b \cdot \left(a \cdot \left(e_t^{2,1} p_t^{*2}\right)^{1-\theta} + (1 - a) \cdot \left(e_t^{3,1} p_t^{*3}\right)^{1-\theta}\right)\right) \] (2.22a)

\[ P_t^{21-\theta} = \delta P_{t-1}^{21-\theta} + (1 - \delta) \cdot \left(b \left(e_t^{1,2} p_t^{*1}\right)^{1-\theta}
+ (1 - b) \cdot \left(a \cdot p_t^{*21-\theta} + (1 - a) \cdot \left(e_t^{3,2} p_t^{*3}\right)^{1-\theta}\right)\right) \] (2.22b)

\[ P_t^{31-\theta} = \delta P_{t-1}^{31-\theta} + (1 - \delta) \cdot \left(b \left(e_t^{1,3} p_t^{*1}\right)^{1-\theta}
+ (1 - b) \cdot \left(a \cdot \left(e_t^{2,3} p_t^{*2}\right)^{1-\theta} + (1 - a) \cdot p_t^{*31-\theta}\right)\right) \] (2.22c)

Further, we can derive a law of motion for a newly defined helper price index \( P_t^i = \left[\int_{a^h}^{a^l} p_t^i(z)^{-\theta} \, dz\right]^{-1/\theta} \), such that

\[ P_t^{i-\theta} = \delta P_{t-1}^{i-\theta} + (1 - \delta) \cdot \left((a^h_i - a^l_i) \cdot p_t^{*i-\theta}\right) \quad (2.23) \]

which can be used for easily determining aggregate demand

\[ y_t^i = \int_{a^l}^{a^h} y_t^i(z) \, dz = \Omega_t^{i-\theta} \cdot P_t^{i-\theta}. \] (2.24)

### 2.3 Physical capital

Total demand for physical capital in country \( i \) is

\[ K_t^i = \int_{a^l}^{a^h} K_t^i(z) \, dz \] (2.25)

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5 Note that prices are set in the buyer’s currency, i.e. exchange rate fluctuations do not feed into the price once it has been fixed.
2. The Model

with

\[ K_i(z) = \frac{y_i(z)}{Z_i^{\alpha \left( \frac{W_i}{1 - \alpha R_i} \right)^1 - \alpha} } \quad (2.26) \]

and thus

\[ K_i = \frac{y_i(z)}{Z_i^{\alpha \left( \frac{W_i}{1 - \alpha R_i} \right)^1 - \alpha} } . \quad (2.27) \]

Capital is rented to the intermediate goods’ producers by a capital rental firm, that invests in it’s capital stock according to the law of motion

\[ K_i = (1 - \Delta) K_{i-1} + I_{i-1} - CK_{i-1}, \quad (2.28) \]

where \( CK_{i-1} = \frac{\phi (K_{i-1} - K_{i-2})^2}{K_{i-1}} \) is a convex capital stock adjustment cost denoted in terms of the final good.

The capital rental firm maximizes it’s expected real future cash flow:

\[
\max_{\tau=0}^\infty E_t \left\{ \rho_{t,t+\tau} \left( \frac{R_{t+\tau}^{i} K_{t+\tau}^{i} - P_{t+\tau}^{i} I_{t+\tau}^{i}}{P_{t+\tau}^{i}} \right) \right\}, \quad (2.29)
\]

This yields the following Euler equation for the capital stock:

\[
E_t R_{t+1}^{i} = E_t \left\{ \left( 1 + \frac{\phi \cdot K_{t+1}^{i} - K_t^{i}}{\rho_{t,t+1}} \right) - (1 - \Delta) - \frac{\phi}{2} \frac{K_t^{i}}{K_{t+1}^{i}} \right\} \quad (2.30)
\]

where \( R_t^{i} = \frac{P_t^{i}}{P_t} \) denotes the rental rate of capital in real terms.

