Business Cycle Dynamics in the Euro Area*

Atılım Seymen†

April 7, 2009

Abstract

The role of global, euro area and country-specific shocks in business cycle dynamics of the euro area are assessed with the aid of SVAR models. It is found that euro area shocks became a relatively more important factor behind cyclical fluctuations of the euro area countries recently. Another robust finding of the paper is that business cycle heterogeneity is driven mainly by country-specific shocks in the euro area and not by heterogeneous responses to common shocks. The Great Moderation is found to be related to changes corresponding to global and country-specific shocks in the euro area, euro area shocks do not play a significant role in this phenomenon. Heterogeneity also underwent a moderation which can be traced back to changes corresponding to country-specific shocks of the member countries.

JEL classification: C32, E32

Keywords: International Business Cycles; Common and Country-Specific Shocks; Structural Vector Autoregression

*Earlier versions have been presented at the Macro-Finance Brown Bag Seminar at the Centre for European Economic Research (ZEW), Mannheim and at the Applied Economics and Econometrics Seminar at the University of Mannheim. I thank the participants for their comments and suggestions. Any errors are my own.

†Address: Centre for European Economic Research (ZEW), P.O. Box 103443, D-68304 Mannheim, Germany. E-mail: seymen@zew.de

1. Introduction

The properties of business cycles in the euro area countries has been the subject of a large literature since the initiation of the European Monetary Union (EMU) process which led to using a common currency – the Euro – in meanwhile 16 countries.[1] The subject is interesting not least because of the fact that common currency and common monetary policy may have – near positive impacts – adverse effects on some of the member countries of a monetary union when their business cycles are not sufficiently synchronised. In particular, the member countries do not pursue own exchange rate and monetary policies in a monetary union and may hence lack flexibility when confronted with shocks.[2] Since central banks optimise and set the monetary policy with respect to the business cycle of an entire zone that shares a common currency, common monetary policy may have destabilizing effects on member countries, of which business cycles deviate to a large extent from the one of the entire single currency area. This is why an important concern of the member countries' policy-makers in the pre-EMU und post-EMU periods has been the extent and sources of business cycle heterogeneity in the euro area, a subject that also triggered extensive academic research.

This paper addresses several issues related to the business cycle dynamics in the euro area from the 1970s to today. A prerequisite for a successful monetary union is that the business cycles of its members are driven by common factors. Therefore, one question of interest in this paper is the extent to which the business cycles of the euro area countries have been driven by common factors in pre-EMU und post-EMU periods. One should differentiate between global and euro-area-specific common factors when dealing with this question, since the EMU process has been taking place concurrently with the globalisation phenomenon, and since both are similarly characterised by features such as a substantial increase in international capital flows and trade relative to former times, stronger financial market integration, higher mobility of labor, etc. across countries. The presumption of a large body of macroeconomic theory suggests that both the EMU process and the globalisation should lead to a stronger

[1] We consider only six member states of the euro area in the empirical application of this paper – Belgium, Germany, Spain, France, Italy and the Netherlands – and discard the other member states due to data related issues.

[2] The optimum currency area theory sets some guidelines on the conditions that should be fulfilled for a successful monetary union. See Mundell (1961) and McKinnon (1963) for the first contributions to the theory.

integration of the euro area economies. This should imply in turn a higher synchronisation of the member countries' business cycles due to the increasing impact of common factors they are subject to. A challenge for macroeconomists is to isolate the effects of the EMU process and the globalisation on the business cycle dynamics of the euro area countries, which requires the measurement of a euro area factor in addition to a global factor as a potential driving force of business cycle fluctuations. In this paper, we measure both factors with the aid of structural vector autoregression (SVAR) models and investigate the role of these factors in cyclical fluctuations of member countries' output by employing variance decompositions.

As noted above, an important concern of the member countries' policy-makers has been the extent and sources of business cycle heterogeneity in the euro area. The most popular tool employed in the literature to assess the heterogeneity in the euro area countries' business cycles is the simple correlation. It has been shown in many studies that business cycles of the euro area countries are positively correlated. However, that the correlations are typically not perfect reflects the fact that there is some heterogeneity involved. Furthermore, macroeconomic theory is not united about the effects of monetary unions on business cycle synchronisation. While there are, as mentioned above, theoretical arguments that suggest higher business cycle synchronisation (and hence less heterogeneity) follows among member countries due to establishment of a monetary union, theoretical arguments have also been put forward that monetary unions might lead to a divergence of the member countries' business cycles.[3]

One of our aims in this study is to assess the extent and sources of business cycle heterogeneity in the euro area and to explore whether heterogeneity became stronger or weaker in the post-EMU period. In theory, two extreme situations can be the driving force of business cycle heterogeneity. On the one hand, countries may be subject to common shocks, but their response to those shocks may differ substantially. Such a case can be seen as reflection of differences between countries in terms of economic structure. The term economic structure refers here to the entire economic environment covering aspects like fiscal policy, natural

[3]The study of Krugman (1991) is the one that is often cited in the context. The core of the argument is that integration would lead to a concentration of industries which might be subject to their peculiar shocks. Such shocks stand for asymmetric shocks affecting only a specific part of the currency area.

and human resources, sectoral structure and specialisation, labor market regulation, etc. On the other hand, countries may be sharing similar economic structures, but may be hit by asymmetric shocks. Both mechanisms are likely to play some role in reality, and our analysis helps shed light on the extent to which these mechanisms explain the observed heterogeneity in the euro area. To this end, we consider two different measures of heterogeneity. The first measure is the simple correlation coefficient between each member country's cycle and the entire euro area cycle. In this context, we compute true and counterfactual correlations. True correlations are generated when all types of shocks are allowed to take place in the empirical model, while counterfactual correlations refer to correlations that would have been observed if at least one source of shocks were set to zero. High and positive counterfactual correlations in the face of common shocks – global or euro area shocks – are interpreted to be reflective of structural similarity of an individual country to the entire euro area.

The second measure of heterogeneity considered in this paper is the differential between the euro area business cycle and the business cycle of a member country. The analysis of differentials brings additional insights on the extent and sources of business cycle heterogeneity. The ideal case is clearly that the cycle of the entire euro area and each member country overlap exactly. Note, however, that there may be differences between the euro area business cycle and the cycle of a member country, even when they are perfectly correlated. We illustrate such a hypothetical situation in Figure 1. The panel on the left-hand side shows the cycle of a reference country together with the cycle of another country. Although both cycles are perfectly correlated, the differential between them is non-zero except on the points where they intersect on the x-axis. Note furthermore that the mean of both cycle series is zero, which implies a zero mean for the differential. While such a perfect-looking situation does not qualify for an exact match of two cycles, the reality is even more complicated than this picture: cycles are not deterministic and do not move symmetrically around turning points as in our example, their amplitude, phase and other characteristics change over time due to shocks that hit economies. This is why we do not content only with a comovement analysis of cycles in this study, but also investigate the driving forces of the differentials.

