BUSINESS CYCLE SYNCHRONIZATION IN THE EUROZONE.
THE ROLE OF ANIMAL SPIRITS

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Abstract:

Business cycles among Eurozone countries are highly correlated. Mainstream macroeconomic models find it difficult to explain this without assuming the existence of common exogenous shocks. We develop a two-country behavioral macroeconomic model in a monetary union setting where the two countries are linked with each other by international trade. The net export of country 1 depends on the output gap of country 2 and on real exchange rate movements. The synchronization of the business cycle is produced endogenously. The main channel of synchronization occurs through a propagation of "animal spirits", i.e. waves of optimism and pessimism that become correlated internationally. We find that this propagation occurs with relatively low levels of trade integration. We analyze the role of the common central bank in this propagation mechanism. We explore the transmission of demand and supply shocks and we study how the central bank affects this transmission. We discuss the main predictions of the model empirically.

Keywords: Animal Spirits, behavioral macroeconomics, business cycles, synchronization

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1. Introduction

It is well known that business cycles are highly synchronized across industrial countries in general and among the members-countries of the Eurozone in particular. We show the extent of this synchronization for the Eurozone countries in Figures 1 and Table 1.

As shown in Figure 1, Eurozone countries have experienced more or less the same business cycle movements over a period of 20 years. The business cycle component is obtained by using a Hodrick-Prescott (HP) filter on the GDP data. The bilateral correlations of the business cycle component of GDP in the Eurozone are presented in Table 1. It is striking to find how high these correlation coefficients are. We find many correlation coefficients of the business cycle components exceeding 0.9. On average we find that this correlation coefficient is 0.82, suggesting a very high degree of synchronization of the business cycles within the Eurozone. The bilateral correlations among the Eurozone countries is on average higher than among the non-Eurozone OECD-countries (see De Grauwe and Ji(2017))[1]. We are aware of the fact that measuring business cycles is fraught with difficulties. However, our findings are consistent with others (see de Haan et al. (2008), Belke, et al. (2016), and Ahmed at al. (2017)) who come to the same conclusion, i.e. there is a high synchronization of the business cycles of the Eurozone countries which in addition is higher than in to the other industrialized countries.

The high degree of synchronization of the business cycles is, of course, influenced by the degree of trade integration. In their seminal article, Frankel and Rose (1998) found that increasing trade integration leads to more synchronization of the business cycles. This has been confirmed by other empirical studies (see Artis and Cleays 2005; Bordo and Helbling 2004). However, De Grauwe and Ji(2017) showed that the trade integration, although significant, has a relatively weak effect on the degree of synchronization of business cycles and explains only a small fraction of the variation in the bilateral correlations of the output gaps. Clearly there are other mechanisms at work driving the synchronization of business cycles. It is the intention of this paper to uncover these other mechanisms.

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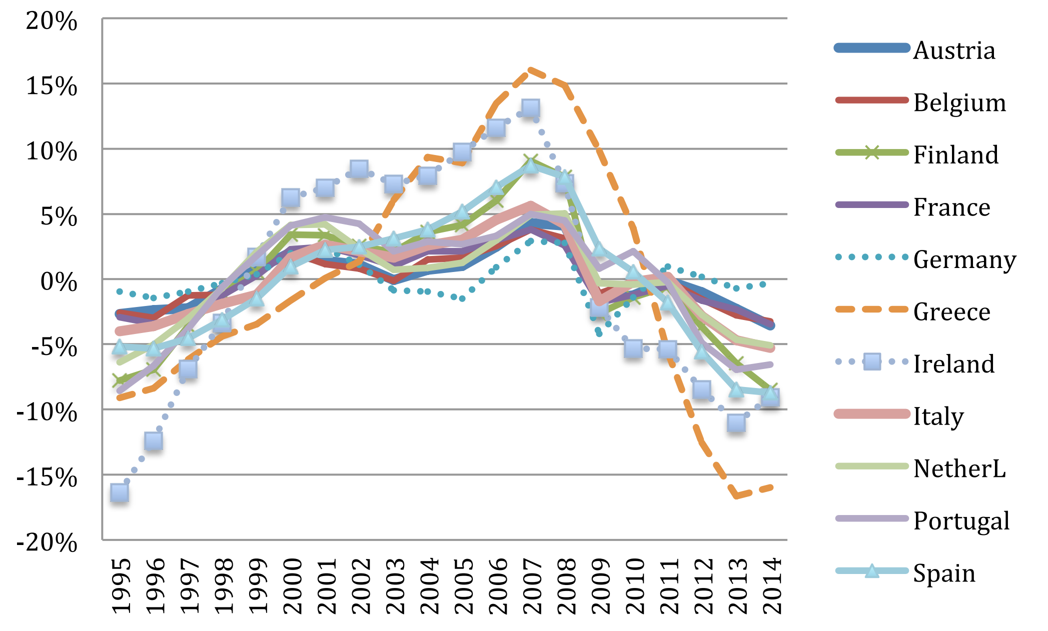
[1] De Grauwe and Ji(2017) find that outside the Eurozone these bilateral correlations can still be called quite high. The average of all the correlation coefficients among non-Euro OECD-countries is 0.6. Thus it appears that in the group of industrial countries outside the Eurozone business cycles are also quite synchronized.

Figure 1. Business cycle component of GDP growth



Source: De Grauwe and Ji(2016)

Table 1: Bilateral correlations: business cycle component of GDP growth in Eurozone (1995-2014)

	AT	BE	FI	FR	DE	GR	IE	IT	NL	PT	ES
AT	1,00										
BE	0,97	1,00									
FI	0,97	0,98	1,00								
FR	0,93	0,95	0,97	1,00							
DE	0,69	0,57	0,55	0,59	1,00						
GR	0,73	0,82	0,84	0,74	0,09	1,00					
IE	0,85	0,89	0,92	0,95	0,41	0,81	1,00				
IT	0,91	0,96	0,98	0,96	0,50	0,86	0,93	1,00			
NL	0,93	0,94	0,93	0,91	0,60	0,75	0,86	0,90	1,00		
PT	0,98	0,89	0,89	0,87	0,37	0,82	0,87	0,90	0,94	1,00	
ES	0,85	0,91	0,94	0,87	0,27	0,97	0,90	0,95	0,86	0,90	1,00

Note: AT: Austria, BE: Belgium, FI: Finland, FR: France, DE: Germany, GR: Greece, IE: Ireland, IT: Italy, NL: Netherlands, PT: Portugal, ES: Spain. Source: OECD and authors' own calculation.

The high synchronization of the business cycles in a monetary union could also be influenced by the high degree of financial integration. However, theory and empirical evidence shows that financial integration has an ambiguous effect on the degree of synchronization of the business cycles (de Haan, et al.(2008), Giannone et al. (2008) and Ahmed, et al.(2017). The latter conclude that “whereas the euro sample coincides with a strong increase in financial synchronization, business cycle synchronization does not change much”, (page 26).

Mainstream macroeconomic DSGE-models have found it difficult to replicate the observed high degree of synchronization of the business cycles, without assuming the existence of common exogenous shocks, real or financial (Backus et al.(1992), Canova and Dellas(1993)), Alpanda and Aysun(2014)). Surprisingly, the DSGE-models have the same difficulties in a monetary union setting. Few papers are trying to address how it has been affected by the monetary union (Giannone et al. (2008)). This has much to do with the structure of DSGE-models. These are models in which rational agents continuously optimize using all available information. Business cycle movements in these models are generated by exogenous shocks that in combination with the existence of price rigidities produce cyclical movements in output and inflation. Thus, in these models cyclical movements in economic activity can only occur as a result of exogenous shocks. Similarly, the correlation of cyclical movements across countries can only occur if countries are hit by the same exogenous shocks.

In this paper we want to go a step further and analyze the implications for a monetary union of the existence of endogenously generated shocks. By the latter we mean shocks that are produced endogenously in the system and that most often are temporary.

We will use a behavioral macroeconomic model in which “animal spirits”, i.e. waves of optimism and pessimism play a central role in driving the business cycles. They have been stressed by Keynes(1936) as being the major forces underlying business cycle movements, (see also Ackerlof and Shiller(2009)). The model was developed by De Grauwe(2012). The extension to a two-country setup as in De Grauwe and Ji(2017) will be used to shed light on two questions.

First, we will show that our behavioral model is capable of replicating this high international synchronization of business cycles without having to assume common shocks. The mechanism that produces this can be described as follows. When a wave of optimism is set in motion in one country, it leads to more output and imports in that country, thereby increasing output in the other country. This positive transmission, even if small, makes it more likely that agents in the latter country that make optimistic forecasts are vindicated, thereby increasing the fraction of agents in that country that become optimists. Thus we obtain a transmission dynamics that although triggered by trade flows is amplified and leads to a strong synchronization of the business cycles across countries.

This endogenously generated synchronization does not mean that common shocks cannot be the source of synchronization. Common shocks have been occasionally very important. It seems to us though that a model that can explain the high international synchronization of business cycles *only* by invoking the existence of common shocks is incomplete.

The second question we want to analyze is how these endogenously generated shocks are transmitted within a monetary union. This question is important because it highlights the role of the common central bank in stabilizing the business cycles in a monetary union, which goes beyond the analysis used in standard DSGE-models where the need to stabilize arises from the existence of price rigidities in the face of exogenous shocks (for an example, see Hollmayr(2011)). We will show that the transmission of business cycle movements is made possible by an endogenous dynamics that leads to correlation of "animal spirits". As will be shown, these can be relatively strong even in the presence of weak trade flows.

We have decided to focus on the real part of the economy in this paper. We want to find out how far one can go in generating cross-country synchronization of the business cycles without the help of financial flows. We do find that one can use a real model that produces cross-correlations that match the observed ones. This does not mean that the introduction of financial flows cannot add interesting information, but as will be shown, it is not strictly necessary to explain the high synchronization of business cycles.

The value added of this paper compared to De Grauwe and Ji(2017) is twofold. First we introduce the crucial role of real exchange rate movements in the synchronization of the business cycles. Second, and more importantly, we will compare our model to the same model under Rational Expectations (RE). This will allow us to isolate the role the non-conventional behavioral expectations formation has on the international synchronization of the business cycle and the transmission of endogenous shocks in a monetary union.

The rest of the paper is organized as follows. In section 2, we provide some additional empirical evidence on the correlation of market sentiments across the Eurozone. This evidence is clearly not definitive. It allows us to stress the need to focus on endogenously generated shocks in a monetary union. In section 3 we present the behavioral New Keynesian macroeconomic model as extended to a two-country monetary union setup. It is based on De Grauwe and Ji(2017), however, we now introduce the real exchange rate as a central mechanisms in the transmission of shocks between countries. We then analyze the predictions of this model and the policy implications (sections 4 to 6). In section 7 we contrast these results with the results obtained in the same New Keynesian framework but assuming Rational Expectations. This comparison will allow us to find out what the role is of animal spirits in the transmission of endogenously generated shocks. We conclude by discussing whether the predictions of this model are validated empirically (section 8).

2. High synchronization of business cycle sentiments in the Eurozone

In the previous section we illustrated the high synchronization of business cycle in the Eurozone. A second piece of empirical evidence that allows us to better understand the nature of the business cycle movements in the Eurozone is obtained from indicators of market sentiments. We use the business confidence index (BCI) as an indicator for market sentiments. The OECD collects this index monthly for most Eurozone member countries. The BCI is based on enterprises' assessment of production, orders and stocks, as well as its current position and expectations for the immediate future. The BCI has been rescaled to yield a long-term average of 100. The more the index exceeds 100, the more optimistic (positive animal spirit) it shows. The more the index is below 100, the more pessimistic (negative animal spirits) it shows.

In Table 2 we show the bilateral correlations of the national BCIs. We find correlation coefficients that are of the same high order as the bilateral correlation coefficients obtained in Table 1. Thus the business cycle movements in the Eurozone and market sentiments appear to be highly correlated across countries.

Table 2: Eurozone bilateral correlations of business confidence index (BCI)

	AT	BE	FI	FR	DE	GR	IT	NL	PT	ES
AT	1									
BE	0.87	1								
FI	0.86	0.85	1							
FR	0.75	0.86	0.83	1						
DE	0.90	0.86	0.73	0.73	1					
GR	0.42	0.47	0.58	0.64	0.20	1				
IT	0.74	0.86	0.83	0.93	0.69	0.70	1			
NL	0.83	0.91	0.81	0.90	0.83	0.60	0.89	1		
PT	0.70	0.82	0.71	0.84	0.66	0.66	0.86	0.91	1	
ES	0.65	0.70	0.70	0.83	0.53	0.75	0.89	0.81	0.85	1

Note: AT: Austria, BE: Belgium, FI: Finland, FR: France, DE: Germany, GR: Greece, IE: Ireland, IT: Italy, NL: Netherlands, PT: Portugal, ES: Spain. Source: OECD and authors' own calculation.

Summarizing the previous empirical observations one can say that there has been a strong common business cycle within the Eurozone since its start. At the same time we observe highly correlated market sentiments of optimism and pessimism. It is the intention of this paper to link these two phenomena.

3. The two-country behavioral model

3.1 Model choice

Mainstream macroeconomics has been based on two fundamental ideas. The first one is that macroeconomic models should be micro-founded, i.e. they should start from individual optimization and then aggregate these individuals' optimal plans to obtain a general equilibrium model. This procedure leads to intractable and well-known aggregation problems (Sonnenschein(1972), Kirman(1992)) that cannot easily be solved. This has led DSGE-model builders to circumvent the aggregation problems by introducing the representative agent, i.e. by assuming that demand and supply decisions in the aggregate can be reduced to decisions made at the individual level.

The second idea is that expectations should be rational, i.e. should take all available information into account, including the information about the structure of the economic model and the distribution of the shocks hitting the economy.

These two ideas lead to problems. First, the use of a representative agent has the effect of brushing under the carpet the interesting sources of macroeconomic dynamics, which come from the fact that agents are heterogeneous and therefore have different beliefs about the state of the economy. Second, the use of rational expectations implies that individual agents have extraordinary cognitive abilities capable of understanding the great complexity of the world. We believe this to be implausible.