2.4 Households’ decision

The representative household in country \( i \) maximizes it’s expected life-time utility described by

\[
U_t = \max_{\tau=0}^\infty E_t \left\{ \sum_{\tau=0}^\infty \beta^\tau u_{t+\tau}^{i} \left( C_{t+\tau}^{i}, M_{t+\tau}^{i}, L_{t+\tau}^{i} \right) \right\}, \quad (2.31)
\]
with
\[ u^i_t = \frac{1}{1 - \Psi} \left( C^i + \kappa \cdot M^i \right)^{(1-\Psi)/\Sigma} - L^i_t \] (2.32)

subject to the budget constraint
\[ M^i_{t+1} + \sum_{j=1}^{3} e^{j,i} A^{j,i}_{t+1} + v^i S^i_{t+1} + P^i C^i_t + T^i_t = M^i_t + \sum_{j=1}^{3} e^{j,i} A^{j,i}_t + (1 + d^i_t) v^i_{t-1} S^i_t + W^i_t L^i_t. \] (2.33)

Note that \( L^i_t = \frac{1}{a^i} \int_{a^i}^{a^i_h} L^i(z) \, dz \) has been defined for simplicity. It denotes per capita labor supply. \( A^{j,i}_t \) is the household’s nominal stock of bonds issued in country \( j \) that are being held at the end of period \( t-1 \). \( R^i_t \) is the respective country’s gross nominal interest rate. \( v^i_t \) is the nominal price of one equity share of the representative intermediate good firm in country \( i \). \( S^i_t \) is the number of equity shares held by the household at the end of period \( t-1 \). \( d^i_t \) denotes the return on equities between period \( t-1 \) and \( t \). \( T^i_t \) is a nominal per capita tax on households.

Note that the overall return on investment in home country firms is
\[ 1 + d^i_t = \frac{v^i_t + \Pi^i_t + R^i_t K^i_t - P^i_t I^i_t}{v^i_{t-1}}, \] (2.34)
where \( \Pi^i_t = \int_{a^i}^{a^i_h} \Pi^i_t(z) \, dz \) denotes the intermediate good producers’ profits in period \( t \) and \( R^i_t K^i_t - P^i_t I^i_t \) is the capital rental firm’s period \( t \) cash flow. Nominal profits of all intermediate good producers in country \( i \) are given by
\[ \Pi^i_t = \Omega^i_t \cdot \bar{P}^i_t (1-\theta) - \frac{R^i_t K^i_t}{\alpha}, \] (2.35)
where \( \bar{P}^i_t \) is a helper price index defined by
\[ \bar{P}^i_t (1-\theta) = \int_{a^i}^{a^i_h} p^i_t(z) (1-\theta) \, dz = \delta \int_{a^i}^{a^i_h} \bar{P}^i_{t-1} (1-\theta) + (1-\delta) (a^i_h - a^i) p^i_s (1-\theta). \] (2.36)

Solving the budget constraint for \( C^i_t \) and substituting the result in the utility function

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\(^{6}\) Remember that \( L^i_t(z) \) was total, i.e. aggregate, labor demand of firm \( z \) in country \( i \).
yields the unconstrained maximization problem of the household. It is solved by the following first order conditions:

\[ \beta \cdot E_t \left\{ \tilde{R}^{i}_{t+1} \cdot \frac{P^i_t}{P^i_{t+1}} \cdot \frac{u^{i}_{C,t+1}}{u^{i}_{C,t}} \right\} = 1, \]  
\[ \beta \cdot E_t \left\{ (1 + d^i_{t+1}) \cdot \frac{P^i_t}{P^i_{t+1}} \cdot \frac{u^{i}_{C,t+1}}{u^{i}_{C,t}} \right\} = 1, \]  
\[ \beta \cdot E_t \left\{ \frac{P^i_t}{P^i_{t+1}} \cdot \frac{u^{i}_{C,t+1} + u^{i}_{M,t+1}}{u^{i}_{C,t}} \right\} = 1, \]

with

\[ u^{i}_{C,t} = \frac{\partial u^{i}_{t}}{\partial C^i_t} = \left( C^i_t \Sigma + \kappa M^i_t \Gamma \right)^{\frac{1-\psi}{\Sigma}} \cdot C^i_t \Sigma^{-1}, \]  
\[ u^{i}_{M,t} = \frac{\partial u^{i}_{t}}{\partial M^i_t} = \frac{\kappa \Gamma}{\Sigma} \left( C^i_t \Sigma + \kappa M^i_t \Gamma \right)^{\frac{1-\psi}{\Sigma}} \cdot M^i_t \Gamma^{-1}, \]

where \( M^i_t = \frac{M^i_t}{P^i_t} \) denote real money holdings.