The Great Moderation has been the subject of a large empirical (and theoretical) literature that covers our sample period. It refers to the decline in volatility of business cycles

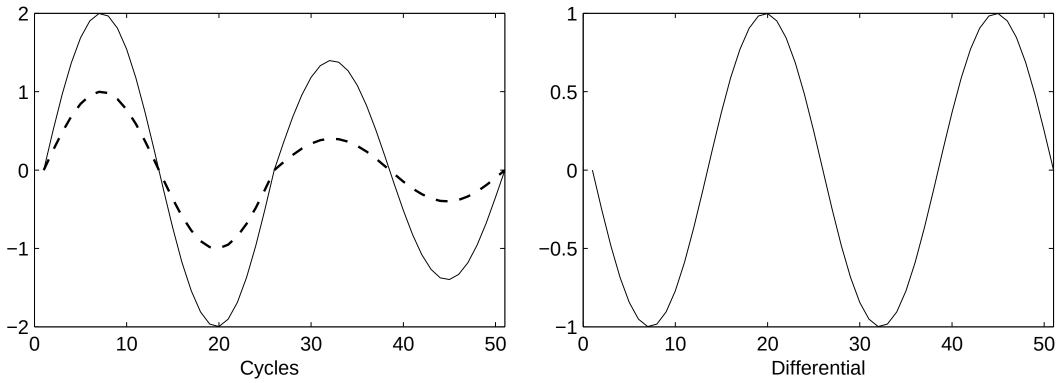

Figure 1: Business cycles and business cycle differential of two hypothetical countries

in industrialised countries after roughly the second half of the 1980s until a short time ago. Different explanations of this phenomenon have been suggested. The concurrence of the decline in business cycle volatility in many countries makes the question interesting whether the Great Moderation is related to changes in international factors. Our empirical framework allows us also to investigate the extent to which the Great Moderation can be attributed to changes related to global, euro area and country-specific shocks in the euro area. Furthermore, we explore whether the decline in output gap volatility has its roots in changes in shock propagation mechanisms or in changes in size of shocks.

Our hypothetical example illustrated in Figure 1 implies that the Great Moderation in output gaps must not necessarily imply a moderation of output gap differentials. Examples of a situation can even be given where the amplitude of both output gaps become smaller, but the amplitude of differentials grows for a while. Yet, we find a moderation of output gap differentials too and explore also the driving forces of this change in the euro area business cycle dynamics.

We start our analysis by discussing the properties of business cycles in the euro area in the next section. In Section 3, the model with which we explore the dynamics underlying euro area business cycles is presented. Section 4 is devoted to the presentation and discussion of the results over two different sub-samples covering pre-EMU and post-EMU periods. In Section 5, results from rolling regressions are discussed and compared with the results from Section 4. Section 6 provides a summary of results and concluding remarks.

2. Data

We start our analysis with descriptive statistics of output gaps and output gap differentials in the euro area. Note that the euro area consists of 16 countries currently, but only 6 member countries are considered in this study – Belgium (bel), Germany (deu), Spain (esp), France (fra), Italy (ita) and the Netherlands (nld). Some of the other member countries are discarded from the sample, since they do not have a long enough history to show an EMU effect in large parts of our sample. For some others, reliable quarterly data is not available over the entire sample period we consider, which spans the time from 1970Q1 to 2007Q4.

We report statistics from two sub-periods, from 1970Q1–1990Q2 and from 1990Q3–2007Q4 throughout the paper. Splitting the entire sample into two sub-periods allows us to capture changes in business cycle dynamics over time. Although a significant moderation of business cycles can be observed for each country in the sample, it is obvious even without referring to any statistical test that the countries do not share a common structural break, see Figure 2 which shows the output gap of the entire euro area together with the output gap of each member country. The most important reason for splitting the sample at 1990Q2 is that after this period exchange controls were abolished and capital could move freely within the then European Economic Community, which constituted the first big practical step towards the creation of the euro. Note that this time period also coincides roughly with the collapse of the Iron Curtain and a new wave in globalisation. It is also the quarter immediately before the German reunification, of the country with the highest economic weight in the euro area. Yet, our choice of splitting the sample at 1990Q2 is still arbitrary. Therefore, we also estimate rolling regressions covering 60 quarters from the beginning of the sample until the end in Section 5 of this paper.

The measure of the business cycle when reporting the descriptive statistics is the asymmetric filter suggested by Christiano and Fitzgerald (2003). This linear filter brings the advantage that we do not lose observations at both ends of the sample when we employ it. We specify the filter such that it eliminates the trend and irregular components of time series that do not correspond to the conventional range of 1.5 to 8 years. However, we carry out a robutsness check with respect to the underlying business cycle definition, since our

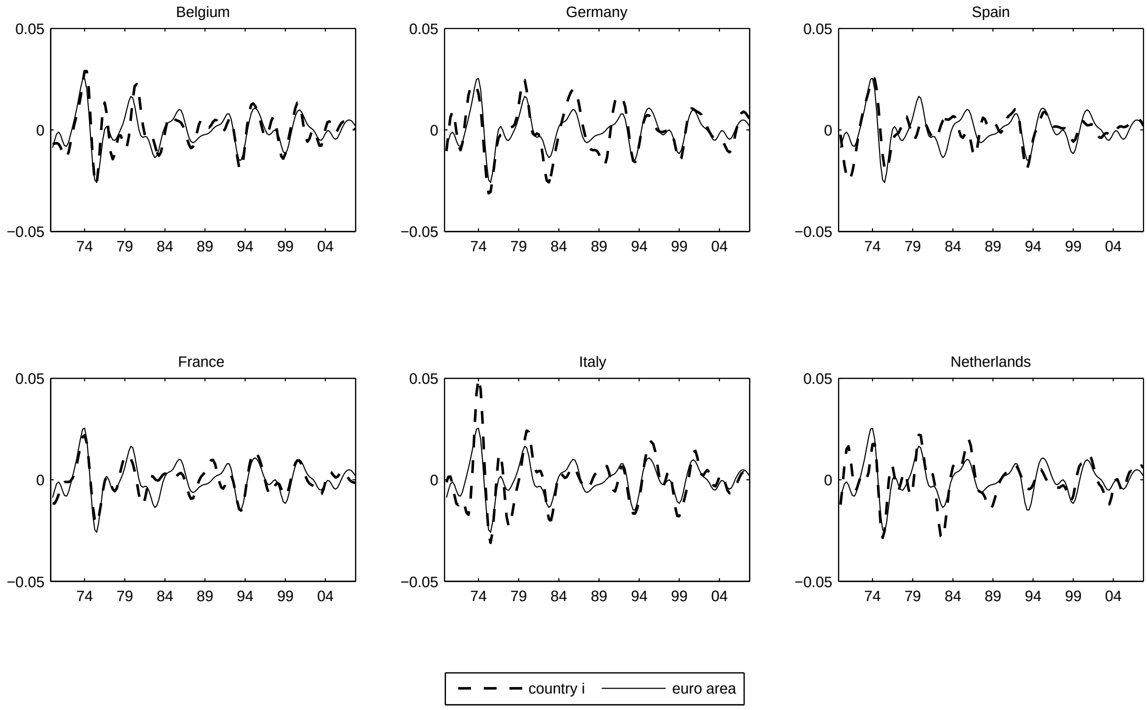

Figure 2: Output gap of individual countries and euro area

conclusions may depend on the definition we choose.[4]