Therefore we make a different choice of model. First, we will bring at center stage the heterogeneity of agents in that they have different beliefs about the state of the economy. As will be shown it is the aggregation of these diverse beliefs that creates a dynamics of booms and busts in an endogenous way. The price we pay is that we do not microfound the model and assume the existence of aggregate demand and supply equations. Second, we assume that agents have cognitive limitations preventing them from having rational expectations. Instead they will be assumed to follow simple rules of thumb (heuristics). Rationality will be introduced by assuming a willingness to learn from mistakes and therefore a willingness to switch between different heuristics. In making these choices we follow the road taken by an increasing number of macroeconomists, which have developed "agent-based models" and "behavioral macroeconomic models" (Tesfatsion, L. (2001), Colander, et al. (2008), Farmer and Foley(2009), Gatti, et al.(2011), Westerhoff(2012), De Grauwe(2012), Hommes and Lustenhouwer(2016)).

3.2 Basic model

Following De Grauwe (2012) and De Grauwe and Ji (2017), we use a simple behavioral macroeconomic model with two countries in a monetary union where they trade with each other. The basic structure of this behavioral model is the same as the mainstream New-Keynesian model as described in e.g. Gali(2008). In the monetary union setting, there is a common central bank with a common short-term interest rate. The model consists of two aggregate demand equations, two aggregate supply equations and a Taylor rule. To keep the model simple, we assume that the two countries are symmetric and therefore exhibit the same parameters.

As mentioned earlier, we do not attempt to micro-found the aggregate demand equations. We consider these to be reduced forms for which there exists sufficient empirical backing. The aggregate demand equations for countries 1 and 2 are specified as follows:

$$y_t^1 = a_1\tilde{E}_t y_{t+1}^1 + (1-a_1)y_{t-1}^1 + a_2\left(r_t - \tilde{E}_t\pi_{t+1}^1\right) + (x_t^1 - m_t^1) + \varepsilon_t^1 \qquad (1)$$

$$y_t^2 = a_1\tilde{E}_t y_{t+1}^2 + (1-a_1)y_{t-1}^2 + a_2\left(r_t - \tilde{E}_t\pi_{t+1}^2\right) + (x_t^2 - m_t^2) + \varepsilon_t^2 \qquad (2)$$

where y_t^1 and y_t^2 are the output gaps for country 1 and 2 in period t, r_t is the common nominal interest rate, π_t^1 and π_t^2 are the rates of inflation for country 1 and 2 in period t, and ε_t^1 and ε_t^2 are white noise disturbance terms for country 1 and 2. $\tilde{E}_t^i$ is the expectations operator where the tilde above E refers to expectations that are not formed rationally. This expectations formations process will be specified subsequently. We follow the procedure introduced in New Keynesian macroeconomic models (Gali(2008) and Woodford(2003)) of adding a lagged output y_{t-1}^1 and y_{t-1}^2 in the demand equation. This is usually justified by invoking habit formation. We also take into account trade links between the two countries: x_t^1 and x_t^2 as the exports of countries 1 and 2, m_t^1 and m_t^2 the imports of countries 1 and 2. These variables are also defined as gaps, i.e. the difference between the actual values and the values obtained in the steady state when the output gap is zero.

$$m_t^1 = x_t^2 = my_t^1 + \mu(R_{t-1} - 1) \tag{3}$$

$$m_t^2 = x_t^1 = my_t^2 + \mu(\frac{1}{R_{t-1}} - 1) \tag{4}$$

$$R_{t-1} = \frac{(1+\pi_0^1)(1+\pi_1^1)\ldots(1+\pi_{t-1}^1)}{(1+\pi_0^2)(1+\pi_1^2)\ldots(1+\pi_{t-1}^2)} \tag{5}$$

In our two-country setup, the imports of countries 1 and 2 are the same as the exports of countries 2 and 1 respectively. Equations (3) and (4) are the import demand equations. We assume that imports of a given country are positively influenced by its output gap (y) and by the real exchange rate, R. The parameter $m > 0$ (the import propensity) measures the sensitivity of imports to changes in the output gap. The parameter $\mu > 0$ measures the elasticity of imports with respect to the real exchange rate. The real exchange rate is defined in (5). It is the ratio of the price indices of country 1 relative to country 2. When this ratio increases relative to its equilibrium (PPP) value, which is 1, country 1's goods become relatively more expensive, leading it to import more from country 2. The reverse then happens in country 2. We assume this effect takes time. As a result the real exchange rate is lagged one period. Using (3) and (4) the aggregate demand equations for countries 1 and 2 can be rewritten as follows:

$$y_t^1 = \frac{a_1}{1+m}\tilde{E}_t y_{t+1}^1 + \frac{1-a_1}{1+m} y_{t-1}^1 + \frac{a_2}{1+m}\left(r_t - \tilde{E}_t \pi_{t+1}^1\right) + \frac{m}{1+m} y_t^2 + \frac{\mu}{1+m}(\frac{1}{R_{t-1}} - R_{t-1}) + \frac{\varepsilon_t^1}{1+m} \tag{6}$$

$$y_t^2 = \frac{a_1}{1+m}\tilde{E}_t y_{t+1}^2 + \frac{1-a_1}{1+m} y_{t-1}^2 + \frac{a_2}{1+m}\left(r_t - \tilde{E}_t \pi_{t+1}^2\right) + \frac{m}{1+m} y_t^1 + \frac{\mu}{1+m}(R_{t-1} - \frac{1}{R_{t-1}}) + \frac{\varepsilon_t^2}{1+m} \tag{7}$$

The aggregate demand equations have a very simple interpretation. Aggregate demand increases when agents expect future income (output gap) to increase and it decreases when the real interest rate increases. The existence of a trade link between the two countries creates additional features in which aggregate demand of country 1 is influenced by country 2 and vice versa. The first feature is that aggregate demand of country 1 increases when aggregate demand of country 2 increases. The second feature is that aggregate demand responds to the real exchange rate, i.e. when the price level of country 1 increases faster than that of country 2, the net exports of county 1 decline and therefore the aggregate demand of country 1 declines. The reverse then happens in country 2.

We assume aggregate supply equations of the New Keynesian Philips curve type with a forward looking component, $\widetilde{E}_t\pi_{t+1}$, and a lagged inflation variable. The lagged inflation is usually introduced in the NK Philips curve to reflect the fact that producers cannot adjust their prices instantaneously.

$$\pi_t^1 = b_1\widetilde{E}_t\pi_{t+1}^1 + (1-b_1)\pi_{t-1}^1 + b_2 y_t^1 + \eta_t^1 \quad (8)$$

$$\pi_t^2 = b_1\widetilde{E}_t\pi_{t+1}^2 + (1-b_1)\pi_{t-1}^2 + b_2 y_t^2 + \eta_t^2 \quad (9)$$

Equations (6)-(9) determine the four endogenous variables, inflation π_t^1 and π_t^2, and output gap y_t^1 and y_t^2, given the nominal interest rate r_t. The model is closed by specifying the way the nominal interest rate is determined. The most popular way to do this has been to invoked the Taylor rule that describes the behavior of the central bank (Taylor(1993)). In a monetary union, this rule is written as follows:

$$r_t = (1-c_3)[c_1(\bar{\pi}_t - \pi^*) + c_2\bar{y}_t] + c_3 r_{t-1} + u_t \quad (10)$$

where (assuming the two countries have the same size), $\overline{\pi_t} = \frac{1}{2}(\pi_t^1 + \pi_t^2)$ and $\bar{y}_t = \frac{1}{2}(y_t^1 + y_t^2)$, π^* is the inflation target and we will assume it is zero. Thus the central bank is assumed to raise the interest when the observed inflation rate of the union increases relative to the announced inflation target. The intensity with which it does this is measured by the coefficient c_1. It has been shown (Woodford(2003) or Gali(2008)) that it must exceed 1 for the model to be stable. This is also sometimes called the "Taylor principle"[2].

When the output gap of the monetary union increases the central bank is assumed to raise the interest rate. The intensity with which it does this is measured by c_2. The latter parameter then also tells us something about the ambitions the central bank has to stabilize output. A central bank that does not care about output stabilization sets c_2=0. We say that this central bank applies strict inflation targeting. Finally, as is commonly done, the central bank is assumed to smooth the interest rate. This smoothing behavior is represented by the lagged interest rate r_{t-1}.

[2] Ideally, the Taylor rule should be formulated using a forward-looking inflation variable, i.e. central banks set the interest rate on the basis of their *forecasts* about the rate of inflation. This is not done here in order to maintain simplicity in the model (again see Woodford(2003), p. 257). As is shown in Woodford(2003) forward looking Taylor rules may not lead to a determinate solution even if the Taylor principle is satisfied.

We have added error terms in each of the equations. These error terms describe the nature of the different shocks that can hit the economy. There are demand shocks ε_t^1 and ε_t^2, supply shocks η_t^1 and η_t^2, and interest rate shocks, u_t . We will generally assume that these shocks are normally distributed with mean zero and a constant standard deviation. We will allow these shocks to be correlated between the two countries in some of the simulation experiments.

3.3 Introducing heuristics in forecasting output and inflation

We take the view that agents have cognitive limitations. They only understand tiny little bits of the world. In such a world agents are likely to use simple rules, heuristics, to forecast the future (see e.g. Damasio 2003; Kahneman 2002; Camerer et al. 2005). Agents who use simple rules of behavior are no fools. They use simple rules only because the real world is too complex to understand, but they are willing to learn from their mistakes, i.e. they regularly subject the rules they use to some criterion of success. This leads to the concept of adaptive learning.

Adaptive learning is a procedure whereby agents use simple forecasting rules and then subject these rules to a "fitness" test, i.e., agents endogenously select the forecasting rules that have delivered the highest performance ("fitness") in the past. Thus, an agent will start using one particular rule. She will regularly evaluate this rule against the alternative rules. If the former rule performs well, she keeps it. If not, she switches to another rule. In this sense the rule can be called a "trial and error" rule.

This "trial and error" selection mechanism acts as a disciplining device on the kind of rules that are acceptable. Not every rule is acceptable. It has to perform well. What that means will be made clear later. It is important to have such a disciplining device, otherwise everything becomes possible. The need to discipline the forecasting rule was also one of the basic justifications underlying rational expectations. By imposing the condition that forecasts must be consistent with the underlying model, the model builder severely limits the rule that agents can use to make forecasts. The adaptive selections mechanism used here plays a similar disciplining role.

As indicated earlier, agents in our model are willing to learn, i.e. they continuously evaluate their forecast performance. This willingness to learn and to change one's behavior is the most fundamental definition of rational behavior. Our agents are rational in the sense that they learn from their mistakes. The concept of “bounded rationality” is often used to characterize this behavior (Simon(1957), Kahneman(2002), Gigerenzer and Selten(2002)).

Heuristics and selection mechanism in forecasting output

Agents are assumed to use simple rules (heuristics) to forecast the future output and inflation. The way we proceed is as follows. We assume two types of forecasting rules. A first rule can be called a “fundamentalist” one. Agents estimate the steady state value of the output gap (which is normalized at 0) and use this to forecast the future output gap[3]. A second forecasting rule is an “extrapolative” one. This is a rule that does not presuppose that agents know the steady state output gap. They are agnostic about it. Instead, they extrapolate the previous observed output gap into the future.

The two rules that are followed in the two countries are specified as in equations (11) and (12). We have dropped the country superscripts here (and in what follows). Thus these two equations apply to agents in both countries.

The fundamentalist rule: $\widetilde{E}_t^f y_{t+1} = 0$ (11)

The extrapolative rule: $\widetilde{E}_t^e y_{t+1} = y_{t-1}$ (12)

This kind of simple heuristic has often been used in the behavioral finance literature where agents are assumed to use fundamentalist and chartist rules (Brock and Hommes(1997), Branch and Evans(2006), De Grauwe and Grimaldi(2006)). Note that agents extrapolate last periods output gap, y_{t-1}, not the contemporaneous output gap, y_t. The latter is not in the information set of agents in period t as it will be the outcome of their forecasts. Only in a rational expectations model where agents are capable of computing the effects of their forecasts on y_t is this possible. Admittedly, (11) and (12) are extremely simple rules. More sophisticated ones (e.g. extrapolation with longer lags) could be used. We experimented with these. In general they do not affect the results in essential ways.

The market forecast is obtained as a weighted average of these two forecasts, i.e.

[3] In De Grauwe(2012) this rule is extended to the case in which agents do not know the steady state output gap with certainty and only have biased estimates of it. This is also done in Hommes and Lustenhouwer(2016).

$$\widetilde{E}_t y_{t+1} = \alpha_{f,t}\widetilde{E}_t^f y_{t+1} + \alpha_{c,t}\widetilde{E}_t^e \qquad (13)$$

$$\widetilde{E}_t y_{t+1} = \alpha_{f,t} 0 + \alpha_{c,t} y_{t-1} \qquad (14)$$

where $\alpha_{f,t}$ and $\alpha_{e,t}$ are the probabilities that agents use a fundamentalist, respectively, an extrapolative rule and $\alpha_{f,t} + \alpha_{e,t} = 1$.

The first step in the analysis then consists in defining a criterion of success. This will be the forecast performance of a particular rule. Thus in this first step, agents compute the forecast performance of the two different forecasting rules as follows:

$$U_{f,t} = -\sum_{k=0}^{\infty} \omega_k [y_{t-k-1} - \tilde{E}_{f,t-k-2} y_{t-k-1}]^2 \qquad (15)$$

$$U_{e,t} = -\sum_{k=0}^{\infty} \omega_k [y_{t-k-1} - \tilde{E}_{e,t-k-2} y_{t-k-1}]^2 \qquad (16)$$

where $U_{f,t}$ and $U_{e,t}$ are the forecast performances (utilities) of the fundamentalist and extrapolating rules, respectively. These are defined as the mean squared forecasting errors (MSFEs) of the forecasting rules; ω_k are geometrically declining weights. We make these weights declining because we assume that agents tend to forget. Put differently, they give a lower weight to errors made far in the past as compared to errors made recently.