Note that (2.37a) and (2.37b) yield the familiar result that expected gross returns on asset holdings have to be equalized, i.e.

\[ E_t \left\{ \tilde{R}^{i}_{t+1} \right\} = E_t \left\{ 1 + d^i_{t+1} \right\}. \]  
\[ E_t \left\{ \tilde{R}^{j}_{t+1} \right\} = E_t \left\{ \tilde{R}^{j}_{t+1} \cdot \frac{e^{j,i}_{t+1}}{e^{j,i}_t} \right\}. \]  

### 2.5 Wage determination

Households are assumed to be wage setters. Thereby, wages can only be changed with a certain probability \( 1 - \xi \). Then, the same reasoning as above holds for the wage rate \( w^{i,*}_t \) set by the household in period \( t \): it is still in effect in period \( t + \tau \) with probability \( \xi^\tau \).

The household sets the wage rate for type \( h \) labor that maximizes it’s expected lifetime
utility subject to the budget constraint \(2.33\) and the labor demand curve

\[
l_t^i(h) = \int_{a_i}^{a_i} l_t^i(h, z) \, dz = \frac{1 - \alpha}{\alpha} \cdot \left( \frac{w_t^i(h)}{W_t^i} \right)^{-\gamma} \cdot \frac{R_t^i K_t^i}{W_t^i}. \tag{2.42}
\]

The optimum wage is therefore determined by

\[
w_{t}^{*, i} = \frac{\sum_{\tau=0}^{\infty} (\beta \xi)^{\tau} E_t \left\{ R_{t+\tau}^i K_{t+\tau}^i W_{t+\tau}^{\gamma - 1} \right\}}{\sum_{\tau=0}^{\infty} (\beta \xi)^{\tau} E_t \left\{ \frac{\partial u_t^i}{\partial C_t^i} \cdot R_{t+\tau}^i K_{t+\tau}^i W_{t+\tau}^{\gamma - 1} \right\}}. \tag{2.43}
\]

Following the same reasoning as above, the wage index obeys the law of motion

\[
W_t^{1-\gamma} = \xi W_{t-1}^{1-\gamma} + (1 - \xi)w_{t}^{*, i 1-\gamma}. \tag{2.44}
\]

### 2.6 Market clearing

Market clearing for the final good implies

\[
ai \cdot C_t^i + I_t^i = ai \cdot Y_t^i. \tag{2.45}
\]

Market clearing on bonds markets is

\[
A_t^{i+1} + a \cdot A_t^{i+2} + (1 - a) \cdot A_t^{i+3} = 0. \tag{2.46}
\]

The government’s budget constraint is in per capita terms given by

\[
T_t^i + M_{t+1}^i - M_t^i = 0, \tag{2.47}
\]

i.e. revenues from increases of the money stock are paid out to households in form of a non-distorting subsidy.

### 3 A symmetric steady state

The model’s behavior in response to small exogenous shocks is approximated by a log-linear expansion around a symmetric steady state in which all real variables are con-
Recall that \( y_i^t = \int_{a_i}^{b_i} y_i(z) \, dz \), such that
\[
y_i^t = a^i \cdot y_i^t(i)
\] (3.1)
in case of symmetric producers. Using \( \bar{Y}_1 = \bar{Y}_2 = \bar{Y}_3 \), this yields
\[
\begin{align*}
\bar{y}_1 &= (1 - b)\bar{Y}^1 + b(a \cdot \bar{Y}^2 + (1 - a) \cdot \bar{Y}^3) = \bar{Y}^1, \\
\bar{y}_2 &= a \cdot (b\bar{Y}^1 + (1 - b)(a \cdot \bar{Y}^2 + (1 - a) \cdot \bar{Y}^3)) = a \cdot \bar{Y}^2, \\
\bar{y}_3 &= (1 - a) \cdot (b\bar{Y}^1 + (1 - b)(a \cdot \bar{Y}^2 + (1 - a) \cdot \bar{Y}^3)) = (1 - a) \cdot \bar{Y}^3,
\end{align*}
\] (3.2)
for the case of a symmetric steady state where \( \bar{P}_i^t = \bar{P}_j^t(z) \) and \( \bar{e}_i^j, \bar{P}_i^t \).