Looking at Figure 2, it immediately catches one's eye that output gaps of member countries are generally strongly correlated with the output gap of the entire euro area, although the correlation is typically not perfect. Table 1 quantifies this observation. All reported correlations exceed 0.5 for both sub-periods. The Spanish cycle was related to the euro area cycle much less in the first sub-period than in the second sub-period. This is not very surprising given the change Spain underwent in its political system in the 1970s and given that its EU membership started at a later date than the other five countries considered in this study. However, following an initial adjustment process after the EU membership in 1986, Spain seems to have caught up with the core countries of the EU in terms of synchronicity of its cycle with the entire euro area.

Table 2 reports the standard deviation of output gaps in the euro area in the two sub-periods. The first and second rows respectively show the standard deviation of the output gap

[4]See, for example, Canova (1998) who reports that "stylized facts" of business cycles vary across different filtering methods. Artis et al. (2004) also mention some studies on business cycle synchronisation in the euro area that come to different conclusions due to disaggrement on the used detrending method.

Table 1: Output gap correlation of member countries with the euro area aggregate

	bel	deu	esp	fra	ita	nld
1970Q1–1990Q2	0.79	0.90	0.56	0.86	0.83	0.76
1990Q3–2007Q4	0.89	0.94	0.82	0.86	0.91	0.82

Abbreviations: bel: Belgium, deu: Germany, esp: Spain, fra: France, ita: Italy, nld: the Netherlands.

Table 2: Output gap volatility

	bel	deu	esp	fra	ita	nld
1970Q1–1990Q2	1.13	1.26	1.13	0.82	1.50	1.13
1990Q3–2007Q4	0.73	0.80	0.64	0.61	0.82	0.55
relative volatility	0.64	0.63	0.57	0.75	0.55	0.49

Notes: The third row shows the relative volatility, i.e. the standard deviation in the second sub-period divided by its counterpart in the first sub-period for each country. See Table 1 for abbreviations.

of the selected countries. As is visible in Figure 2 too, the volatility of output gaps decreased in each member country in the second half of the sample, and the standard deviations in Table 2 confirm this result. The third row of Table 2 shows the relative volatility, i.e. the standard deviation in the second sub-period divided by its counterpart in the first sub-period for each country. The relative decline in output gap volatility is least in France, where the output gap standard deviation in the second sub-period was 0.75 times the standard deviation in the first sub-period.

We had mentioned in the introduction that investigation of output gap differentials might provide additional valuable information on business cycle heterogeneity in the euro area. Differentials are computed by subtracting the realisation of the cyclical measure, i.e. the output gap computed with the Christiano-Fitzgerald filter, in the euro area from its counterpart in a member country. For example, if the realisation of the euro area output gap is 0.01 in a certain time period, this means that the euro area output is 1 percent above its long-run trend. When the output gap in Germany is 0.006 in the same period, i.e. 0.6 percent

Table 3: Output gap differential volatility

	bel	deu	esp	fra	ita	nld
1970Q1–1990Q2	0.69	0.57	0.99	0.49	0.88	0.74
1990Q3–2007Q4	0.34	0.30	0.38	0.33	0.36	0.36
relative volatility	0.49	0.52	0.39	0.67	0.40	0.49

Notes: The third row shows the relative volatility, i.e. the standard deviation in the second sub-period divided by its counterpart in the first sub-period for each country. See Table 1 for abbreviations.

above its long-run trend, the output gap differential between the euro area and Germany is $0.01 - 0.006 = 0.004$, i.e. 0.4 percent. Hence, the output gap differential shows what should happen in a member country so that its business cycle position coincides exactly with the business cycle position at a certain time point in the entire euro area.

Our hypothetical example illustrated in Figure 1 made clear that there is no a priori reason for the Great Moderation in output gaps to lead to a decline in output gap differential volatility. There can also be given examples such that the volatility of output gap differentials are higher or lower than the volatility of the underlying output gaps. Output gap differentials of the selected member countries are shown in Figure 3. The first observation is that amplitude and shape of differentials changes across countries. So, the member countries have clearly distinct relationships with the entire euro area.[5] Second, the volatility of an output gap differential is always lower than the volatility of the corresponding member country's output gap. Finally, output gap differentials also underwent a moderation like output gaps, which speaks for decreasing heterogeneity among the euro area cycles. The latter observation is quantified in Table 3.

To summarise, the properties of both output gaps and the output gap differentials between member countries and the aggregate euro area have changed after the 1990s. The descriptive analysis also points to the fact that each member country has its own peculiar relationship with the entire euro area. In Sections 4 and 5, we show how these developments

[5]This assessment is supported by correlations of output gap differentials of the chosen countries, which are often negative or insignificantly different from zero, and positive in only three cases. We do not report these correlations in the paper to save space.

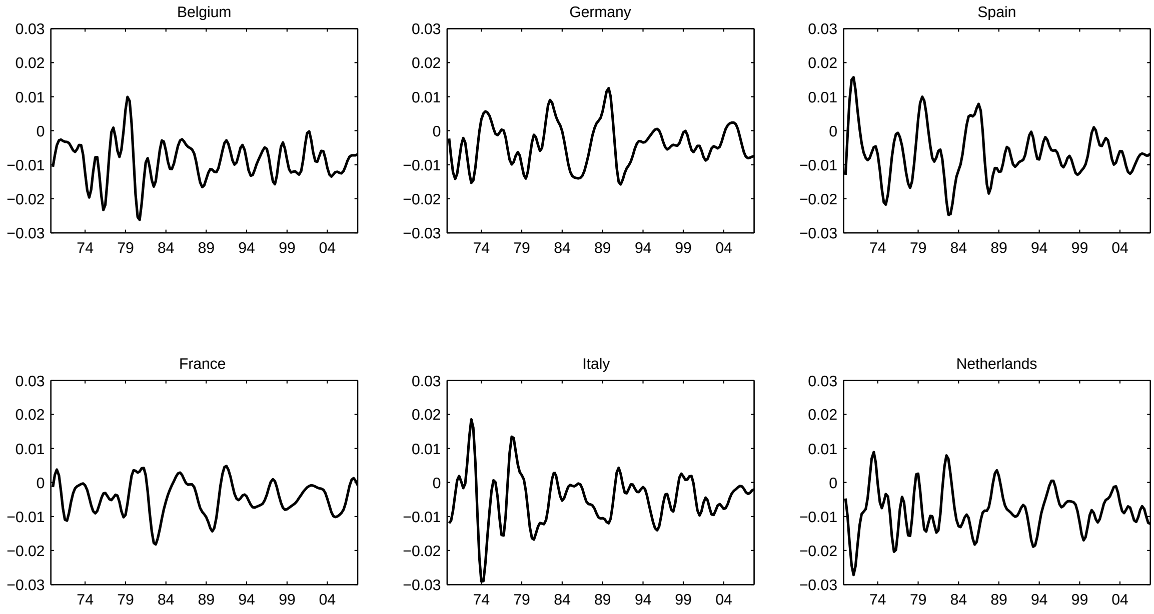

Figure 3: Output gap differentials in the euro area

are related to global, euro area and country-specific factors.