The next step consists in evaluating these forecast performances (utilities). We apply discrete choice theory (see Anderson, de Palma, and Thisse, (1992) for a thorough analysis of discrete choice theory and Brock & Hommes(1997) for the first application in finance) in specifying the procedure agents follow in this evaluation process. If agents were purely rational they would just compare $U_{f,t}$ and $U_{e,t}$ in (15) and (16) and choose the rule that produces the highest value. Thus under pure rationality, agents would choose the fundamentalist rule if $U_{f,t} > U_{e,t}$, and vice versa. However, things are not so simple. Psychologists have found out that when we have to choose among alternatives we are also influenced by our state of mind. The latter is to a large extent unpredictable. One way to formalize this is that the utilities of the two alternatives have a deterministic component (these are $U_{f,t}$ and $U_{e,t}$ in (15) and (16)) and a random component $\varepsilon_{f,t}$ and $\varepsilon_{e,t}$ The probability of choosing the fundamentalist rule is then given by

$$\alpha_{f,t} = P\left[(U_{f,t} + \varepsilon_{f,t}) > (U_{e,t} + \varepsilon_{e,t})\right] \qquad (17)$$

In words, this means that the probability of selecting the fundamentalist rule is equal to the probability that the stochastic utility associated with using the fundamentalist rule exceeds the stochastic utility of using an extrapolative rule. In order to derive a more precise expression one has to specify the distribution of the random variables $\varepsilon_{f,t}$ and $\varepsilon_{e,t}$. It is customary in the discrete choice literature to assume that these random variables are logistically distributed (see Anderson, Palma, and Thisse(1992)). One then obtains the following expressions for the probability of choosing the fundamentalist rule:

$$\alpha_{f,t} = \frac{exp(\gamma U_{f,t})}{exp(\gamma U_{f,t}) + exp(\gamma U_{e,t})} \qquad (18)$$

Similarly the probability that an agent will use the extrapolative forecasting rule is given by:

$$\alpha_{e,t} = \frac{exp(\gamma U_{e,t})}{exp(\gamma U_{f,t}) + exp(\gamma U_{e,t})} = 1 - \alpha_{f,t} \qquad (19)$$

Equation (18) says that as the past forecast performance of the fundamentalist rule improves relative to that of the extrapolative rule, agents are more likely to select the fundamentalist rule for their forecasts of the output gap. Equation (19) has a similar interpretation. The parameter γ measures the "intensity of choice" or "the willingness to learn from the past performance"[4].

The probabilities $\alpha_{f,t}$ and $\alpha_{e,t}$ can also be interpreted as the fractions of agents that use a fundamentalist and extrapolative forecasting rule, respectively. These fractions are determined by the rules (18) and (19) and are time dependent. This illustrates an important feature of the model, i.e. the heterogeneity of beliefs and their shifting nature over time.

As argued earlier, the selection mechanism used should be interpreted as a learning mechanism based on "trial and error". When observing that the rule they use performs less well than the alternative rule, agents are willing to switch to the more performing rule. Put differently, agents avoid making systematic mistakes by constantly being willing to learn from past mistakes and to change their behavior.

Heuristics and selection mechanism in forecasting inflation

Agents also have to forecast inflation. A similar simple heuristics is used as in the case of output gap forecasting, with one rule that could be called a fundamentalist rule and the other an extrapolative rule. (See Brazier et al. (2006) for a similar setup). Some experimental evidence in support of the two rules for inflation forecasts in a New Keynesian model can be

[4] γ is related to the variance of the random components $\varepsilon_{f,t}$ and $\varepsilon_{e,t}$. If the variance is very high, γ approaches *0.* In that case agents decide to be fundamentalist or extrapolator by tossing a coin and the probability to be fundamentalist (or extrapolator) is exactly 0.5. When $\gamma = \infty$ the variance of the random components is zero (utility is then fully deterministic) and the probability of using a fundamentalist rule is either 1 or 0.

found in a paper by Pfajfar and Zakelj (2009). For a survey of the experimental evidence see Hommes(2016). We assume an institutional set-up in which the central bank of the monetary union announces an explicit inflation target. The fundamentalist rule then is based on this announced inflation target, i.e. agents using this rule have confidence in the credibility of this rule and use it to forecast inflation. Agents who do not trust the announced inflation target use the extrapolative rule, which consists extrapolating inflation from the past into the future.

The fundamentalist rule will be called an "inflation targeting" rule. It consists in using the central bank's inflation target to forecast future inflation, i.e.

$$\widetilde{E}_t^{tar} = \pi^* \qquad (20)$$

where the inflation target π^* is normalized to be equal to 0. The "extrapolators" are defined by

$$E_t^{ext}\pi_{t+1} = \pi_{t-1} \qquad (21)$$

The market forecast is a weighted average of these two forecasts, i.e.

$$\widetilde{E}_t\pi_{t+1} = \beta_{tar,t}\widetilde{E}_t^{tar}\pi_{t+1} + \beta_{ext,t}\widetilde{E}_t^{ext}\pi_{t+1} \qquad (22)$$

i.e. $$\widetilde{E}_t\pi_{t+1} = \beta_{tar,t}\pi^* + \beta_{ext,t}\pi_{t-1}$$

$$\beta_{tar,t} + \beta_{ext,t} = 1 \qquad (24)$$

The same selection mechanism is used as in the case of output forecasting to determine the probabilities of agents trusting the inflation target and those who do not trust it and revert to extrapolation of past inflation, i.e.

$$\beta_{tar,t} = \frac{\exp(\gamma U_{tar,t})}{\exp(\gamma U_{tar,t}) + \exp(\gamma U_{ext,t})} \qquad (25)$$

$$\beta_{ext,t} = \frac{\exp(\gamma U_{ext,t})}{\exp(\gamma U_{tar,t}) + \exp(\gamma U_{ext,t})} \qquad (26)$$

where $U_{tar,t}$ and $U_{ext,t}$ are the forecast performances (utilities) associated with the use of the fundamentalist and extrapolative rules. These are defined in the same way as in (15) and (16), i.e. they are the negatives of the weighted averages of past squared forecast errors of using fundamentalist (inflation targeting) and extrapolative rules, respectively.

3.4 Defining animal spirits

The forecasts made by extrapolators and fundamentalists play an important role in the model. In order to highlight this role we derive an index of market sentiments from the endogenously obtained fractions $\alpha_{e,t}$ and $\alpha_{f,t}$. We will call these "animal spirits". They reflect how optimistic or pessimistic these forecasts are, and they are obtained endogenously from the model[5].

The definition of animal spirits is as follows:

$$S_t = \begin{cases} \alpha_{e,t} - \alpha_{f,t} & \text{if } y_{t-1} > 0 \\ -\alpha_{e,t} + \alpha_{f,t} & \text{if } y_{t-1} < 0 \end{cases} \tag{27}$$

where S_t is the index of animal spirits. This can change between -1 and +1. There are two possibilities:

- When $y_{t-1} > 0$, extrapolators forecast a positive output gap. The fraction of agents who make such a positive forecasts is $\alpha_{e,t}$. Fundamentalists, however, then make a pessimistic forecast since they expect the positive output gap to decline towards the equilibrium value of 0. The fraction of agents who make such a forecast is $\alpha_{f,t}$. We subtract this fraction of pessimistic forecasts from the fraction $\alpha_{e,t}$ who make a positive forecast. When these two fractions are equal to each other (both are then 0.5) market sentiments (animal spirits) are neutral, i.e. optimists and pessimists cancel out and $S_t = 0$. When the fraction of optimists $\alpha_{e,t}$ exceeds the fraction of pessimists $\alpha_{f,t}$, S_t becomes positive. As we will see, the model allows for the possibility that $\alpha_{e,t}$ moves to 1. In that case there are only optimists and $S_t = 1$.
- When $y_{t-1} < 0$, extrapolators forecast a negative output gap. The fraction of agents who make such a negative forecasts is $\alpha_{e,t}$. We give this fraction a negative sign. Fundamentalists, however, then make an optimistic forecast since they expect the negative output gap to increase towards the equilibrium value of 0. The fraction of agents who make such a forecast is $\alpha_{f,t}$. We give this fraction of optimistic forecasts a positive sign. When these two fractions are equal to each other (both are then 0.5) market sentiments (animal spirits) are neutral, i.e. optimists and pessimists cancel out and $S_t = 0$. When the fraction of pessimists $\alpha_{e,t}$ exceeds the fraction of optimists $\alpha_{f,t}$, S_t becomes negative. The fraction of pessimists, $\alpha_{e,t}$, can move to 1. In that case there are only pessimists and $S_t = -1$.

[5] It should be noted that these animal spirits are unrelated to "sunspot equilibria" in the sense of Cash and Shell(1983). The latter arise because of the existence of a random variable individuals believe matters for the economic outcome. Our animal spirits arise endogenously as a result of agents with cognitive limitations switching between different heuristics in search of the best possible forecast

3.5 Solution of the model

The model has non-linear features making it difficult to arrive at analytical solutions. That is why we will use numerical methods to analyze its dynamics. In order to do so, we have to calibrate the model, i.e. to select numerical values for the parameters of the model. In Table 3 the parameters used in the calibration exercise are presented. The values of the parameters are based on what we found in the literature (see Gali(2008) for the demand and supply equations and Blattner and Margaritov(2010) for the Taylor rule). We relied on Brock and Hommes(1997) for the intensity of choice parameter, γ, and on Corsetti, et al. (2008) for the price sensitivity of imports. We will perform extensive sensitivity analyses varying several parameters (c2, m, μ and zet). The model was calibrated in such a way that the time units can be considered to be quarters. The three shocks (demand shocks, supply shocks and interest rate shocks) are independently and identically distributed (i.i.d.) with standard deviations of 0.2%. These shocks produce standard deviations of the output gap and inflation that mimic the standard deviations found in the empirical data using quarterly observations for the US and the Eurozone.

Table 3: Parameter values of the calibrated model

a1 = 0.5	coefficient of expected output in output equation
a2 = -0.2	interest elasticity of output demand
b1 = 0.5	coefficient of expected inflation in inflation equation
b2 = 0.05	coefficient of output in inflation equation
c1 = 1.5	coefficient of inflation in Taylor equation
c2 = 0.5	coefficient of output in Taylor equation
c3 = 0.8	interest smoothing parameter in Taylor equation
$\gamma = 2$	intensity of choice parameter
$m = 0.3$	import propensity
μ = 0.1	price sensitivity of imports (gap)
$\sigma_{\varepsilon} = 0.2$	standard deviation shocks output
$\sigma_{\eta} = 0.2$	standard deviation shocks inflation
$\sigma_{u} = 0.2$	standard deviation shocks Taylor
$\rho = 0.5$	measures the speed of declining weights in mean squares errors (memory parameter)
π* = 0	the central bank's inflation target; for some simulations π* = 2 (indicated)
zet=0	correlation of common shock

4. Results of the model: the basics

In this section we present some of the basic results of simulating the model using the calibration discussed in the previous section. We first present the results of the simulation exercises in the time domain. This will allow us to understand the dynamics produced by the model. In the next sections we perform sensitivity analyses. Figure 2 presents the simulated output gaps in the two countries. We find a relatively high correlation of these output gaps between the two countries. This correlation is 0.8. Underlying this is an import propensity (m) of 0.3 and a price elasticity of import demand (μ) of 0.1, and importantly a zero correlation of across countries' exogenous demand and supply shocks. Thus the model produces a synchronization of business cycles, without the need to have international correlations of demand and supply shock. The international synchronization comes mainly from "the animal spirits". These are shown in figure 4. As explained in the previous section, the "animal spirits" measure market sentiments, i.e. optimism and pessimism in forecasting.

We observe that the model produces waves of optimism and pessimism that can lead to a situation in which everybody becomes optimist (i.e. $S_t=1$) or pessimist (i.e. S_t = -1). These waves of optimism and pessimism are generated endogenously and arise because optimistic (pessimistic) forecasts are self-fulfilling and therefore attract more agents into being optimists (pessimists).

The correlation of these animal spirits and the output gap is high in each country. In the simulations reported in figure 3 this correlation reaches 0.94 in both countries. Underlying this correlation is the self-fulfilling nature of expectations. When a wave of optimism is set in motion, this leads to an increase in aggregate demand (see equation 1). This increase in aggregate demand leads to a situation in which those who have made optimistic forecasts are vindicated. This attracts more agents using optimistic forecasts. This leads to a self-fulfilling dynamics in which most agents become optimists. The reverse is also true. A wave of pessimistic forecasts can set in motion a self-fulfilling dynamics leading to a downturn in economic activity (output gap). At some point most of the agents have become pessimists.

It now appears that the model produces an international contagion of animal spirits. This is seen from the same figure 3 showing the animal spirits in both countries. These animal spirits are highly correlated between the two countries reaching 0.77. The mechanism that produces this can be described as follows. When a wave of optimism is set in motion in country 1, it leads to more output and imports in that country, thereby increasing output in country 2. This positive transmission, even if small, makes it more likely that agents in country 2 that make optimistic forecasts are vindicated, thereby increasing the fraction of agents in country 2 that become optimists. Thus we obtain a transmission dynamics that although triggered by trade flows (m=0.3) is amplified and leads to a strong synchronization of the business cycles across countries.