Aggregate supply of the final good equals aggregate consumption and investment
\[
a^i \cdot \bar{Y}^i = \bar{y}^i = a^i \cdot \bar{C}_i^i + \Delta \bar{K}_i^i.
\] (3.3)

Further, due to (2.27) it is
\[
\bar{K}_i^i = \frac{\bar{y}_i^i}{Z^i} \cdot \left[ \frac{\alpha}{1 - \alpha} \cdot \frac{\bar{W}_i^i}{\bar{R}_i^i} \right]^{1-\alpha},
\] (3.4)
where
\[
\bar{R}_i^i = \frac{1}{\beta} - (1 - \Delta).
\] (3.5)

Per capita labor demand in the steady state is
\[
\bar{L}^i = \frac{1}{a^i} \cdot \frac{1 - \alpha}{\alpha} \cdot \frac{\bar{R}_i^i}{\bar{W}_i^i} \cdot \bar{K}_i^i.
\] (3.6)

The real price to be set by a fraction \( \delta \) of the producers of the intermediate good is given by the pricing equation (2.22) as
\[
\bar{R}P_i^i = \frac{1}{\pi_i} \cdot \left( \frac{\pi_i^{1-\theta} - \delta}{1 - \delta} \right)^{\frac{1}{1-\pi}},
\] (3.7)

\footnote{Note that symmetry applies to per-capita variables or, equivalently, the EU and the US are symmetric.}
solving the price setting equation for marginal costs gives

\[ \bar{MC}^i = \frac{\theta - 1}{\theta} \cdot (\delta \beta - 1) \cdot \bar{\pi}^i \cdot \bar{RP}^i. \] (3.8)

The real wage is determined by the wage setting equation (2.4) as

\[ \bar{w}^* = \bar{W} = \frac{\gamma}{\gamma - 1} \cdot \bar{u}_C^i. \] (3.9)

where

\[ \bar{u}_C^i = \frac{\partial \bar{w}^i}{\partial \bar{C}^i} = \left( \bar{C}^i \Sigma + \kappa \bar{M}^i \Gamma \right)^{\frac{1}{\beta} - \Sigma} \cdot \bar{C}^i \Sigma^{-1}. \] (3.10)

Note for future reference that

\[ \bar{u}_M^i = \frac{\kappa \Gamma}{\Sigma} \left( \bar{C}^i \Sigma + \kappa \bar{M}^i \Gamma \right)^{\frac{1}{\beta} - \Sigma} \cdot \bar{M}^i \Gamma^{-1}. \] (3.11)

In order to simplify the log-linear approximation presented in the following section I will assume a zero inflation steady state. This assumption will be relaxed in future versions of this paper. For now, it implies for the nominal interest rate that

\[ \bar{r}^i = \frac{1}{\beta}. \] (3.12)

Steady state real money demand according to (2.37c) is given by

\[ \bar{M}^i = \left[ \frac{1}{\kappa \Gamma} \cdot \left( \frac{1}{\beta} - 1 \right) \cdot \bar{C}^i \Sigma^{-1} \right]^{\frac{1}{\beta - 1}}. \] (3.13)

4 Log-linear approximation

The model’s behavior can now be approximated in the vicinity of the steady state.

Production of the final good is log-linearized by

\[ \tilde{Y}_t^1 = (1 - b) \cdot \tilde{y}_t^1 + b \cdot \left( a^{(\theta - 1)/\theta} \cdot \tilde{y}_t^1 + (1 - a)^{(\theta - 1)/\theta} \cdot \tilde{y}_t^1 \right) \] (4.1)

\[ \tilde{Y}_t^2 = b \cdot \tilde{y}_t^2 + (1 - b) \cdot \left( a^{(\theta - 1)/\theta} \cdot \tilde{y}_t^2 + (1 - a)^{(\theta - 1)/\theta} \cdot \tilde{y}_t^2 \right) \] (4.2)

* The following sections are particularly incomplete. Please check http://www.uni-koeln.de/wiso-fak/donges/fichtner.html for current versions.
\[ \hat{Y}_t^3 = b \cdot \hat{y}_t^{1,3} + (1 - b) \cdot \left( a^{(\theta - 1)/\theta} \cdot \hat{y}_t^{2,3} + (1 - a)^{(\theta - 1)/\theta} \cdot \hat{y}_t^{3,3} \right) \] (4.3)

The respective country specific demand is then given by

\[ \hat{y}_{it}^{i,j} = -\theta \cdot \left( \hat{e}_{it}^{i,j} + \hat{P}_{it}^i - \hat{P}_{jt}^j \right) + \hat{Y}_t^j \] (4.4)