3. Econometric Methodology

The econometric analysis of this paper builds on a modified framework of Giannone and Reichlin (2005), who investigate the level of business cycle heterogeneity with the aid of bivariate vector autoregression (VAR) models comprising the euro area output and the output of a member country of the euro area. Using an approach similar to that of Stock and Watson (2005), Giannone and Reichlin distinguish between euro area and country-specific shocks. The euro area shocks are defined as shocks that affect the entire euro area as well as the individual countries in the period they occur, while country-specific shocks are labelled as such since they are spilled over from a certain country of origin to the rest of the euro area with a time lag. An important methodological handicap of this approach is that it takes into account only two sources of shocks – euro area and country-specific – which brings two disadvantages for our analysis. First, we want to assess the role of global and euro area shocks in business cycle dynamics of the euro area. Business cycle synchronisation may get stronger, for example, due to both global and euro area shocks over time, but the bivariate model may falsely attribute it to euro area shocks or spillovers from country-specific shocks. Second, from a technical point of view, the model may suffer from omitted-variables bias if global shocks have indeed a significant explanatory power for the dynamics. In order to overcome these potential shortcomings, we augment the bivariate framework of Giannone and Reichlin (2006) with US output following Giannone and Reichlin (2005, 2006) and Perez et al. (2006). Three types of shocks – global, euro area and country-specific shocks – are estimated. Global shocks are labelled as such since they influence the output in the US, the euro area and individual euro area countries immediately in the period they take place. The euro area and country-specific shocks are defined in the same manner as described above.

3.1. Bivariate Models

The first bivariate model of Giannone and Reichlin (2006) follows from a simpler version of the strategy followed by Stock and Watson (2005). The moving average representation of the bivariate model underlying the empirical analysis is given by

$$\begin{bmatrix} \Delta y_t^{EA} \\ \Delta y_t^i \end{bmatrix} = \begin{bmatrix} \mu^{EA} \\ \mu^i \end{bmatrix} + \sum_{j=0}^{\infty} \begin{bmatrix} \Theta_{j,11} & \Theta_{j,12} \\ \Theta_{j,21} & \Theta_{j,22} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{EA} \\ \varepsilon_t^i \end{bmatrix} \tag{1}$$

where Δy_t^{EA} and Δy_t^i stand respectively for the first-differenced log output of the euro area and country i at period t, μ^{EA} and μ^i stand for constant terms, $\Theta_{j,kl}$ is the (k,l) element of the j^{th} moving average coefficient matrix, and ε_t^{EA} and ε_t^i are defined as euro area and country-i shocks, respectively. The crucial identification restriction in this system is that country-specific shocks affect the euro area aggregate only with a lag of one quarter. Therefore, the immediate effect of a country-specific shock on the euro area in the period it occurs is limited to the population share of the country the shock stems from. Formally,

$$\Theta_0 = \begin{bmatrix} \Theta_{0,11} & p_i \Theta_{0,22} \\ \Theta_{0,21} & \Theta_{0,22} \end{bmatrix} \tag{2}$$

where p_i is the population share of country i in the euro area.

Five important differences to the study of Giannone and Reichlin in our application are that (i) we work with quarterly data (at the cost of losing some countries in the sample) as is typical in studies dealing with business cycles, while Giannone and Reichlin use annual data; (ii) we estimate the VARs in first differences or a cointegrated VAR depending on the results of corresponding statistical tests, while Giannone and Reichlin estimate them in levels which may potentially lead to spurious results due to unit roots in the data; (iii) our bivariate VAR models include four lags of the endogenous variables, while Giannone and Reichlin assume only one lag; as we discuss later, this is an important point since the assumption of one lag may drive one of the findings of Giannone and Reichlin; (iv) we estimate the model in sub-periods in order to capture the potential changes in the size of shocks as well as their transmission so that changes due to the EMU process and the globalisation as well as the driving forces of the Great Moderation can be detected; and (v) we compare output gaps in the euro area computed with the Christiano-Fitzgerald filter, while Giannone and Reichlin concentrate on output level or growth.

Giannone and Reichlin (2006) also investigate with a similar model to the first one the business cycle relationship between the US and the euro area. The second model reads

$$\begin{bmatrix} \Delta y_t^{US} \\ \Delta y_t^{EA} \end{bmatrix} = \begin{bmatrix} \mu^{US} \\ \mu^{EA} \end{bmatrix} + \sum_{j=0}^{\infty} \begin{bmatrix} \Theta_{j,11} & \Theta_{j,12} \\ \Theta_{j,21} & \Theta_{j,22} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{US} \\ \varepsilon_t^{EA} \end{bmatrix} \tag{3}$$

with

$$\Theta_0 = \begin{bmatrix} \Theta_{0,11} & 0 \\ \Theta_{0,21} & \Theta_{0,22} \end{bmatrix} \tag{4}$$

so that euro area shocks are spilled over to the US with only one lag while the US shock affects both the US and the euro area in the period they occur.

3.2. Trivariate Model

The bivariate model in (1) does not allow us to distinguish between global and euro area shocks which may bias our conclusions. Therefore, we find it useful to augment it with another variable – the US output – in the way the model in (3) suggests. This enables us to isolate the effects of US, euro area and country-specific shocks for each member country.

We interpret the US shocks to be standing for global shocks throughout the paper, since the US economy dominates the global economy.

The trivariate model we work with is a natural extension of the strategy followed by Giannone and Reichlin (2006). It combines the aforementioned two types of bivariate models those authors work with. Furthermore, the model resembles the model employed by Perez et al. (2006), who work with trivariate VARs containing the output of the US, EU15 and one of the G7 countries except the US. Our innovation is (i) to consider the euro area instead of the EU15, since the euro area is a more coherent group in terms of being subject to common policy and is our subject of interest; (ii) to take into account the population shares of the member countries in the identification scheme in the way Giannone and Reichlin (2006) do, which is a more reasonable restriction than the zero restriction used by Perez et al. (2006) for the impact of German, French and Italian shocks on EU15 output.