Figure 2: simulation of the output gaps in countries 1 and 2

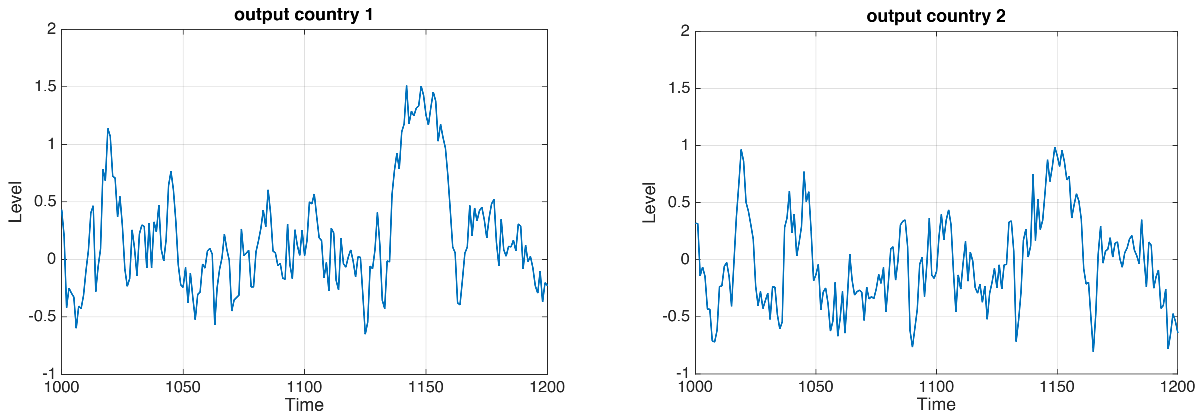
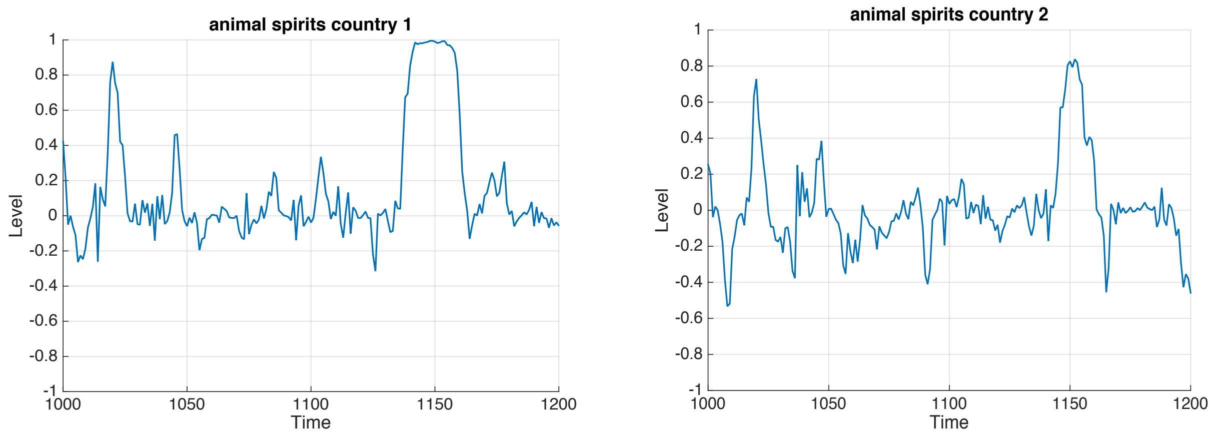


Figure 3: simulation of the animal spirits in countries 1 and 2



Note: Figures 1 and 2 show the simulations in the time domain in a subsample of 200 periods (for a total simulation run of 2000 periods)

It is also interesting to analyse the frequency distribution of the output gaps and animal spirits in the two countries. We show these in Figures 4 and 5. We observe first that the distribution of the output gaps is not normal, producing excess kurtosis and fat tails. Applying a Jarque-Bera test leads us to reject normality.

There is now a significant body of empirical evidence showing that the output gap (and also the growth of output) in the Eurozone and other OECD countries do not exhibit a Gaussian distribution, and that they are characterized by excess kurtosis and fat tails. Fagiolo et al. (2008) and Fagiolo et al. (2009) did important econometric analysis documenting the non-normality of the distribution of output gas and growth rates of GDP. Thus, our model predicts that in the real world the output gap does not follow a normal distribution but that it is characterized by excess kurtosis and fat tails. This feature of the higher moments of the output gap is generated endogenously in the model. It is not the result of imposing such a feature on the stochastic shocks hitting the economy.

Figure 4: Frequency distributions of the output gaps in countries 1 and 2

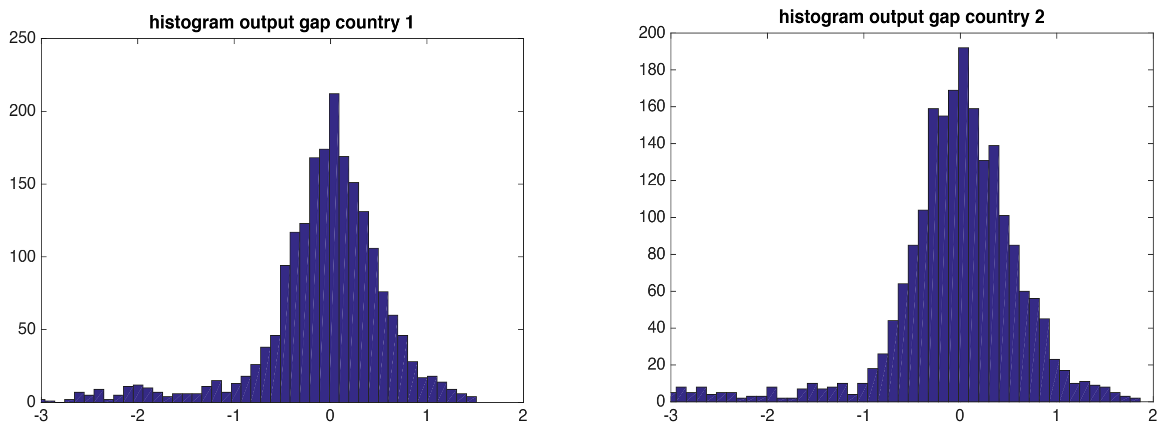
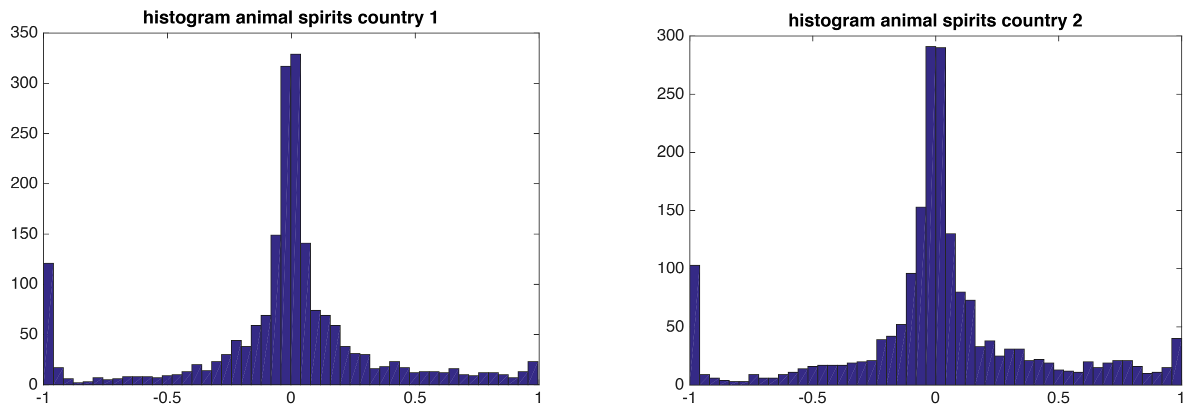


Figure 5: Frequency distributions of the animal spirits in countries 1 and 2



Note: These simulations in the frequency domain use the whole 2000 simulation periods

Second, we find that the non-normality of the output gap is related to the fact that the animal spirits have a concentration around 0 and close to -1 and +1. The interpretation is that there are normal times when animal spirits are neutral (equal to 0). That's when the output gaps are close to zero. Occasionally, animal spirits take on extreme values (positive or negative), creating strong booms and busts. We will show later that during these turbulent periods the international correlation of output gaps is the highest.

5. Results of the model: factors affecting synchronization of business cycle

In this section we analyze the factors that influence the synchronization of the business cycles across countries. We do this by presenting sensitivity analyses, i.e. we study how the correlations of the output gaps between the two countries are influenced by a number of important parameters of the model. We will focus on trade integration, the price elasticity of import demand, the correlation of exogenous shocks, and the degree of stabilization of the output gap by the common central bank.

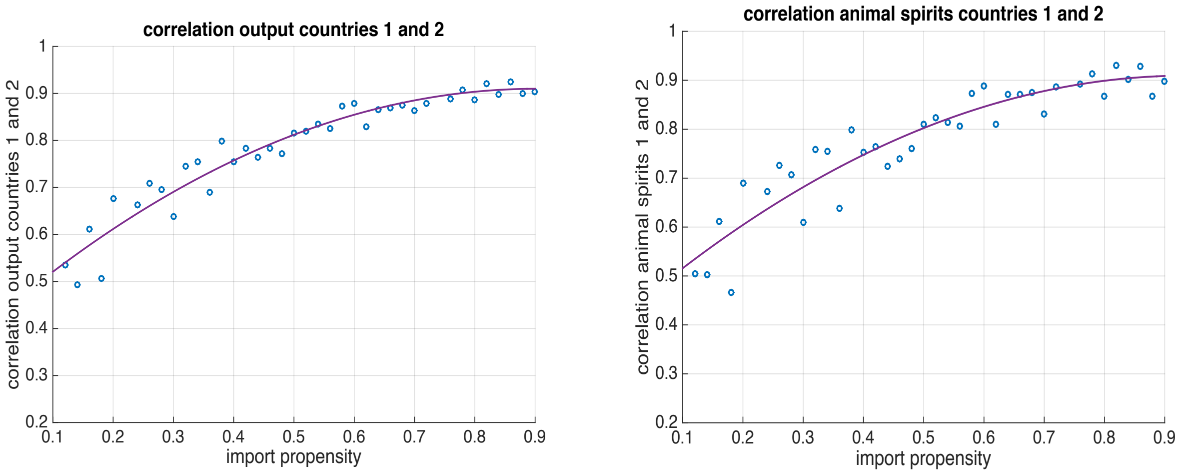
5.1 Synchronization of business cycles and trade integration

We first focus on how trade integration (measured by the import propensities, m) affects the correlation of output gaps and animal spirits across countries. We show the results in figure 6. On the horizontal axis we set out the import propensities and allow it to change from 0.1 to 0.8. On the vertical axis we set out the correlation of output gaps between the two countries (left graph) and the correlation of animal spirits (right graph) that we obtain in the model for each value of m. We find strikingly that even when there is very little trade between the two countries (m=0.1) the model produces relatively strong positive correlations of output gaps and animal spirits. As trade integration increases the degree of correlation increases. This relation is non-linear. When m increases the correlations increase fast and then level off. Further trade integration has very little additional impact on the synchronization of the business cycles.

Two results stand out here. First, the fact that when trade is quite low there is a significant synchronization of the business cycles and of animal spirits. This feature may be the result of the fact that this is a monetary union where one central bank sets the interest rate for the union as a whole. Thus the common central bank is the source of a common shock. We return to this issue to analyze the strength of this effect in section 5.4.

The other interesting result is the non-linear relation between the intensity of trade and the synchronization of the business cycles. Most of the synchronization is reached for relatively low levels of trade integration. Thus relatively low levels of trade are enough to trigger the contagion of animal spirits and through this channel the synchronization of the business cycles.

Figure 6: International correlation of output gaps and animal spirits: importance of import propensity



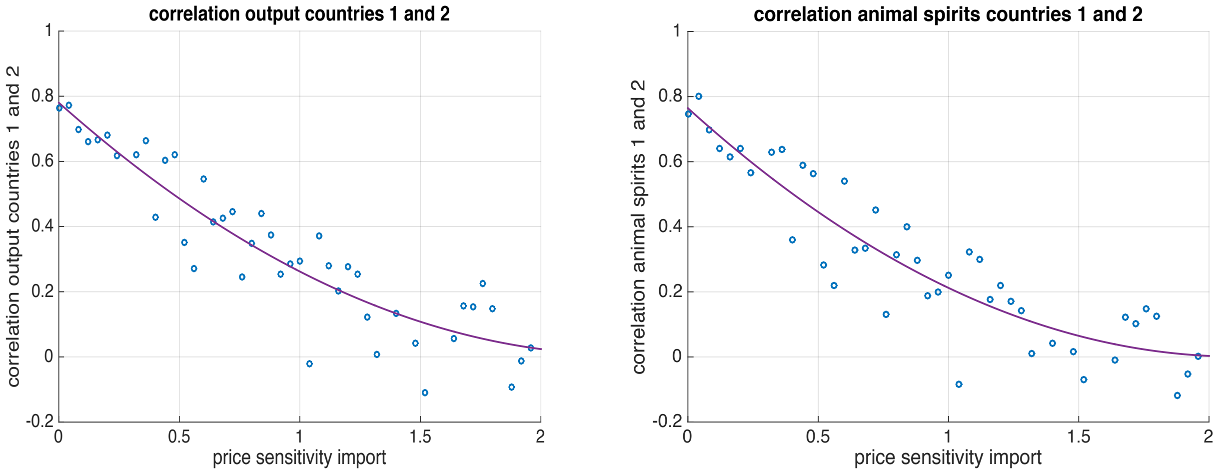
Note: each point represents the correlation coefficient obtained for a particular value of m (import propensity) in a simulation run of 2000 periods.

5.2 Synchronization of business cycles and price elasticity of trade

The synchronization of output and animal spirits is very much influenced by the price sensitivity of imports. This is shown in Figure 7. It shows the relation between the price elasticity of imports and the international correlation of output gaps (left graph). We observe that when imports are not price sensitive (close to 0) the correlation of output gaps is very high (close to 0.8). When μ is allowed to increase the international correlation of the output gaps declines A similar feature is observed in the right graph of Figure 8 that shows the relation between the price elasticity of import (μ) and the correlation of animal spirits between the two countries.

How can this result be interpreted? Let us start from a boom originating in country 1. Such a boom leads to an increase in the domestic price level and thus to a real appreciation in country 1. This real appreciation has the effect of reducing the demand of country 1's output and as a result reduces the boom conditions in country 1. This then also limits the strength of animal spirits. Less will be transmitted to the second country. The stronger is the price elasticity of trade the more the boom originating in country 1 is "bottled up" in that country, and the less of it is transmitted to the second country. This is due to the fact that the real appreciation following a domestic boom tends to reduce the intensity of the boom and thus also its transmission.