The price index’s law of motion according to (2.22) is log-linearized as

\[ \hat{P}_t^i = \delta \hat{P}_{t-1}^i + (1 - \delta) \cdot \sum_{j=1}^3 b_{i,j} \left( \hat{e}_{t}^{j,i} + \hat{P}_{t}^{j} \right), \] (4.5)

the price set in period \( t \) by the price-changing firms is

\[ \hat{p}_{t}^{i,i} = \hat{\Xi}_{t}^{i,a} - \hat{\Xi}_{t}^{i,b} \] (4.6)

where

\[ \hat{\Xi}_{t}^{i,a} = (1 - \beta \delta) \cdot \left( \hat{\alpha}^{i,t} + \hat{\Omega}_t^i + \hat{MC}_t^i \right) + \beta \delta \cdot E_t \{ \hat{\Xi}_{t+1}^{i,a} \} \] (4.7)

\[ \hat{\Xi}_{t}^{i,b} = (1 - \beta \delta) \cdot \left( \hat{\alpha}^{i,t} + \hat{\Omega}_t^i - \hat{P}_t^i \right) + \beta \delta \cdot E_t \{ \hat{\Xi}_{t+1}^{i,b} \} \] (4.8)

has been defined for computational simplicity and

\[ \hat{MC}_t^i = a \hat{R}_t^i + (1 - a) \left( \hat{W}_t^i - \hat{P}_t^i \right) - \hat{Z}_t^i. \] (4.9)

Aggregate demand faced by domestic producers of the intermediate good is approximated by

\[ \hat{y}_t^i = \hat{\Omega}_t^i - \theta \hat{P}_t^i, \] (4.10)

where \( \hat{P}_t^i \) in case of symmetric producers obeys the law of motion

\[ \hat{P}_t^i = \delta \hat{P}_{t-1}^i + (1 - \delta) \hat{p}_{t}^{i,i} \] (4.11)

and

\[ \hat{\Omega}_t^i = (1 - b) \left[ \theta \cdot \hat{P}_t^1 + \hat{Y}_t^1 \right] + [\theta (\hat{P}_t^2 + \hat{e}_{t}^{2,1}) + a \cdot \hat{Y}_t^2 + (1 - a) \cdot \hat{Y}_t^3] \] (4.12a)

\[ \hat{\Omega}_t^2 = b \left[ \theta (\hat{P}_t^1 - \hat{e}_{t}^{2,1}) + \hat{Y}_t^1 \right] + (1 - b) \left[ \theta \cdot \hat{P}_t^2 + a \cdot \hat{Y}_t^2 + (1 - a) \cdot \hat{Y}_t^3 \right] \] (4.12b)
The production function of the intermediate good does not require an approximation. Denoted in deviations from the steady state and aggregated over all producers, it is

\[
\hat{y}_i = \hat{Z}_i + \alpha \cdot \hat{K}_i + (1 - \alpha) \cdot \hat{L}_i,
\]

where log productivity \(\hat{Z}_i\) is assumed to follow a VAR(1) process:

\[
\begin{bmatrix}
\hat{Z}_1 \\
\hat{Z}_2 \\
\hat{Z}_3
\end{bmatrix} = \Upsilon \cdot
\begin{bmatrix}
\hat{Z}_{1, t-1} \\
\hat{Z}_{2, t-1} \\
\hat{Z}_{3, t-1}
\end{bmatrix} +
\begin{bmatrix}
\varepsilon_{Z, 1} \\
\varepsilon_{Z, 2} \\
\varepsilon_{Z, 3}
\end{bmatrix}.
\]

The capital stock is given by

\[
\hat{K}_i = \hat{y}_i - \hat{Z}_i + (1 - \alpha) \cdot (\hat{W}_i - \hat{P}_i - \hat{R}_i),
\]

it’s Euler equation is log-linearized by

\[
\left(\frac{1}{\beta} - 1 + \Delta\right) E_t \{\hat{R}_{t+1}\} = E_t \left\{\frac{1}{\beta} \cdot (\hat{u}_{C,t} - \hat{u}_{C,t+1}) - \phi \cdot \left(\beta \hat{K}_{t+2} - (1 + \beta) \hat{K}_{t+1} + \hat{K}_t\right)\right\}
\]

The capital stock’s law of motion is given by

\[
\hat{K}_i = (1 - \Delta) \hat{K}_{i, t-1} + \Delta \hat{R}_{i, t-1},
\]

labor demand by

\[
\hat{L}_i = \hat{R}_i - (\hat{W}_i - \hat{P}_i) + \hat{K}_i.
\]