The trivariate model is given by

$$\begin{bmatrix} \Delta y_t^{US} \\ \Delta y_t^{EA} \\ \Delta y_t^{i} \end{bmatrix} = \begin{bmatrix} \mu^{US} \\ \mu^{EA} \\ \mu^{i} \end{bmatrix} + \sum_{j=0}^{\infty} \begin{bmatrix} \Theta_{j,11} & \Theta_{j,12} & \Theta_{j,13} \\ \Theta_{j,21} & \Theta_{j,22} & \Theta_{j,23} \\ \Theta_{j,31} & \Theta_{j,31} & \Theta_{j,33} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{US} \\ \varepsilon_t^{EA} \\ \varepsilon_t^{i} \end{bmatrix}, \tag{5}$$

which is hence analogous to (1), the only difference being that the US output, the corresponding coefficients as well as a US shock (which we assume to represent a global shock) are now a part of the VAR too. In this case, the impact effect of shocks on the output of the US, the euro area and country i is given by

$$\Theta_0 = \begin{bmatrix} \Theta_{0,11} & 0 & 0 \\ \Theta_{0,21} & \Theta_{0,22} & p_i\Theta_{0,33} \\ \Theta_{0,31} & \Theta_{0,32} & \Theta_{0,33} \end{bmatrix}. \tag{6}$$

The zero entries in the first row of Θ_0 that determines the impact effects of shocks imply that euro area and country-specific shocks do not influence the US economy in the period they occur.

3.3. Business Cycle Generating Process

Our empirical results all follow from estimated processes that generate the business cycles of the US, the euro area and each member country considered in this study. Based on the business cycle generating process, counterfactual correlations can be computed, and variance decompositions or decompositions of changes in cyclical dynamics can be carried out.

Contrary to Section 2, of which reported statistics are obtained by applying the asymmetric Christiano-Fitzgerald filter directly on the observed output data, we make the computations based on processes in the rest of the paper. To this end, we apply the symmetric Christiano-Fitzgerald filter to each sub-component of each variable in (5). The approximate process generating the cyclical component of, for example, the output of country k for $k = US, EA, i$, $\tilde{y}_t^k$, can be written as

$$\tilde{y}_t^k = \sum_{j=-\kappa}^{\kappa} \Psi_{j,k,US}\varepsilon_{US,t+j} + \sum_{j=-\kappa}^{\kappa} \Psi_{j,k,EA}\varepsilon_{EA,t+j} \sum_{j=-\kappa}^{\kappa} \Psi_{j,k,i}\varepsilon_{i,t+j}, \tag{7}$$

where $\Psi_{j,k,l}$ for $l = US, EA, i$ stand for coefficients of the business cycle generating process of country k output for $k = US, EA, i$ with respect to structural shocks, and $\varepsilon_{l,t+j}$ for $l = US, EA, i$ stand for shocks at period $t + j$. Note that $\Psi_{j,k,l}$ are functions of estimated moving average coefficients in (5) and of coefficients of the symmetric Christiano-Fitzgerald filter.[6]

4. Results from Sub-samples

We are interested in answering three basic questions using the afore described empirical framework: (i) To what extent are the business cycles of the euro area countries driven by common factors? (ii) What are the extent and sources of heterogeneity in the euro area in terms of business cycles? (iii) Which mechanisms led to the moderation of business cycles and business cycle differentials in the euro area? The questions are addressed in the given order in the following. Since the output dynamics of each country is distinct from each other, we applied the conventional information criteria to determine the optimal number of lags as

[6] An appendix showing the derivation of the coefficients in (7) will soon be available from the author.

well as tested for cointegration in each country-specific model for each sub-period considered. The results with respect to information criteria differ across countries and sub-periods for each country. For the sake of comparibility, we estimated each country-specific model with four lags. A cointegration rank of zero resulted from Johansen tests for the sample from 1970Q1–1990Q2 and a rank of one for the sample from 1990Q3–2007Q4 in many cases, to which we stick when reporting the following benchmark results.

4.1. Driving Forces of Business Cycles

In this sub-section, we shed light on the role global, euro area and country-specific shocks play in the cyclical fluctuations of the member countries. A variance decomposition analysis is employed to this end. The variance of the cyclical component of output, $var\left(\tilde{y}_t^k\right)$ for $k = US, EA, i$, is given by

$$var\left(\tilde{y}_t^k\right) = \sum_l \left[\left(\sum_{j=-\kappa}^{\kappa} \Psi_{j,k,l}^2\right)\sigma_l^2\right], \tag{8}$$

where σ_l for $l = US, EA, i$ stands for the standard deviation of the global, euro area or country-specific shock in the corresponding model, which follows from (7). Hence, the share of the structural shock l on the variance of the output cycles of country k for $k = US, EA, i$ is nothing but

$$s_{kl}^i = \left[\left(\sum_{j=-\kappa}^{\kappa} \Psi_{j,k,l}^2\right)\sigma_l^2\right] / \sum_l^K \left[\left(\sum_{j=-\kappa}^{\kappa} \Psi_{i,jk}^2\right)\sigma_l^2\right], \tag{9}$$

which follows from the country-specific trivariate model of country i.

Table 4 shows the shares of shocks in the output gap variance of the euro area countries in the two sub-periods of interest. The importance of adding a global factor to the bivariate model is immediately clear, since the global shock drives the output gap variance of some member countries in both sub-periods to an important extent. The variance decomposition exercise also shows that euro area economies underwent important changes over the entire sample period. In the first sub-period, country-specific shocks are the main driving force of output gap fluctuations in all countries but Germany and France. In the latter countries, global shocks have the biggest weight and euro area shocks are also important. Particularly

Table 4: Shares of shocks in output gap variance of euro area countries

	Sample: 1970Q1–1990Q2					
	bel	deu	esp	fra	ita	nld
global shock	0.21	0.59	0.10	0.37	0.30	0.37
euro area shock	0.38	0.28	0.08	0.36	0.12	0.24
country shock	0.40	0.13	0.82	0.28	0.58	0.39

	Sample: 1990Q3–2007Q4					
	bel	deu	esp	fra	ita	nld
global shock	0.16	0.08	0.15	0.30	0.07	0.34
euro area shock	0.58	0.36	0.58	0.47	0.29	0.51
country shock	0.26	0.55	0.28	0.23	0.64	0.16

Note: See Table 1 for abbreviations.

in France, euro area shocks are as important as global shocks in the first sub-period. Euro area shocks have relatively small (in the Netherlands) or even negligible (in Spain and Italy) impacts. They seem, however, to be of some import for the Belgian output cycles.

The picture changes substantially in the second sub-period. The share of country-specific shocks in the output gap variance decreases in countries except Germany and Italy. There is virtually no change in that share in France, which was already low in the first period. A striking observation is the increase in the share of euro area shocks in the output gap variance of all countries in the sample. The most significant changes occur in Belgium, Spain and the Netherlands, where euro area shocks have weights over 0.5 in the second sub-period. The estimated shares of euro area shocks range between 0.29 and 0.58 in the second sub-period, which is much higher than its counterpart in the first sub-period where the range is between 0.08 and 0.38.