Figure 7: International correlation of output gaps and animal spirits: importance of price sensitivity of imports



Note: each point represents the correlation coefficient obtained for a particular value of μ (price sensitivity of imports) in a simulation run of 2000 periods.

5.3 Synchronization of business cycles and correlation of shocks

Up to now we have assumed that the international correlation of demand and supply shocks is zero. Thus, despite the absence of common shocks, our model was capable of generating strong international correlations of the business cycles. Of course, exogenous shocks do matter. In this section we focus on how the existence of common shocks affects our results. The way we do this is to analyse the sensitivity of the international synchronization of business cycles to correlations of the shocks (both demand and supply).

In Figure 8 we present the results. We show the sensitivity of the synchronization of business cycles (left graph) resp. animal spirits (right graph) to the correlation of shocks in the monetary union. We assume shocks both in the demand and supply equations. We vary the correlation between -1 and +1. The vertical axes as before show the correlations of output gaps and animal spirits across countries. We find a strongly non-linear relation.

In order to understand the results, let us start from the zero correlation of shocks (this was what we assumed until now). We then observe a correlation of the output gaps of about 0.7. When the shocks become positively correlated, the synchronization of the business cycles increases. It reaches 1 when the shocks are perfectly positively correlated. Note, however, that the contribution of common shocks to the synchronization of the business cycles is limited. When we go from zero correlation to perfect correlation of shocks the correlation of output gaps increases from 0.7 to 1, a relatively small increase.

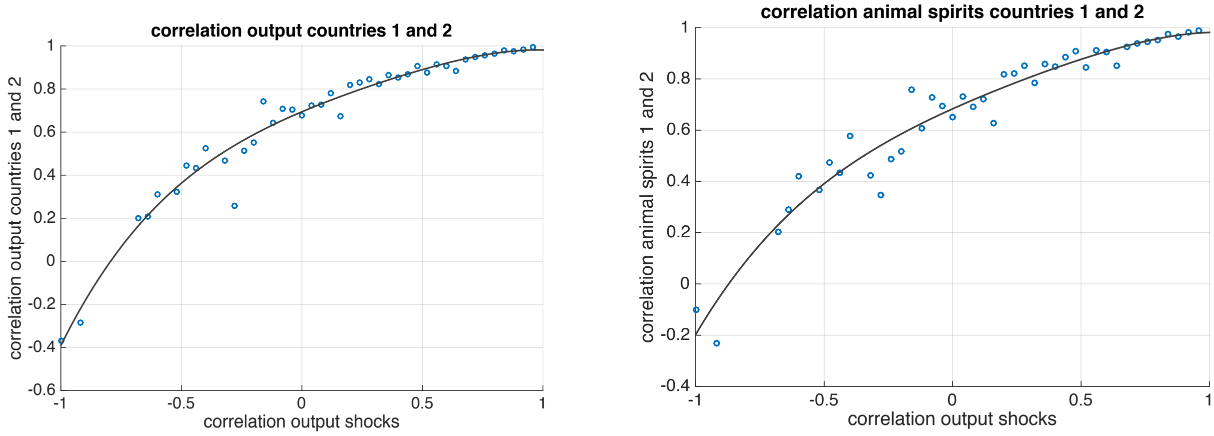
Let us now move in the other direction, starting from the zero correlation of shocks. We obtain a quite surprising result: we have to allow the correlation of shocks to reach -0.8 before the correlation of the output gaps becomes negative. Thus, for quite large negative correlations of shocks, the output gaps remain positively correlated.

The right graph of Figure 8 shows the relation between the international correlation of shocks and the correlation of animal spirits across countries. We find a very similar non-linear relationship. In particular, we find that one needs a lot of negative correlation of shocks to make the correlation of animal spirits negative. Put differently, animal spirits remain positively correlated for relatively large negative correlations of shocks.

Where do these results come from? The answer is the existence of one central bank. The latter sets an interest rate that is the same for both countries according to the Taylor rule. This interest rate setting relation is also subject to random shocks. But since the same rule applies to both countries one has a source of common shocks in these two countries. This then allows animal spirits to be positively correlated even if all the other shocks are negatively correlated. We will return to this issue in section 5.4.

In De Grauwe and Ji(2017) we compared the correlation coefficients obtained in a monetary union with those obtained in a model of two "standalone countries" with each having its own central bank applying its own Taylor rule. We found that in the latter case the correlation line is shifted downwards. This difference has to do with the fact that in this model two central banks set their own interest rate thereby eliminating a source of common shock.

Figure 8: International correlation of output gaps and animal spirits: importance of the correlation of output shocks



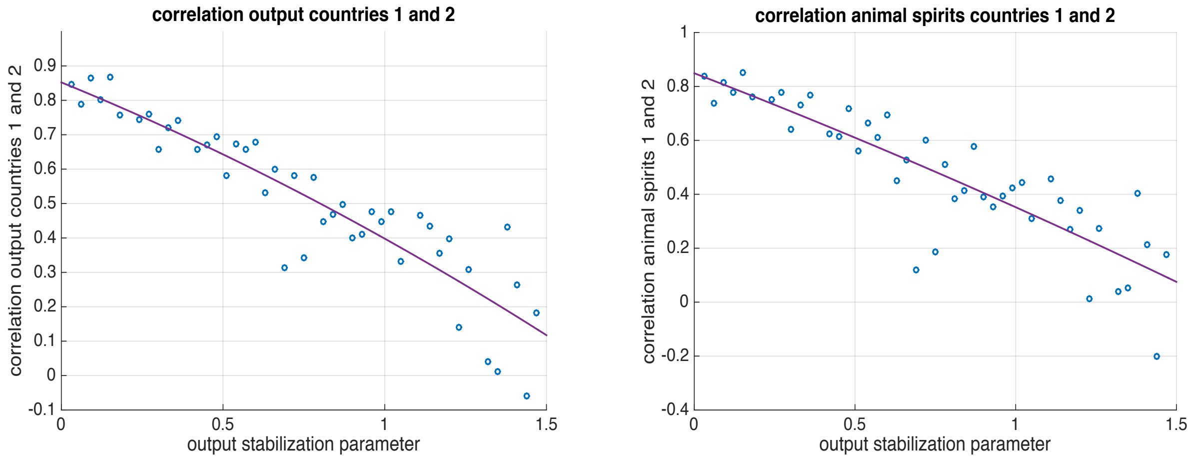
Note: each point represents the correlation coefficient obtained for a particular value of zet (the correlation of outpu chocks) in a simulation run of 2000 periods.

5.4 Synchronization of business cycles and output stabilization

The degree of output stabilization exerted by the central bank has important effects on the emergence of animal spirits in our behavioral model. We showed earlier (De Grauwe(2012)) that by a more forceful output stabilization (as measured by the coefficient c_2 in the Taylor rule equation), the central bank can reduce the intensity of the movements in animal spirits. Given the importance of animal spirits in propagating business cycles from one country to the other, the central bank's stabilization efforts can have a significant impact on this propagation. We analyze this issue here.

We do this by studying the sensitivity of the international correlations of the output gaps and animal spirits with respect the output coefficient c_2 in the Taylor rule. The results are shown in figure 9. We allow the Taylor output parameter (c_2) to vary from 0 to 1.5 (horizontal axes) and compute the corresponding correlations of the output gaps (left graph) and animal spirits (right graph).

Figure 9: International correlation of output gaps and animal spirits: importance of output stabilization



Note: each point represents the correlation coefficient obtained for a particular value of c2 (output stabilisation parameter in the Taylor rule) in a simulation run of 2000 periods.

The results confirm the importance of output stabilization for the international propagation of business cycles. In general when the central bank increases its effort to stabilize output (c_2 increases) the correlation of the output gaps across countries declines. By increasing this parameter the common central bank can significantly reduce the synchronization of the business cycles in the monetary union.

In De Grauwe and Ji(2017) we compared the monetary union result with the result obtained in a model with two independent central banks using their own Taylor rule. We found that in the case of monetary independence the increase in the stabilization effort has a stronger negative effect on the international correlation of the business cycles. The reason is that in this model the existence of two central banks increases their effectiveness in "taming the animal spirits". As a result the international propagation of these animal spirits is also reduced. This leads to less synchronization of the business cycles.

6. Results of the model: International transmission of demand and supply shocks

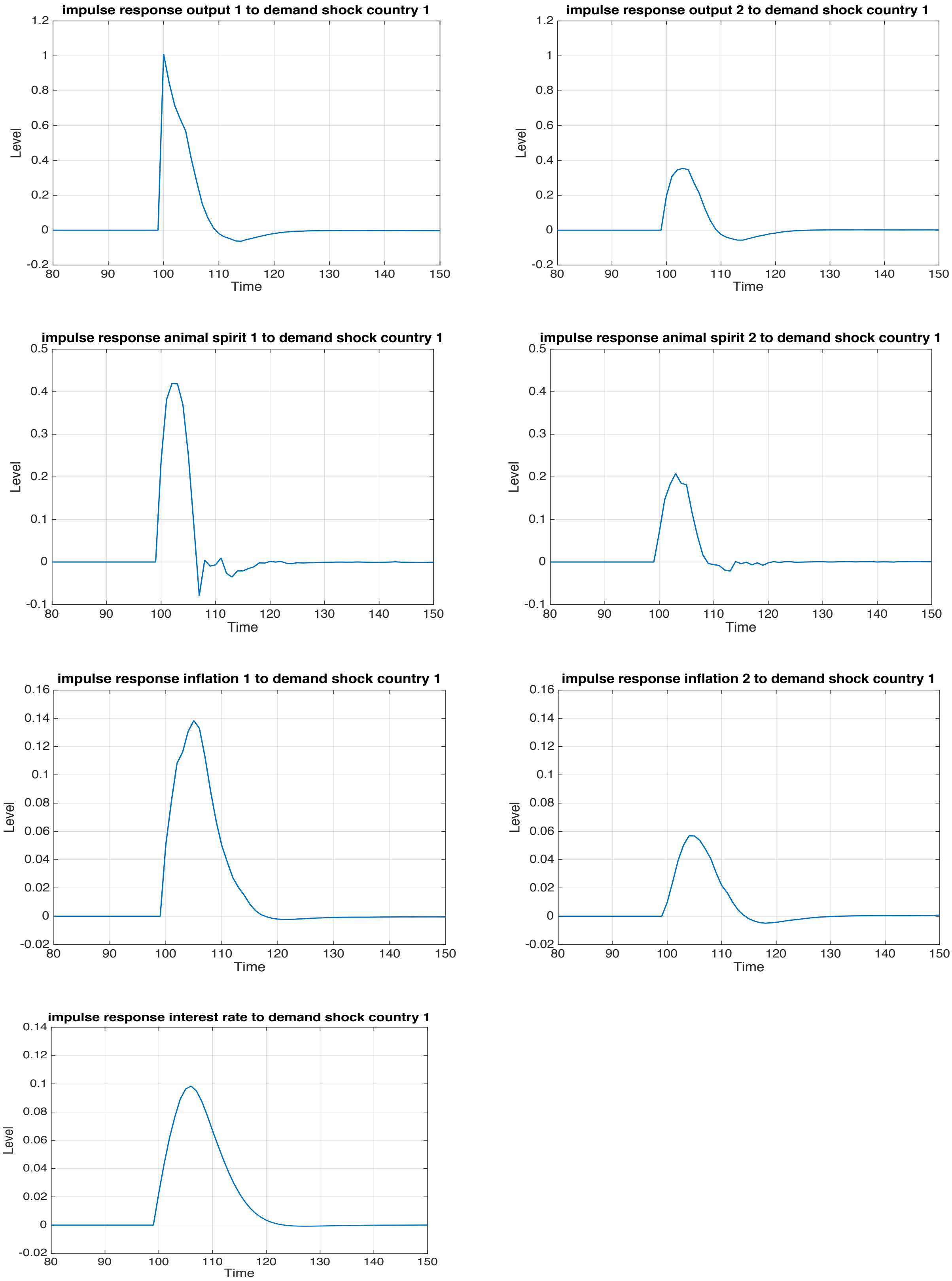
6.1 Transmission of demand shocks

In this section we analyze how a demand shock in country 1 (e.g. produced by a fiscal policy stimulus) is transmitted to country 2. In the next section we will focus on supply shocks.

We compute impulse responses to the demand shock for a number of macroeconomic variables. These are shown in Figure 10. Before interpreting the results, it is important to stress that, in contrast to linear rational expectations models as we will illustrate in section 7, the impulse responses depend on the timing of the shock. Put differently, an impulse response computed with one realization of the stochastic shocks in the demand and supply equations of the model will be different from an impulse response to exactly the same shock but performed using another realization of these stochastic shocks. This is the case even when all parameters of the model are identical. We will return to this feature of the model in the next section and argue that it introduces an important dimension of uncertainty about the transmission of exogenous shocks.

As expected, the demand shock in country 1 raises output and inflation in that country. In addition, it stimulates positive animal spirits. The transmission of the positive demand shock to country 2 is quite weak, despite the fact that we assume an import propensity of 0.3. The weak transmission is explained by the policy response of the common central bank. Following the demand shock of country 1 the common central bank raises the common interest rate. The latter has the effect of raising the real interest rate in country 2 more than in country 1. As a result the restrictive monetary policy has a stronger bite in country 2 than in country 1, offsetting the positive effect of country 1's demand increase. Thus in a monetary union demand shocks in one country have a weakened effect on the other country.