The wage index’ law of motion in linearized form is

\[
\hat{W}_i = \xi \cdot \hat{W}_{i, t-1} + (1 - \xi) \cdot \hat{w}^{*, i},
\]

the optimum wage to be set in period \(t\) is

\[
\hat{w}^{*, i} = \hat{w}_{i, c} - \hat{w}_{i, d}
\]
with
\[ \hat{\Xi}^{i,c}_t = (1 - \beta \xi) \cdot (\hat{R}^i_t + \hat{P}^i_t + \hat{K}^i_t + (\gamma - 1)\hat{W}^i_t) + \beta \xi \cdot E_t \hat{\Xi}^{i,c}_{t+1}, \] (4.21)
\[ \hat{\Xi}^{i,d}_t = (1 - \beta \xi) \cdot (\hat{u}^{i,C}_{C,t} + \hat{R}^i_t + \hat{K}^i_t + (\gamma - 1)\hat{W}^i_t) + \beta \xi \cdot E_t \hat{\Xi}^{i,d}_{t+1}. \] (4.22)

Further, it is
\[ \hat{u}^{i,C}_{C,t} = \left( \Sigma \cdot \frac{\kappa}{\bar{M}^i_{\Gamma}} \cdot \bar{C} + \frac{(1 - \Psi)\kappa \Gamma}{\bar{M}^i_{\Gamma}} \cdot \left( \bar{C} - \kappa \bar{M}^i_{\Gamma} \right) \cdot (\hat{M}^i_t - \hat{P}^i_t) \right), \] (4.23)
and the household’s Euler equations are
\[ E_t \left\{ \hat{R}^{i,j}_{t+1} - (\hat{P}^{i,j}_{t+1} - \hat{P}^i_t) + \left( \hat{u}^{i,C,j}_{C,t+1} - \hat{u}^{i,C}_{C,t} \right) \right\} = 0 \] (4.24)
\[ E_t \left\{ \hat{P}^{i,j}_{t+1} - (\hat{P}^{i,j}_{t} - \hat{P}^i_t) + \left( \hat{u}^{i,C,j}_{C,t+1} - \hat{u}^{i,C}_{C,t} \right) \right\} = 0 \] (4.25)
\[ E_t \hat{u}^{i,M,j}_{M,t+1} = E_t \left\{ \frac{\bar{u}^{i,C}_{C,t} + \frac{\bar{u}^{i,M}_{M}}{\bar{a}^i}}{\hat{M}^i_t} \cdot \left( \hat{u}^{i,C,j}_{C,t} + \hat{P}^{i,j}_{t+1} - \hat{P}^i_t \right) - \bar{u}^{i,C}_{C,t} \cdot \hat{u}^{i,C,j}_{C,t+1} \right\}, \] (4.26)
where \( D^i_{t+1} = (1 + d^i_{t+1}) \) denotes gross return on equities. Note that
\[ \hat{u}^{i,M}_{M,t} = \hat{u}^{i,C}_{C,t} + (1 - \Sigma)\hat{C}^i_t + (\Gamma - 1) \left( \hat{M}^i_t - \hat{P}^i_t \right) \] (4.27)
and the equilibrium interest rate is governed by UIP such that
\[ E_t \hat{R}^{i,j}_t = E_t \left\{ \hat{R}^{i,j}_{t+1} + \hat{e}^{i,j}_{t+1} - \hat{e}^{i,j}_t \right\}. \] (4.28)
Goods market equilibrium is given by
\[ \bar{Y}^i \cdot \hat{Y}^i = \bar{C}^i \cdot \hat{C}^i + \frac{\bar{P}^i}{\bar{a}^i} \cdot \hat{P}^i. \] (4.29)

I assume for now that money supply is entirely exogenous, i.e.
\[ \left[ \begin{array}{c} \hat{M}^1_t \\ \hat{M}^2_t \\ \hat{M}^3_t \\ \hat{M}^4_t \end{array} \right] = \left[ \begin{array}{c} \varepsilon^M_{1,t} \\ \varepsilon^M_{2,t} \\ \varepsilon^M_{3,t} \end{array} \right]. \] (4.30)

9 Future versions of this paper will look deeper into the implications of endogenously determined money supply, e.g. due to a fixed exchange rate or a Taylor (1993) type rule of monetary policy.
Business cycle synchronization is regularly attributed to two major sources: the impact of common shocks on the considered economies and the influence of the transmission of country specific shocks. Several authors, including Canova and Marrinan (1998) and Schmitt-Grohé (1998), have shown that in order to simulate realistic output fluctuations in an international business cycle model, transmission alone is not sufficient. Instead, the presence of common exogenous shocks appears to be necessary to quantitatively match the data gathered in empirical studies. Other authors (see, among others, Anderson et al., 1999; Laxton and Prasad, 2000) however point out the importance of trade linkages for the synchronization of international business cycles.