4.2. Heterogeneity

Rising share of euro area shocks in the output gap volatility of member countries contributes to higher business cycle synchronisation only if those shocks lead to homogeneous dynamics across the member countries. Therefore, the subject of this sub-section is the driving forces of heterogeneity in the euro area. In order to account for the relative importance of differing shock propagation mechanisms and of exposition to asymmetric shocks in business cycle heterogeneity within the euro area, two tools are employed. First, counterfactual correlations are computed in order to see whether common shocks alone lead to high correlations of the entire euro area cycles with indiviual member countries' cycles. Counterfactual correlation analysis gives us hints on the homogeneity of the relationship of each member country with the entire euro area. Second, we apply the previous variance decomposition analysis to output gap differentials for estimating the driving forces of them.

4.2.1. Counterfactual Correlations

We estimate six different trivariate models. All these models imply that the output gaps of the US, the euro area and a member country comprise three counterfactual series, i.e. series that would have been observed if only one of the three structural shocks in the model took place. The counterfactual correlations are correlations that are computed between such series with respect to each one of the shocks. Formally,

$$corr\left(\tilde{y}_t^m, \tilde{y}_t^n|l\right) = \frac{cov\left(\tilde{y}_t^m, \tilde{y}_t^n|l\right)}{\sqrt{var\left(\tilde{y}_t^m|l\right) var\left(\tilde{y}_t^n|l\right)}}, \tag{10}$$

where $corr\left(\tilde{y}_t^m, \tilde{y}_t^n|l\right)$ stands for the correlation between the output gaps of countries m and n when only the shock l takes place and the other shocks are set to zero, $cov\left(\tilde{y}_t^m, \tilde{y}_t^n|l\right)$ stands for the corresponding covariance, and $var\left(\tilde{y}_t^m|l\right)$ and $var\left(\tilde{y}_t^n|l\right)$ are the variance of the output gaps of countries m and n conditional on shock l. Since we are interested in the relationship between a member country and the entire euro area in our analysis, we compute counterfactual correlations only between member countries' and the euro area's output gaps with respect to each shock. Note that under the business cycle generating process in (7), the covariance of both series is given by

$$cov\left(\tilde{y}_t^{EU}, \tilde{y}_t^i|l\right) = \left(\sum_{j=-\kappa}^{\kappa} \Psi_{j,EU,l}\Psi_{j,i,l}\right)\sigma_l^2. \tag{11}$$

The corresponding variances can also be inserted to (10) using a formula analogous to (8). The term counterfactual correlation refers to the fact that those correlations correspond

Table 5: True and counterfactual correlations of output gaps with the euro area

	Sample: 1970Q1–1990Q2					
	bel	deu	esp	fra	ita	nld
true	0.86	0.91	0.60	0.91	0.84	0.84
only global shock	0.99	0.99	0.87	1.00	0.97	0.97
only euro area shock	0.90	0.98	0.60	0.99	0.92	0.99
only country shock	0.95	0.64	0.98	0.96	0.90	0.56

	Sample: 1990Q3–2007Q4					
	bel	deu	esp	fra	ita	nld
true	0.90	0.92	0.86	0.91	0.91	0.76
only global shock	0.86	0.97	0.90	0.98	0.90	0.78
only euro area shock	0.96	0.99	0.96	0.99	0.97	0.89
only country shock	0.85	0.91	0.82	0.69	0.92	0.09

Note: See Table 1 for abbreviations.

to only one aspect of reality. A high (low) counterfactual correlation between the sub-components of the euro area and a member country output gaps with respect to a certain shock implies similar (diverse) shock propagation with respect to that shock over the business cycle.

Table 5 shows the true and counterfactual correlations based on the trivariate models of the euro area countries in the two sub-periods. In both panels, the first row contains the true correlations between the output gap of a member country and the euro area output gap in the corresponding period. [7] The second, third and fourth rows show the counterfactual correlations with respect to global, euro area and country-specific shocks, respectively. For example, we would have observed a correlation of 0.87 between the output gaps of Spain and the euro area if only global shocks had taken place in the first sub-period, while the counterfactual correlation corresponding to the country-specific shock of Spain is 0.98 in the first sub-period.

The counterfactual correlations with respect to common shocks, i.e. global and euro area

[7]Note that the reported true correlations in Table 5 follow directly from the (almost) ideal estimated business cycle generating process. The underlying filter is the symmetric fixed-length filter of Christiano-Fitzgerald. The reported true correlations in Table 5 are slightly different from the ones reported in Table 1, which follow from applying the asymmetric Christiano-Fitzgerald filter to the observed data.

shocks, have generally been quite high in both sub-periods for the member countries. Only the counterfactual correlations of the Netherlands with respect to these two shocks were slightly lower than the other countries' corresponding correlations in the second sub-period.

The counterfactual correlations with respect to country-specific shocks are more diverse and on average somewhat lower than the counterfactual correlations with respect to the common shocks. Interesting is that in some cases the true correlation is lower than all reported counterfactual correlations in both sub-periods. This result is due to the fact that counterfactual correlations are computed under the assumption that a member country and the euro area are both subject to only one and the same shock (one of global, euro area or country-specific of the particular country), while the true correlations are generated when the series are subject all shocks, which leads to a more mixed picture.

That the counterfactual correlations with respect to country-specific shocks are highly positive is indeed a quite different result than what Giannone and Reichlin (2006) obtain. They report very low countenfactual correlations with respect to country-specific shocks. Yet, we believe that this may be implied by their methodology. First, their measure of the business cycle is the growth rate. Second, they assume a lag order of one in their estimations. Moreover, they impose a contemporaneous zero restriction on the impact of the country-specific shocks on the euro area output growth. It is not surprising that such a structure leads to low counterfactual correlations with respect to country-specific shocks. Nevertheless, we obtain that each country-specific shock has a distinct effect on the euro area output. Figure 4 shows that the response of the euro area output to different country-specific shocks varies with respect to the country the shocks are stemming from. Hence, our counterfactual correlation exercise brings us to the similar conclusion as Giannone and Reichlin (2006) that "asymmetries are explained by idiosyncratic shocks rather than heterogeneous responses to common shocks" in the euro area.