Figure 10: Impulse responses to positive demand shock in country 1



6.2 Transmission of supply shocks

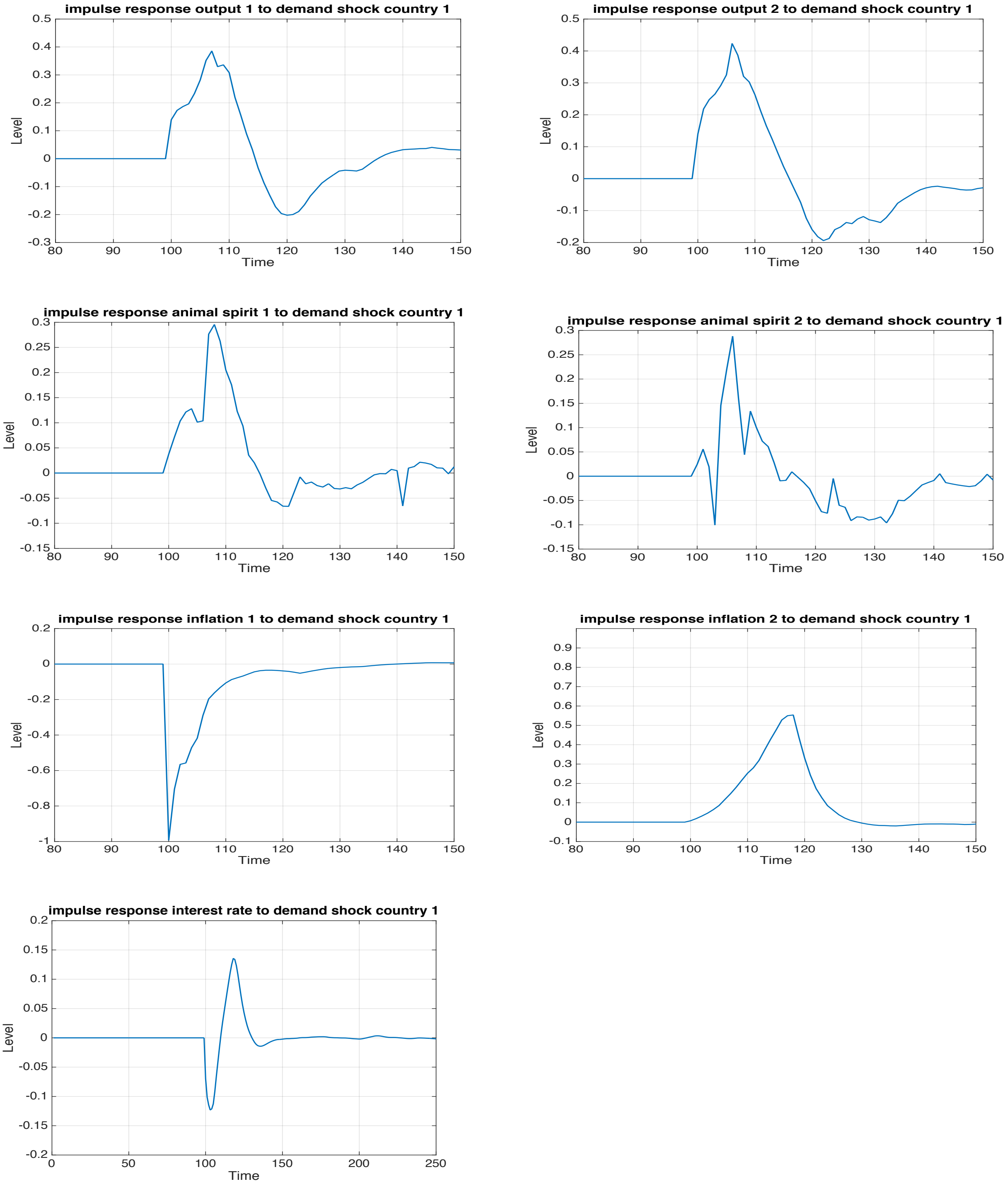
In this section we analyse how supply shocks are transmitted. We focus on a positive supply shock in country 1. This could be due to a productivity increase that shifts the supply curve downwards. We show the impulse responses in Figure 11.

As expected, the positive supply shock in country 1 raises the output gap and lowers the rate of inflation in that country. In addition, animal spirits become optimistic, enhancing the positive effect of the supply shock on the output gap. The striking feature of Figure 11 is the way the supply shock in country 1 is transmitted to country 2. We now find that country 1's supply shock has a stronger impact on country 2's output gap and animal spirits than on country 1's. Thus the positive shock originating in country 1 has an amplified effect on the business cycle of country 2.

This surprising result is due (again) to the reaction of the common central bank. We observe that the latter lowers the union's interest rate following the supply shock in country 1. It does this because the supply shock has a strong negative effect on inflation. Given the high weight attached to inflation in the Taylor rule the central bank lowers the interest rate (despite the fact that the output gaps have increased). This lowering of the (nominal) interest rate has very different effects in the two countries. In country 1 the rate of inflation declines by more than the decline in the nominal interest rate. This is due to the fact that the rate of inflation of country 1 has a weight of only 50% in the common central bank's Taylor rule. Thus in country 1 the real interest rate actually increases. The opposite occurs in country 2. There inflation increases as a result of the boom generated by the supply shock in country 1. As a result, the real interest rate declines significantly in country 2 boosting aggregate demand and thereby reinforcing the positive effect of country 1's supply shock.

We conclude that in a monetary union where the common central bank gives a high weight to inflation in its policy rule, a supply shock originating in one country has an amplified effect on country 2. This amplification comes from the fact that the common interest rate rule transforms the positive supply shock originating in country 1 into a positive demand shock in country 2 which makes animal spirits in that country even more optimistic than in country 1, thereby reinforcing the positive transmission. It is clear that this amplification effect would not exist if each country had its own central bank and would set its own interest rate.

Figure 11: Impulse responses to positive supply shock in country 1



This phenomenon whereby a positive supply shock in one member-country of the union is transformed into a demand shock in the other member-countries may have occurred in the Eurozone during the period 2004-05 when the German government instituted major labour market reforms. These can be considered to have produced a positive supply shock in

Germany. It was transmitted to the rest of the Eurozone when the ECB loosened its monetary policies helping to boost aggregate demand in the periphery countries.

6.3 Transmission of shocks and uncertainty.

The impulse responses discussed in the previous section create the impression that our model is capable of tracing the transmission process following these shocks with great precision. This is in fact not the case. There is a lot of uncertainty about this transmission process. This uncertainty exists both for the transmission of demand and supply shocks. In this section we analyze the issue of uncertainty in the transmission process in greater detail. We first concentrate on the demand shocks and then on the supply shock.

Demand shock and uncertainty

We analyse the uncertainty in the transmission process by presenting the frequency distribution of the short-term effects of the demand shock in country 1. This frequency distribution was derived as follows. We simulated 1000 impulse responses to the same demand shock in country 1, assuming each time a different realization of stochastic shocks. We then collected the impulse response obtained in the 4th period after the demand shock occurred. In so doing we obtained 1000 short-term output responses. We plot these in the frequency domain. The results are shown in Figure 12. We find an extreme variation of these output responses both in country 1 and country 2. To repeat, this variation is only related to the fact that the 1000 simulations of the demand shock in country 1 occur with different "initial conditions" (different realizations of stochastic shocks). Thus, it matters a great deal when the demand shock occurs. For example, the effect of the demand shock in country 1 may be very different depending on whether the shock occurs during a recession, a boom or in more normal business cycle conditions. In order to obtain further insight in this question we plot the short-term output responses in country 2 against the animal spirits in country 2 prevailing at the time of the demand shock in country 1. We present the results in figure 13. The results are quite interesting. We observe that when the animal spirits are around 0, which means that there is no optimism or pessimism, the transmission of demand shocks from country 1 to country 2 are small. On average the multipliers are around 0.25. However, when the economy is gripped by extreme optimism (leading to a boom) or to extreme pessimism (leading to a recession) the transmission of the same shock in country 1 to country 2 becomes much larger. On average the multipliers increase to approximately 0.45.

Figure 12: Short-term output responses to demand shock in country 1

Country 1 Country 2

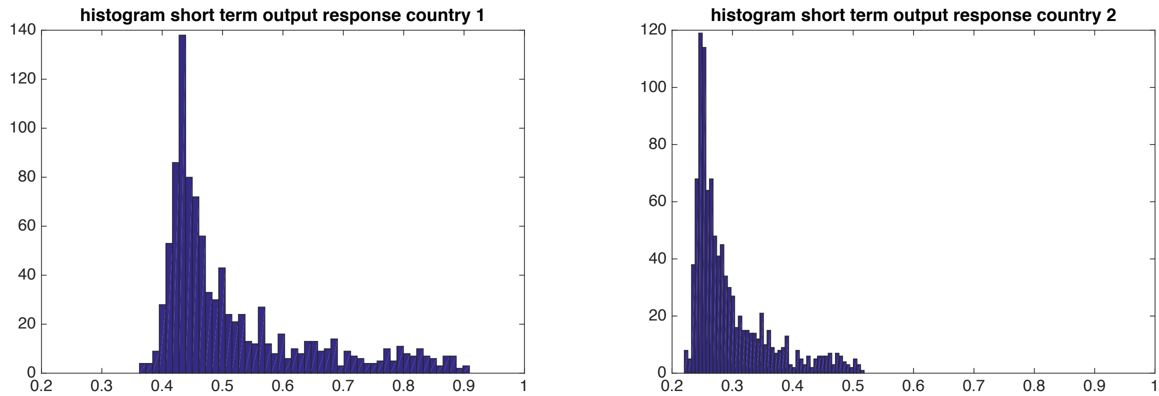
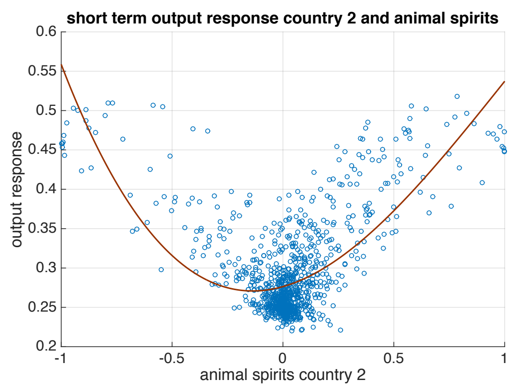


Figure 13: Short-term output responses and animal spirits (country 2)



This result suggests that during periods of recession, like the one the Eurozone has experienced immediately after the debt crisis of 2010, a fiscal expansion in one country, say Germany, can have a much higher impact on the other Eurozone countries than in normal times. A word of caution, however, is appropriate. We observe from figure 13 that there is a lot of variation around the mean effect shown by the quadratic line.

Supply shock and uncertainty

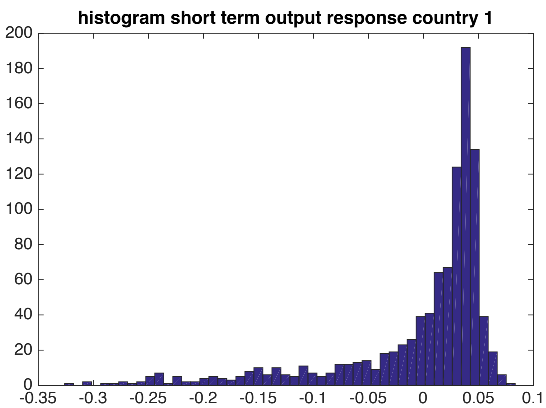
We now analyze the uncertainty surrounding the transmission of the supply shock occurring in country 1 is transmitted in countries 1 and 2. We show the frequency distribution of the short-term output effects in countries 1 and 2 in Figure 14. We observe the same phenomenon as the one observed with the demand shock. There is a great variation in the short-term output responses to the supply shock in countries 1 and 2. We note that on average the short-term output response is stronger in country 2 than in country 1. We analyzed the reasons for this amplification effect in the previous section.

In Figure 15 we plot the short-term output effects in country 2 against the animal spirits in country 2. We observe a similar phenomenon as noted in the previous section. The size of the transmission of the supply shock depends on the intensity of the animal spirits. When these are extreme (positive of negative) the negative output effects in country 2 are significantly higher than when market sentiments are neutral.

We conclude from this analysis that the transmission of shocks is clouded in great uncertainty. This uncertainty has to do with the fact that the exact moment the shock occurs matters. In other words, history matters. Shocks that occur in one particular moment in history can have very different effects on the economy than the same shock occurring at another moment.

Figure 14: Short-term output responses to supply shock in country 1

Country 1 **Country 2**



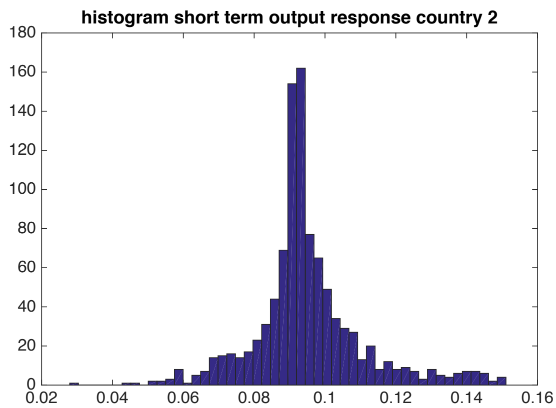
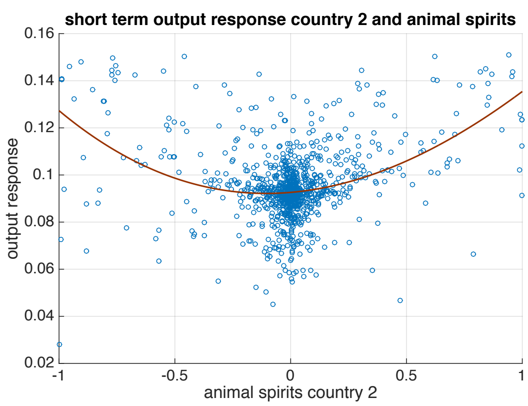


Figure 15: Short-term output responses and animal spirits (country 2)



7. Comparing the Behavioral model with Rational Expectations

The model consisting of the two aggregate demand functions, the two aggregate supply functions and the common Taylor rule can be solved assuming rational expectations (RE). We do this in the present section using the same parameter values as those used in the behavioral model. In both models we assume the same distributions of the stochastic shocks (iid with zero mean and std = 0.2) and compare the results obtained under RE with the results of our behavioral model. We concentrate first on the correlations of the output gap obtained in these two models. We show the results in table 4. We compute these correlation coefficients for different levels of the import propensity, *m*. The contrast between the models is striking. First the behavioral model produces much higher cross-country correlations of the output gaps than the RE model. This illustrates the importance of animal spirits as an independent force in producing international synchronization of the business cycles. Second, the difference in the correlation coefficients produced by the two models narrows as *m* increases. Put differently, with low import propensities the RE model produces very low correlation coefficients. These increase faster than in the behavioral model when *m* increases.