The model presented here allows for two exogenous shocks: monetary policy shocks due to changes in money supply, and supply shocks due to changes in the country specific technology parameter. The present paper focuses on the transmission properties of supply side technology shocks. Money supply is assumed to be exogenous and constant.

The model’s parameter setting follows, where applicable, Kollmann (2001). The parameters not used in Kollmann’s model, namely the relative size of the European economies ($a$ and $1-a$, respectively) and the weight of transatlantic goods in domestic production of the final good ($b$), are chosen in order to match a) the relative size of Germany and France and b) to approximately match the Euro area’s 2003 export quota of 35%. The selected parameters are outlined in the table below. In future versions of this paper I will estimate/calibrate the model’s parameters to match the features of the European economies, thereby allowing a closer look at the specific properties of the ‘European business cycle’. The estimates for the technology parameter’s law of motion are taken from Fichtner (2003), where Solow residuals of Germany, France and an aggregate of the U.S., UK and several European countries are estimated.

10 In contrast to the simulations in Fichtner (2003), I set off-diagonal elements of $\Upsilon$ to zero in order to provide an unbiased analysis of the model’s endogenous dynamics.

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5.1 Transmission of idiosyncratic technology shocks

A positive technology shock in country 2 leads to a sharp rise in productivity and output of the intermediate good. It further implies due to increasing marginal products, a long-run rise in investment in country 2. The relative price of country 2’s intermediate good on world markets will fall due to the higher supply, thus leading by definition to an increase of the relative price of the other countries’ goods. A diminishing demand for intermediate goods produced in the rest of the world naturally occurs. See figure 1 for impulse response functions of a 1% technology shock in country 2.

As can clearly be seen, goods and capital market integration lead to considerable parallels of output of the final good $Y$. Even though the shock affects only one country in the European region, with no transportation delays or costs assumed, the shock directly feeds into the production of the final good in the other European region and, due to the production bias to a minor extent, in the production of the final good in country 1.

Apparently, in this setup the influence of asynchronous shocks can explain a large fraction of business cycle synchronization. This is of course due to the fact that output is defined in terms of a goods’ basket (the ‘final good’) which is highly synchronized across countries. With output of the final good being synchronized, it is clear that consumption in all countries is highly correlated. Inspecting figure 1 closer reveals however, that there are no synchronization tendencies to be observed in the intermediate good production. In contrast, due to the worsening of the terms of trade, i.e. the increase of the relative price of country 2’s and 3’s intermediate good leads to a decrease of exports and thus to lower output.

5.2 The impact of transatlantic shocks

Transatlantic transmission of U.S. specific supply shocks is often considered a major source of business cycle fluctuations in Europe and, hence, a reason for parallels in the European countries’ economic development (see e.g. Kwark [1999]). Analyzing the role
5 Some First Results: The impact of technology shocks

of U.S. specific shocks in the model presented above is simply done by shocking country 1’s technology parameter. The resulting impulse responses are depicted in figure 2.

In this case, output of the final good in the European economies reacts completely synchronous. The decrease of the relative price of country 1’s good leads strengthened imports from the USA which increase production of the final good in Europe. As the exchange rates $\hat{e}^{2,1}_t$ and $\hat{e}^{3,1}_t$ react perfectly synchronous and the production functions imply identical demand functions for the intermediate good, the impact of the shock on the production of the final good in country 2 and 3 is exactly the same. Note again, that the technology shock in country 1 has adverse effects on the production of the intermediate good in 2 and 3.

5.3 The impact of common shocks

As pointed out earlier, another major source of business cycle fluctuations and synchronization is the impact of common shocks on different countries. The model presented above allows to me to easily simulate the outcome of such a common shock, i.e. a shock setting every country’s technology parameter 1% above it’s steady state level. The re-
Some First Results: The impact of technology shocks

Figure 2: Response of the economies to a country 1 specific technology shock.

Results are depicted in figure 2. It does not come as a surprise that this shock has by far the quantitatively strongest impact on business cycle fluctuations. Further, the output of the final good and of the intermediate good show strong parallels between the countries under observation. Note that the symmetry of the shock's impact tends to result in reduced trade compared to asynchronous shocks. That is of course due to the fact that the influence on relative prices, i.e. the terms of trade, is evened out.