4.2.2. Driving Sources of Output Gap Differentials

We carry out next a variance decomposition in order to detect the driving forces of output gap differentials. We are interested in whether our previous finding on heterogeneity is also supported by this type of an analysis. Note that there is no a priori reason for the driving

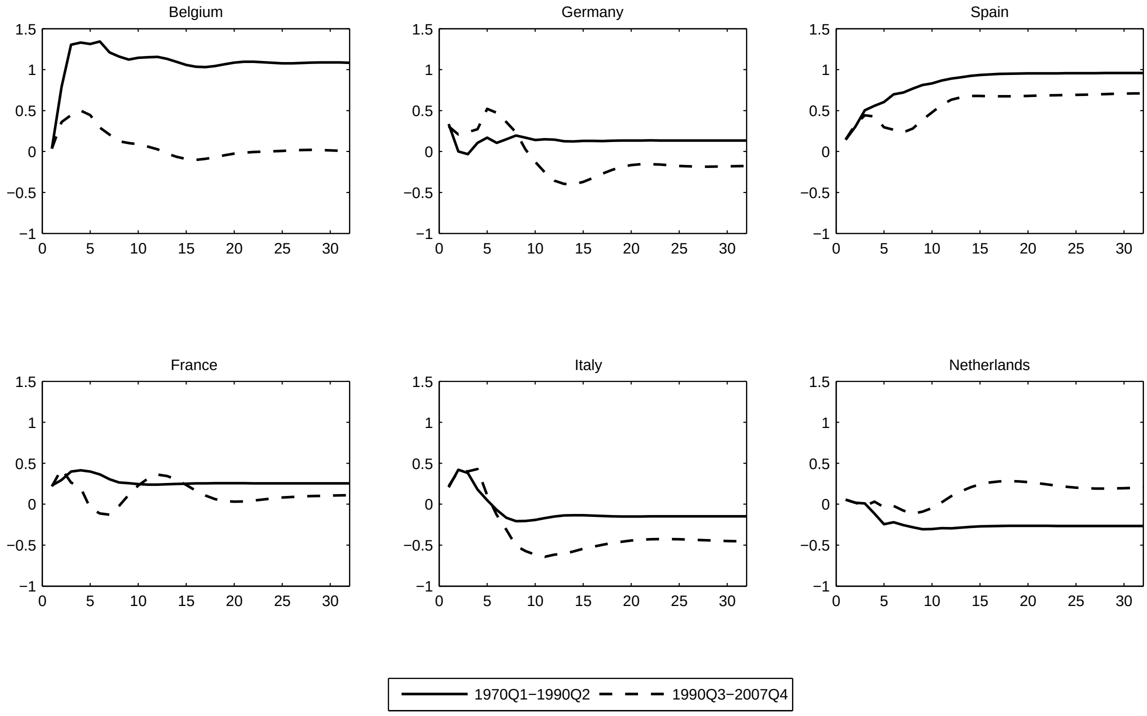

Figure 4: Response of euro area output to country-specific shocks

force of output gap differentials to be the same as the driving force of output gaps. According to Table 6, which shows the shares of shocks in the output gap differential variance of the euro area countries, the driving force of this variance is the own shock for every member country in the first sub-period, while the impact of global and euro area shocks is relatively small. The picture changes to a certain extent in the second sub-period. Own shocks remain still the main driving force of differentials in all member countries but Spain, where global and euro area shocks respectively have shares of 0.38 and 0.28 in the second sub-period. In Belgium and the Netherlands, global and euro area shocks gain in importance in the volatility of output gap differentials too. However, country-specific shocks are the clearly dominant driving force of the differentials of Germany, France and Italy – the biggest three economies of the euro area.

4.3. The Great Moderation

The descriptive statistics reported in Section 2 pointed to important changes in business cycle dynamics of the euro area since the 1970s. Output gap volatility and output gap

Table 6: Shares of shocks in output gap differential variance of euro area countries

	Sample: 1970Q1–1990Q2					
	bel	deu	esp	fra	ita	nld
global shock	0.08	0.19	0.15	0.22	0.10	0.07
euro area shock	0.30	0.19	0.20	0.06	0.09	0.02
country shock	0.62	0.62	0.65	0.72	0.82	0.90

	Sample: 1990Q3–2007Q4					
	bel	deu	esp	fra	ita	nld
global shock	0.26	0.09	0.38	0.09	0.09	0.29
euro area shock	0.21	0.04	0.28	0.17	0.10	0.31
country shock	0.53	0.87	0.34	0.75	0.82	0.40

Note: See Table 1 for abbreviations.

differential volatility were both lower after the 1990s. This change may theoretically result from two fundamental sources: (i) changes in the size of shocks; or (ii) changes in shock transmission. In the following, we first document changes in the size of shocks and shocks transmission. Then, we conduct a different type of decomposition analysis than before in order to detect the driving forces of the moderation of both output gap volatility and output gap differential volatility.

4.3.1. Size of Shocks

The widely used approach in the SVAR literature is to set the standard deviation of structural shocks to 1. Such a normalisation does not affect conventional impulse response functions, variance decompositions or counterfactual correlations. Since we are interested in changes in the shock propagation as well as the size of shocks in this study, we carry out a different type of normalisation than in most SVAR studies. Instead of assuming that the covariance matrix of structural shocks is an identity matrix, we assume that the covariance matrix is diagonal but do not set its diagonal elements to unity. Then, in order to make an exact identification possible, we normalise the contemporaneous relationships among the endogenous variables of the VAR.

The first two panels of Table 7 show the estimated standard deviations of global, euro area and country-specific shocks with each country-specific model for the two sub-periods. The last panel shows the relative standard deviation between the two sub-periods, i.e., each standard deviation in the first panel divided by the corresponding standard deviation in the second panel. Thus, a figure higher than 1 in the last panel indicates that the standard deviation of the corresponding shock has decreased in the second period relative to the first period. Note that the ideal situation would be that the entries corresponding to global and euro area shocks in the first and second rows of each panel are exactly the same for in each country's estimated model. This is, however, not possible with the simple methodology we apply. Yet, the reported values are generally roughly close to each other. Looking at the last panel, two important changes regarding the size of shocks can be read out. First, the standard deviation of both global and euro area shocks decreased in the second sub-period relative to the first sub-period. The relative decline is higher in the case of global shocks, that is, their standard deviation decreased more strongly than the standard deviation of euro area shocks. Second, the size of country-specific shocks decreased as well in all countries except Belguim. The decline in France is also relatively weaker in comparison to the other member countries of our sample.

4.3.2. Shock Propagation

The conventional tool employed by macroeconomists for examining the shock propagation is the impulse response function. Figures 3a-3c show the response of output in the euro area countries to a one-unit global, euro area and country-specific shock for the first (solid) and the second sub-period (dashed), respectively. Thus, we can assess whether the euro area economies underwent structural changes over time. For example, if the response to a certain shock in the second sub-period period is lower than in the first sub-period, then this implies, evertyhing else equal, that the share of that shock in the variance of output fluctuations has decreased due to the change in the propagation of the shock. Moreover, we can also see whether the change is only quantitative, i.e. in the magnitude of the impulse response or also qualitative, i.e. in the shape of the impulse response in a certain country.

It arises from Figure 3b that the response of all member countries in the sample changed a lot from the first sub-period to the second, which has possibly a lot to do with the EMU

Table 7: Standard deviation of shocks

	Sample: 1970Q1–1990Q2					
	bel	deu	esp	fra	ita	nld
global shock	8.53	8.75	8.94	8.74	8.90	8.69
euro area shock	4.53	3.16	4.54	4.20	4.03	4.40
country shock	2.18	4.51	5.67	3.15	6.58	10.08

	Sample: 1990Q3–2007Q4					
	bel	deu	esp	fra	ita	nld
global shock	4.07	3.97	3.75	3.79	4.15	3.88
euro area shock	2.36	1.37	2.31	2.03	1.94	2.46
country shock	2.65	2.95	2.58	2.47	3.16	3.50

	Relative standard deviation					
	bel	deu	esp	fra	ita	nld
global shock	2.09	2.20	2.38	2.31	2.14	2.24
euro area shock	1.92	2.31	1.97	2.07	2.08	1.79
country shock	0.82	1.53	2.19	1.27	2.08	2.88

Notes: The third panel shows the relative standard deviation, i.e. each standard deviation in the first panel divided by its counterpart in the second panel. See Table 1 for abbreviations.