We noted earlier that the correlation coefficients produced by the behavioral model comes close to those observed empirically. The RE model cannot produce such correlation coefficients except by assuming that the shocks hitting the economies are correlated, and/or assuming very high import propensities.

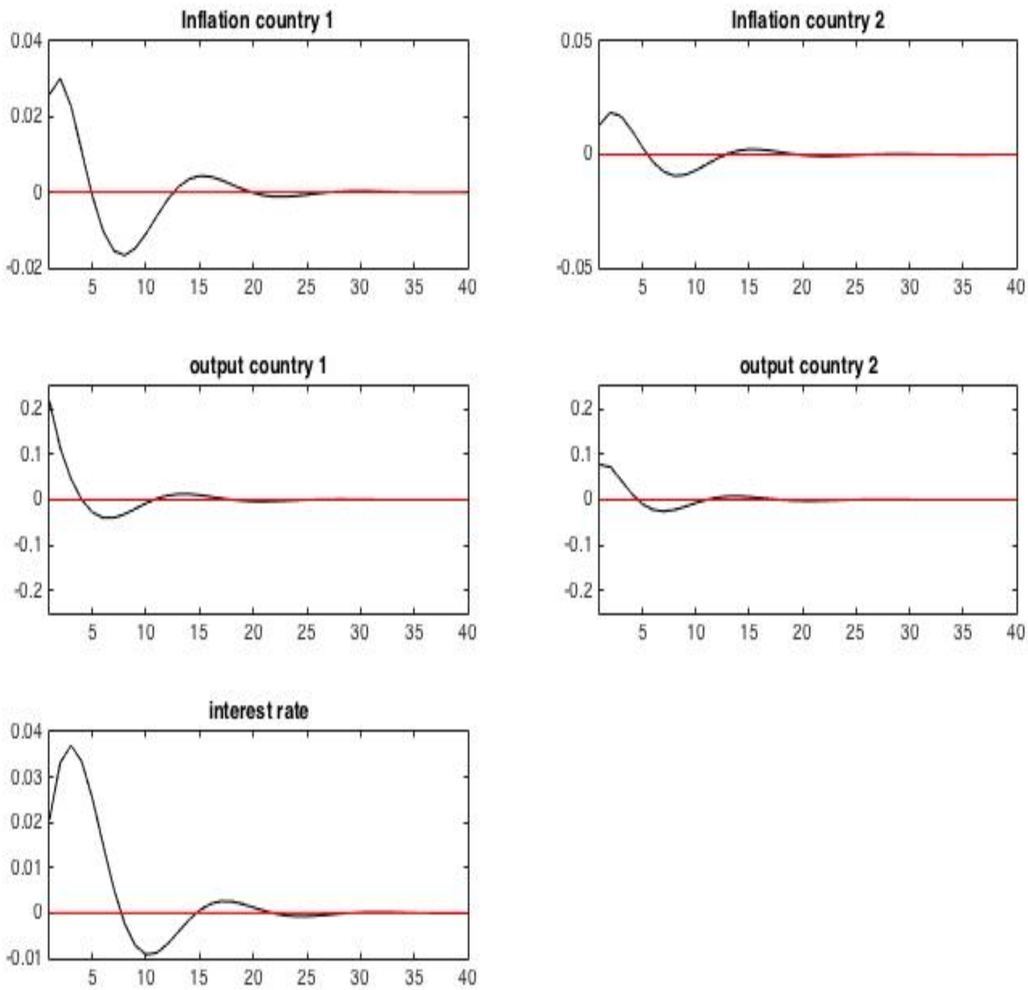
Table 4: International correlations of the output gaps

m	0,2	0,4	0,6	0,8
Behavioral model	0,61	0,76	0,85	0,91
RE model	0,13	0,39	0,53	0,62

The next step in the analysis consisted in comparing the impulse responses to the same shock. We computed the impulse responses to a positive demand shock in country 1 in the two models. The results for the RE-mode are shown in Figure 16. These should be compared to the impulse responses of the behavioral model shown in Figure 10. A comparison of the two figures leads to the conclusion that the impact of the positive demand shock on output and inflation in the two countries in the behavioral model is significantly higher than in the RE-model. This also leads the central bank to raise the interest rate more in the former than in the latter model. This difference has everything to do with the existence of animal spirits in the behavioral model. These tend to intensify the demand shock by creating optimism that reinforces the positive effects of the demand shocks. As a result, the central bank is forced to raise the interest rate more in the behavioral than in the RE-model.

There is a second difference that relates to uncertainty. As discussed in the previous section the impulse responses in the behavioral model depend on the initial conditions. This uncertainty is absent from the impulse responses in the RE-Model.

Figure 17: Impulse responses to positive demand shock in country 1 (RE-model)



Finally we produced a number of business cycle statistics (mean, standard deviation, autocorrelation) of the output gaps and inflation rates in the Behavioral and the RE-model. As we will want to compare these with empirical data in section 8, we restrict the time domain to 80 quarters (20 years). We show the results in Table 5. We observe that we obtain similar values of the mean and the standard deviations. The autocorrelations, however, are significantly higher in the Behavioral than in the RE-model. Note that we feed both models with the same iid exogenous shocks, i.e there is no autocorrelation in the shocks. In addition, the lag structures in the two models are identical. Thus, the Behavioral model generates more autocorrelation in the output gap and inflation endogenously than the RE-model. As we will show in the next section, the Behavioral model better tracks the empirical autocorrelation patterns in the output gap and inflation.

Table 5: Business cycle statistics Behavioral and RE-model

Behavioral model	mean	stdev	autocorr
output gap 1	-0,07	0,75	0,94
output gap 2	-0,57	1,09	0,96
inflation 1	1,86	0,31	0,8
inflation 2	2,29	0,57	0,82
RE-model	mean	stdev	autocorr
output gap 1	0,12	0,6	0,77
output gap 2	-0,4	0,82	0,79
inflation 1	2,2	0,40	0,63
inflation 2	2,1	0,44	0,59

Note: results based on simulation of 80 periods (20 years).
The inflation results assume the central bank has 2% target.

8. Empirical discussion

In this section we provide empirical evidence that is consistent with the predictions made by our behavioral model.

8.1 Business cycle statistics

We compare empirically generated means, standard deviations and autocorrelations of output gaps and inflation with those generated by the Behavioral and RE-models. We selected France and Germany during the Eurozone period (1999-2016). We show the results in Table 6. These should be compared with Table 6. We find that the means are very comparable. The empirical standard deviations are somewhat larger than the theoretical ones. Finally, the empirical autocorrelations are above 0.9. This is also what we obtain with the behavioral model, in contrast with the RE-model, which predicts significantly lower autocorrelations.

Table 6: Business cycle statistics France and German (1999-2016)

Eurozone	mean	stdev	autocorr
output gap France	-0,09	1,63	0,92
output gap Germany	-0,66	1,78	0,96
inflation France	1,59	0,91	0,81
inflation Germany	1,51	0,83	0,76

Sources: Output gap: Oxford Economics; inflation: Eurostat

8.2 Non-normality of the distribution of the output gap

Our model predicts that the output gap does not follow a normal distribution but that it is characterized by excess kurtosis and fat tails (Figure 4). We obtained this result even though the shocks in demand, supply and Taylor rule are normally distributed. In the RE-version of our model we obtain a normally distributed output gap under the same assumption about the distribution of the shocks.

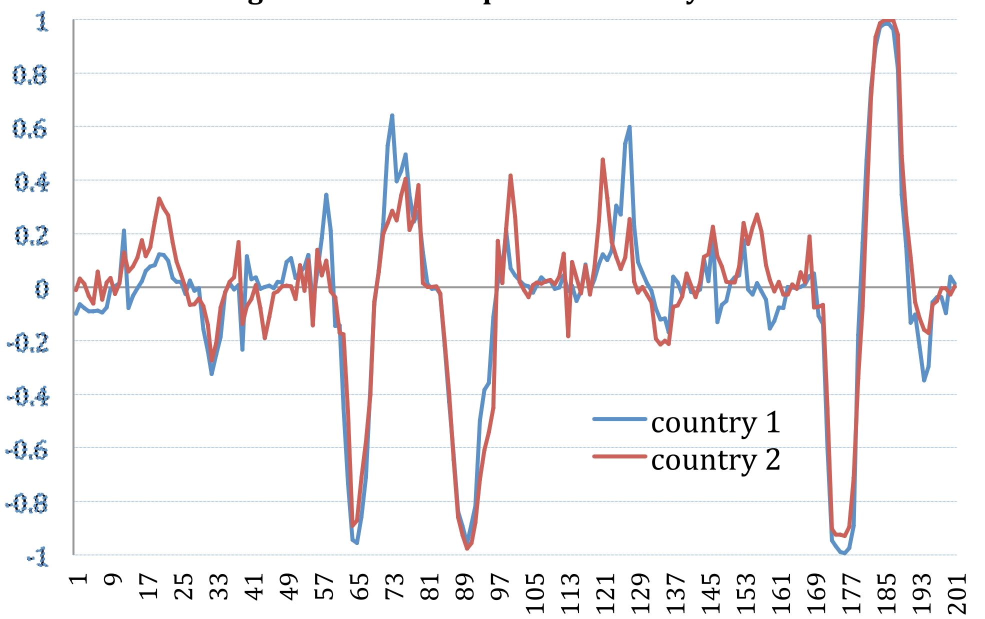
We noted in section 3 that there is strong empirical evidence that output gaps and the growth rates of output in the OECD-countries are not normally distributed. One could object to this empirical evidence that the large shocks observed in the output gaps can also be the result of large exogenous shocks. As a result, non-normality does not necessarily contradict the results obtained under Rational Expectations. RE-models can generate non-normal distributions of the output gap if the shocks follow a non-normal distribution.

The claim that is made here is not that the economy cannot sometimes be hit by large shocks, but that a theory that claims that large movements in output can *only* occur because of exogenous shocks is not a powerful theory. It necessitates finding a new exogenous explanation for every large boom and bust observed in output. Put differently, for every boom or every bust a new story has to be told. Such a theory has little predictive power. Our theory allows for an explanation that is generated within the model. It is, therefore, more powerful.

8.3 The correlation pattern of animal spirits is non-linear

In our theoretical model the fat tails in the distribution of the output gap are related to the concentration of animal spirits at the extreme ends of their distribution, i.e. we obtain intense booms and busts when sentiments of optimism and pessimism are intense. This feature has an interesting implication for the international correlation of animal spirits. Our model predicts that the correlation pattern of animal spirits is non-linear, i.e. during tranquil periods (most of the time) the international correlation of animal sprits is weak. This correlation is very high when the animal spirits reach extreme values of optimism or pessimism. Thus the strong international correlation of animal spirits is driven mainly by the extreme values of these animal spirits. This feature is made clear visually in Figure 18 that shows the simulated animal spirits in a typical simulation of the model.

Figure 18: Animal spirits in country 1 and 2



Source: simulation result of the theoretical model

We show this feature of the model in a more precise way in Table 7. This presents the international correlations of animal spirits for different ranges of variation of the animal spirits. We have arranged the range of variation from low to high. We observe that the observations of animal spirits located in a band of variation between -0.01 and +0.01 show a correlation of only 0.09. As we increase this band the correlation increases. For the whole sample we obtain a correlation of 0.94. Moving further down the first column we concentrate on values of animal spirits that come closer and closer to 1. The observations of animal spirits that are less than 1% from the extremes of +1 and -1 show a correlation of 0.9998.

Table 7: Correlation animal spirits countries 1 and 2

<table>
<tr><th>Animal spirit index: from low to high</th><th>Correlation</th><th>Number of observations</th></tr>
<tr><td>|Anspirit|<0.01</td><td>0,09</td><td>180</td></tr>
<tr><td>|Anspirit|<0.05</td><td>0,25</td><td>595</td></tr>
<tr><td>|Anspirit|<0.1</td><td>0,44</td><td>832</td></tr>
<tr><td>|Anspirit|<0.2</td><td>0,60</td><td>1118</td></tr>
<tr><td>|Anspirit|<0.5</td><td>0,79</td><td>1497</td></tr>
<tr><td>Full sample</td><td>0,94</td><td>1998</td></tr>
<tr><td>|Anspirit|>0.5</td><td>0,97</td><td>501</td></tr>
<tr><td>|Anspirit|>0.8</td><td>0,986</td><td>299</td></tr>
<tr><td>|Anspirit|>0.9</td><td>0,991</td><td>234</td></tr>
<tr><td>|Anspirit|>0.95</td><td>0,995</td><td>180</td></tr>
<tr><td>|Anspirit|>0.99</td><td>0,9998</td><td>93</td></tr>
</table>

Note: |Anspirit| is the absolute value of animal spirit of country 1 in our simulation

We tested the theoretical prediction of a non-linearity of the correlation pattern of animal spirits between the Eurozone countries. We selected the same business confidence index discussed in the previous sections and we computed the bilateral correlation coefficients between pairs of countries of the Eurozone for different ranges of variations of the indices. We show the average bilateral correlation results in Table 8 (in Appendix 2 we present all the bilateral correlations between different Eurozone countries)

Table 8. Correlation of Business Confidence Index (BCI) across Eurozone

<table>
<tr><th>German BCI (from low to high)</th><th>Average bilateral correlation</th></tr>
<tr><td>99.5-100.5</td><td>0.64</td></tr>
<tr><td>Total sample</td><td>0.75</td></tr>
<tr><td><99.5 | >100.5</td><td>0.77</td></tr>
<tr><td><99.2 | >100.8</td><td>0.81</td></tr>
<tr><td><99.1 | >100.9</td><td>0.83</td></tr>
<tr><td><99.0 | >101.0</td><td>0.86</td></tr>
<tr><td><98.0 | >102.0</td><td>0.95</td></tr>
</table>

Note: The BCI data is obtained from OECD monthly data. The BCI has been scaled to yield a long-term average of 100.
The data on Ireland are incomplete in Ireland is incomplete therefore our calculations of bilateral correlations do not include Ireland.
See Appendix 3 for the matrices which present the bilateral correlations between different Eurozone countries given the range of business confidence index

We find that when the observations of the business confidence indices are restricted to lie between 99.5 and 100.5 the bilateral correlations are low compared to the total sample (i.e.