Concluding, the model’s predictions concerning business cycle synchronization depend crucially on the macroeconomic aggregate one takes into account when analyzing the fluctuations. Speaking in terms of the final good, comparable to the GDP to be observed in reality, business cycles are strongly synchronized across Europe independent of the kind of shock. However, looking at intermediate good production, business cycles are not as synchronized as one would expect from empirical studies. On this level, common shocks appear to play the major role in synchronization tendencies.
6 Concluding remarks

This paper presented a perfect foresight, three-country general equilibrium model in the spirit of the seminal Redux model developed by Obstfeld and Rogoff (1995). It follows closely the specifications as outlined by Ghironi (2000) in that it assumes that the world economy can be represented by a two region/three country structure. It further builds heavily on the paper presented by Kollmann (2001), which inspired the country’s internal structure. Nominal rigidity is modeled by assuming a Calvo (1983) price setting mechanism for goods’ prices and wages.

Using this framework, I am able to analyze interdependencies between countries with explicitly specified microfoundations, thus allowing for a profound analysis of international interdependencies.

In the present paper, the properties of the model with regard to the synchronization of international business cycles are discussed. The model employed here provides some indication for a relevant role of transmission-related synchronization tendencies. This result contrasts sharply with previous works attributing international business cyc-
cle coherence mainly to production interdependencies and common supply side shocks (see e.g. Canova and Marrinan, 1998). Yet, the rather weak endogenous transmission mechanisms have been discussed as a major shortcoming of all real business cycle models (Backus et al., 1995; Baxter and Crucini, 1995). From a theoretical perspective, it seems quite plausible that the rigidities introduced in the model described above indeed strengthen the endogenous transmission mechanism. With price rigidities and monopoly profits (prices are set above marginal costs), output becomes demand-determined in the short run. If a shock raises demand (e.g. due to increased imports being induced by a higher technology level in a foreign country), it will be profitable for the home producer to increase it’s production even if he cannot change his price. The transmission of technology shocks will thus have a stronger impact on national business cycles than it does in the supply-side dominated RBC models.

Depending on the macroeconomic aggregate taken into account, business cycle synchronization ranges from ‘perfectly correlated’ to ‘strongly asynchronous’. It further depends on the kind of shock assumed. The model implies that the output of the non-tradable final good is strongly synchronous among the European economies. In case of a technology shock on the U.S. economy and a common shock, business cycles in Europe react perfectly synchronized. In case of an asymmetric shock on the German economy, European business cycles still are quite synchronous. On this level, trade related transmission apparently has a relevant role for parallels in aggregate cyclical behavior.

In contrast, the European countries’ output of the intermediate good show strongly diverging reactions in response to a shock in Germany. Yet, intermediate good output shows parallels in response to common shocks or a shock in the U.S. On this level, synchronization thus appears to be mainly the outcome of exogenous shocks on the economies under observation.

Taking these results together leads to the conclusion that trade related transmission can explain an important fraction of business cycle fluctuations and economic synchronization. This result appears to be especially relevant from a European point of view, where a strong synchronization between business cycles is empirically well documented, while theoretical work addressing the question of sources and mechanisms of this phenomenon remains scarce. Given the extraordinary political and economic integration of the European economies, one might expect transmission effects to be of predominant importance for synchronizing the European cycles. While earlier work implied a rather weak impact of trade-related transmission on European business cycle synchronization (see Fichtner, 2003), these results were subject to a fundamental problem of real busi-
ness cycle theory: the lack of links provided by international monetary economics such as exchange rate regimes or monetary policy measures. The model presented in this paper allows a more thorough examination of those factors and thus a more reliable assessment of the underlying mechanisms of the European Business Cycle.

Future versions of this paper will therefore take a closer look at the implications of specific European conditions. First of all, the role of the monetary union between the European economies will be analyzed. As a second step, the calibration/estimation of the model’s structural parameters according to European circumstances will allow a trustworthier evaluation of the mechanisms discussed above. This holds especially true if differences between the economies are taken into account. Additionally, shifting to a stochastic setting will allow to assess the econometric performance of the model in a more reliable way by simulating the model and comparing the resulting time series’ second moments to empirically gathered data. Improving and extending the model along those lines will finally result in a model which actually is capable to be employed as a “workhorse model” of the European economic area and provide important insights into highly relevant questions such as the effects of the eastern enlargement of the European Monetary Union, the necessity of fiscal policy coordination or the consequences of different monetary policy regimes.

References


References


[to be completed]