0.64 vs. 0.75). Conversely when we restrict the observations to lie in ranges of large variation, the average bilateral correlation increase significantly vis-a-vis the total sample. In the range of observations where the BCI is either below 98 (extreme pessimism) or above 102 (extreme optimism) we find correlation coefficients typically exceeding 0.9 and the average bilateral correlation reaches 0.95. These high correlations for extreme values of animal spirits are predicted by our theoretical model.

9. Conclusion

We started this paper by the observation that the degree of synchronization of the business cycles in the Eurozone is very high. It is also higher than what can be explained by trade flows. It can also not easily be explained by high financial integration in the monetary union.

Standard macroeconomic models have found it difficult to mimick the high synchronization of business cycles without introducing common exogenous shocks. Thus in these models the international synchronization of business cycles is exogenously produced phenomenon.

In this paper we used a two-country behavioral macroeconomic model in a monetary setting where the two countries are linked with each other by international trade. The net export of country 1 depends on the output gap of country 2 and on real exchange rate movements. The synchronization of the business cycle is produced endogenously. The main channel of synchronization occurs through a propagation of "animal spirits", i.e. waves of optimism and pessimism that get correlated internationally. We found that this propagation occurs with relatively low levels of trade integration. In addition, once a particular level of trade integration is reached further integration does not increase the synchronization of business cycles anymore.

We also found that the propagation of animal spirits and thus the synchronization of the business cycles is enhanced by the fact that in a monetary union the common central bank is a source of common shocks. This helps to introduce correlation between the animal spirits of the member countries.

The degree of output synchronization is very much influenced by the intensity with which the central bank stabilizes output. When that intensity is high, the central bank is able "to tame the animal spirits". In so doing it reduces the propagation dynamics of these animal spirits.

We also studied the transmission of a demand shock in one country towards the other country. We find that the size of the transmission very much depends on "initial conditions", i.e. the business cycle situation of the countries involved. When the business cycle is extreme, i.e. dominated by either extreme pessimism or optimism the transmission of the demand shock is significantly higher than when "Great Moderation" prevails. There is, however, great uncertainty about the size of this transmission.

The striking feature of these results is that in the absence of animal spirits the uncertainty about the transmission of both the demand and supply shocks tends to disappear. In addition, the multipliers become significantly smaller. Animal spirits not only have the effect of creating great uncertainty about the transmission of shocks between countries, they also tend to amplify the effects of demand and supply shocks in both countries. We came to this conclusion by comparing our behavioral model with a macroeconomic model with the same New Keynesian features solved under Rational Expectations.

We also studied the transmission of a supply shock from one country to the other. We found that when countries are part of a monetary union, a positive supply shock in one country is transformed into a strong positive demand shock in the other country. This has to do with the fact that the common central bank reacts to the lower inflation produced by the supply shock by lowering the union interest rate. As a result, the second country experiences a decline in the real interest rate and an increase in aggregate demand. This effect disappears in a regime where the countries are not members of a monetary union and set their own interest rates.

Finally we also performed an exercise in empirical verification. Our model makes a number of predictions that can be tested. First, it predicts that the distribution of the output gap is non-normal. This prediction is confirmed by empirical evidence. Second, the model predicts that there is a strong correlation of animal spirits across countries and that this correlation is non-linear, i.e. that it is very strong when animal spirits are intense and weak in tranquil periods. Using the OECD indices of business confidence we tested these predictions and we could not reject them.

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Appendix 1: Solving the model assuming that π*=0

The solution of the model is found by first substituting (10) into (6) and (7) and rewriting in matrix notation. This yields:

$$\begin{bmatrix} 1-\frac{0.5*a\prime 2*c2}{1+m} & -\frac{0.5*a\prime 2*c2+m}{1+m} & -\frac{0.5*a\prime 2*c1}{1+m} & -\frac{0.5*a\prime 2*c1}{1+m} \\ -\frac{0.5*a\prime 2*c2+m}{1+m} & 1-\frac{0.5*a\prime 2*c2}{1+m} & -\frac{0.5*a\prime 2*c1}{1+m} & -\frac{0.5*a\prime 2*c1}{1+m} \\ -b2 & 0 & 1 & 0 \\ 0 & -b2 & 0 & 1 \end{bmatrix} \begin{bmatrix} y_t^1 \\ y_t^2 \\ \pi_t^1 \\ \pi_t^2 \end{bmatrix} =$$

$$\begin{bmatrix} \frac{a_1}{1+m} & 0 & \frac{-a_2}{1+m} & 0 \\ 0 & \frac{a_1}{1+m} & 0 & \frac{-a_2}{1+m} \\ 0 & 0 & b1 & 0 \\ 0 & 0 & 0 & b1 \end{bmatrix} \begin{bmatrix} \tilde{E}_t y_t^1 \\ \tilde{E}_t y_t^2 \\ \tilde{E}_t \pi_t^1 \\ \tilde{E}_t \pi_t^2 \end{bmatrix} + \begin{bmatrix} \frac{1-a_1}{1+m} & 0 & 0 & 0 \\ 0 & \frac{1-a_1}{1+m} & 0 & 0 \\ 0 & 0 & 1-b_1 & 0 \\ 0 & 0 & 0 & 1-b_1 \end{bmatrix} \begin{bmatrix} y_{t-1}^1 \\ y_{t-1}^2 \\ \pi_{t-1}^1 \\ \pi_{t-1}^2 \end{bmatrix} + \begin{bmatrix} a2*c3 \\ a2*c3 \\ 0 \\ 0 \end{bmatrix} r_{t-1} + \begin{bmatrix} \frac{\mu}{1+m}\left(\frac{1}{R_{t-1}} - R_{t-1}\right) \\ \frac{\mu}{1+m}\left(R_{t-1} - \frac{1}{R_{t-1}}\right) \\ 0 \\ 0 \end{bmatrix} +$$

$$\begin{bmatrix} \frac{a'2*u_t+\varepsilon_t^1}{1+m} \\ \frac{a'2*u_t+\varepsilon_t^2}{1+m} \\ \eta_t^1 \\ \eta_t^2 \end{bmatrix}$$

where $a'_2=a_2(1-c_3)$

Or $$\boldsymbol{AZ_t} = \boldsymbol{B\widetilde{E_t}\,Z_{t+1}} + \boldsymbol{CZ_{t-1}} + \boldsymbol{b}r_{t-1} + \boldsymbol{U_{t-1}} + \boldsymbol{v_t} \qquad \text{(A1)}$$

where bold characters refer to matrices and vectors. The solution for $\boldsymbol{Z_t}$ is given by

$$\boldsymbol{Z_t} = \boldsymbol{A^{-1}}\left[\boldsymbol{B\widetilde{E_t}\,Z_{t+1}} + \boldsymbol{CZ_{t-1}} + \boldsymbol{b}r_{t-1} + \boldsymbol{U_{t-1}} + \boldsymbol{v_t}\right] \qquad \text{(A2)}$$

The solution exists if the matrix $\boldsymbol{A}$ is non-singular. The system (A2) describes the solution for y_t^1, y_t^2, π_t^1 and π_t^2 given the forecasts of y_t^1, y_t^2, π_t^1 and π_t^2. The latter have been specified in equations (11)-(26) and can be substituted into (A2). We then obtain a system of non-linear difference equations. Finally, the solution for r_t is found by substituting y_t^1, y_t^2, π_t^1 and π_t^2 obtained from (A2) into Taylor rule equation (10).

The model has non-linear features making it difficult to arrive at analytical solutions. That is why we will use numerical methods to analyze its dynamics. In order to do so, we have to calibrate the model, i.e. to select numerical values for the parameters of the model. In appendix 2 the parameters used in the calibration exercise are presented. They are based on Gali(2008). The model was calibrated in such a way that the time units can be considered to be quarters. A sensitivity analysis of the main results to changes in the some of the parameters of the model will be presented. The three shocks (demand shocks, supply shocks and interest rate shocks) are independently and identically distributed (i.i.d.) with standard deviations of 0.2%. We also allow the demand and supply shocks to be correlated across countries in some analyses. It will turn out that these correlations affect the transmission of business cycles across countries.

Appendix 2: Non-linear correlation pattern animal spirits (1999-2016)

Correlation of business confidence index when 99.5<BIC<100.5; Observation 52; Average correlation:0.64

	AT	BE	FI	FR	DE	GR	IT	NL	PT	ES
AT	1.00									
BE	0.48	1.00								
FI	0.52	0.70	1.00							
FR	0.26	0.80	0.56	1.00						
DE	0.45	0.53	0.36	0.32	1.00					
GR	0.50	0.69	0.52	0.77	0.17	1.00				
IT	0.38	0.86	0.72	0.92	0.35	0.80	1.00			
NL	0.32	0.86	0.65	0.87	0.47	0.67	0.89	1.00		
PT	0.45	0.85	0.70	0.82	0.45	0.73	0.92	0.93	1.00	
ES	0.59	0.71	0.75	0.80	0.33	0.81	0.87	0.72	0.83	1.00

Correlation of business confidence index (full sample); Observation 216. Average correlation: 0.75

	AT	BE	FI	FR	DE	GR	IT	NL	PT	ES
AT	1.00									
BE	0.87	1.00								
FI	0.86	0.85	1.00							
FR	0.75	0.86	0.83	1.00						
DE	0.90	0.86	0.73	0.73	1.00					
GR	0.42	0.47	0.58	0.64	0.20	1.00				
IT	0.74	0.86	0.83	0.93	0.69	0.70	1.00			
NL	0.83	0.91	0.81	0.90	0.83	0.60	0.89	1.00		
PT	0.70	0.82	0.71	0.84	0.66	0.66	0.86	0.91	1.00	
ES	0.65	0.70	0.70	0.83	0.53	0.75	0.89	0.81	0.85	1.00

Correlation of business confidence index when BIC <99.5 or BIC>100.5; Observation 164. Average correlation: 0.77

	AT	BE	FI	FR	DE	GR	IT	NL	PT	ES
AT	1.00									
BE	0.90	1.00								
FI	0.89	0.87	1.00							
FR	0.81	0.87	0.88	1.00						
DE	0.93	0.89	0.78	0.79	1.00					
GR	0.42	0.45	0.58	0.62	0.23	1.00				
IT	0.80	0.86	0.87	0.94	0.74	0.70	1.00			
NL	0.87	0.92	0.84	0.91	0.86	0.60	0.90	1.00		
PT	0.73	0.81	0.72	0.85	0.69	0.65	0.85	0.90	1.00	
ES	0.66	0.70	0.70	0.83	0.57	0.74	0.90	0.83	0.86	1.00

Correlation of business confidence index when BIC<99.2 or BIC>100.8; Observation 115. Average correlation: 0.81

	AT	BE	FI	FR	DE	GR	IT	NL	PT	ES
AT	1.00									
BE	0.93	1.00								
FI	0.92	0.91	1.00							
FR	0.86	0.90	0.92	1.00						

DE	0.94	0.91	0.83	0.84	1.00					
GR	0.48	0.49	0.61	0.63	0.27	1.00				
IT	0.84	0.88	0.92	0.95	0.77	0.75	1.00			
NL	0.93	0.94	0.93	0.93	0.88	0.66	0.92	1.00		
PT	0.82	0.84	0.84	0.88	0.74	0.74	0.87	0.91	1.00	
ES	0.74	0.73	0.82	0.86	0.62	0.85	0.93	0.84	0.84	1.00

Correlation of business confidence index when BIC<99.1 or BIC>100.9
Observation 100. Average correlation: 0.83

	AT	BE	FI	FR	DE	GR	IT	NL	PT	ES
AT	1.00									
BE	0.94	1.00								
FI	0.95	0.92	1.00							
FR	0.92	0.91	0.93	1.00						
DE	0.95	0.93	0.86	0.91	1.00					
GR	0.51	0.49	0.61	0.59	0.30	1.00				
IT	0.88	0.89	0.92	0.95	0.82	0.73	1.00			
NL	0.94	0.94	0.94	0.96	0.89	0.66	0.94	1.00		
PT	0.85	0.85	0.85	0.87	0.77	0.73	0.87	0.91	1.00	
ES	0.78	0.74	0.83	0.86	0.66	0.83	0.94	0.85	0.84	1.00

Correlation of business confidence index when BIC<99 or BIC>101; Observation 84. Average correlation: 0.86

	AT	BE	FI	FR	DE	GR	IT	NL	PT	ES
AT	1.00									
BE	0.96	1.00								
FI	0.96	0.93	1.00							
FR	0.94	0.93	0.93	1.00						
DE	0.95	0.94	0.88	0.94	1.00					
GR	0.60	0.54	0.66	0.62	0.39	1.00				
IT	0.93	0.92	0.94	0.96	0.88	0.73	1.00			
NL	0.96	0.94	0.95	0.96	0.91	0.71	0.96	1.00		
PT	0.86	0.85	0.87	0.90	0.78	0.80	0.91	0.92	1.00	
ES	0.84	0.80	0.88	0.89	0.75	0.83	0.94	0.89	0.91	1.00

Correlation of business confidence index when BIC<98 or BIC>102; Observation 29. Average correlation: 0.95

	AT	BE	FI	FR	DE	GR	IT	NL	PT	ES
AT	1.00									
BE	0.98	1.00								
FI	1.00	0.98	1.00							
FR	0.97	0.99	0.97	1.00						
DE	0.97	0.99	0.97	1.00	1.00					
GR	0.87	0.79	0.87	0.75	0.73	1.00				
IT	0.99	0.99	0.99	0.99	0.98	0.83	1.00			
NL	1.00	0.98	0.99	0.98	0.98	0.85	0.99	1.00		
PT	0.99	0.96	0.99	0.95	0.94	0.90	0.98	0.97	1.00	
ES	0.99	0.96	0.99	0.95	0.94	0.90	0.98	0.97	0.99	1.00