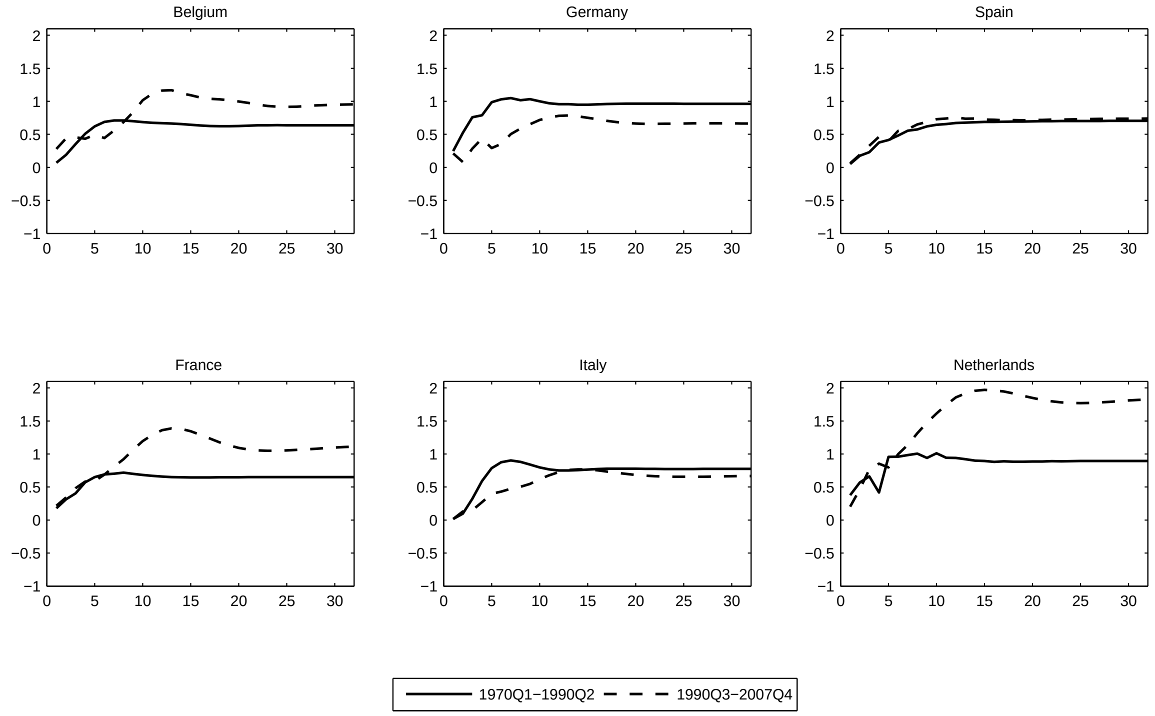

Figure 3a: Response to global shock

process. The same can be argued also for the response of output to global shocks in all countries but Spain and to country-specific shocks in all countries but Italy. In general, it is hard to draw conclusions from Figures 3a-3c that apply to all countries similarly. Every country seems to have rather its own peculiar story. Therefore, we use a tool for assessing the impact of changes in magnitude of shocks as well as in their transmission which encompasses both effects in a unifying framework in the following.

4.3.3. Moderation of Output Gaps

Quoting Stock and Watson (2005), "the variance of [output gap] in a given country can change because the magnitude of the shocks impinging on that economy have changed or because the effects of those shocks have changed." The foregoing findings show that both effects are relevant for the euro area economies: on the one hand, the volatility of global, euro area and country-specific shocks and, on the other hand, the response of the economies to those shocks underwent changes. In order to compute the weight of both channels in the Great Moderation observed in every euro area country, we employ the decomposition

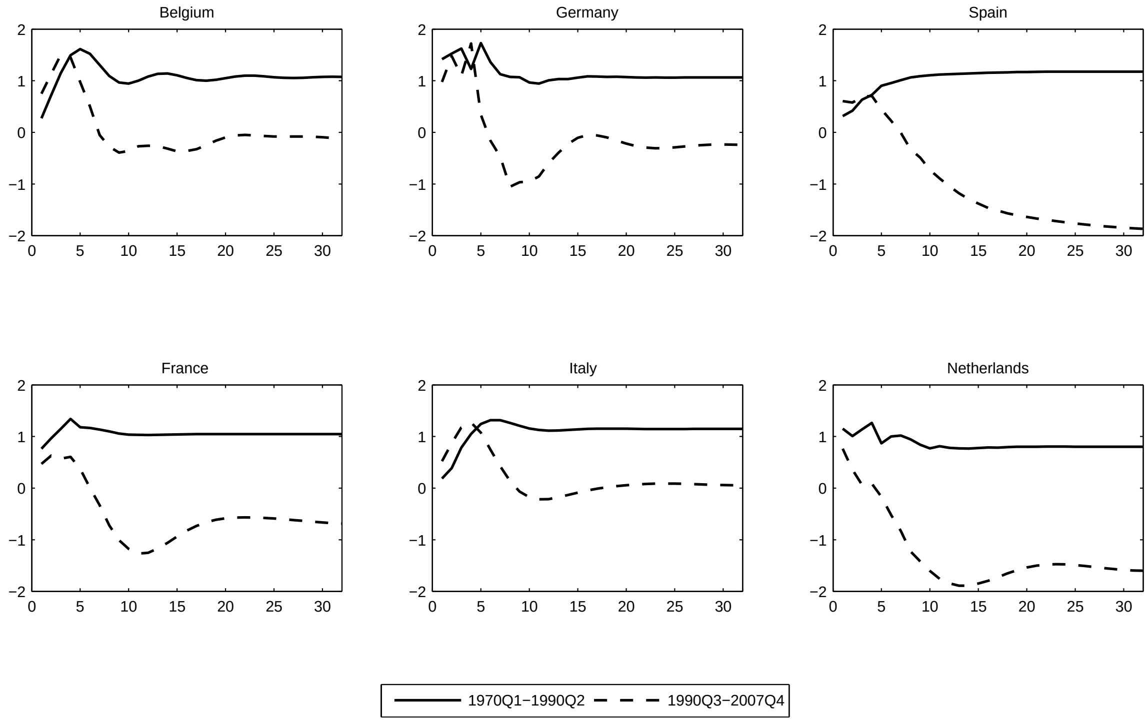

Figure 3b: Response to euro area shock

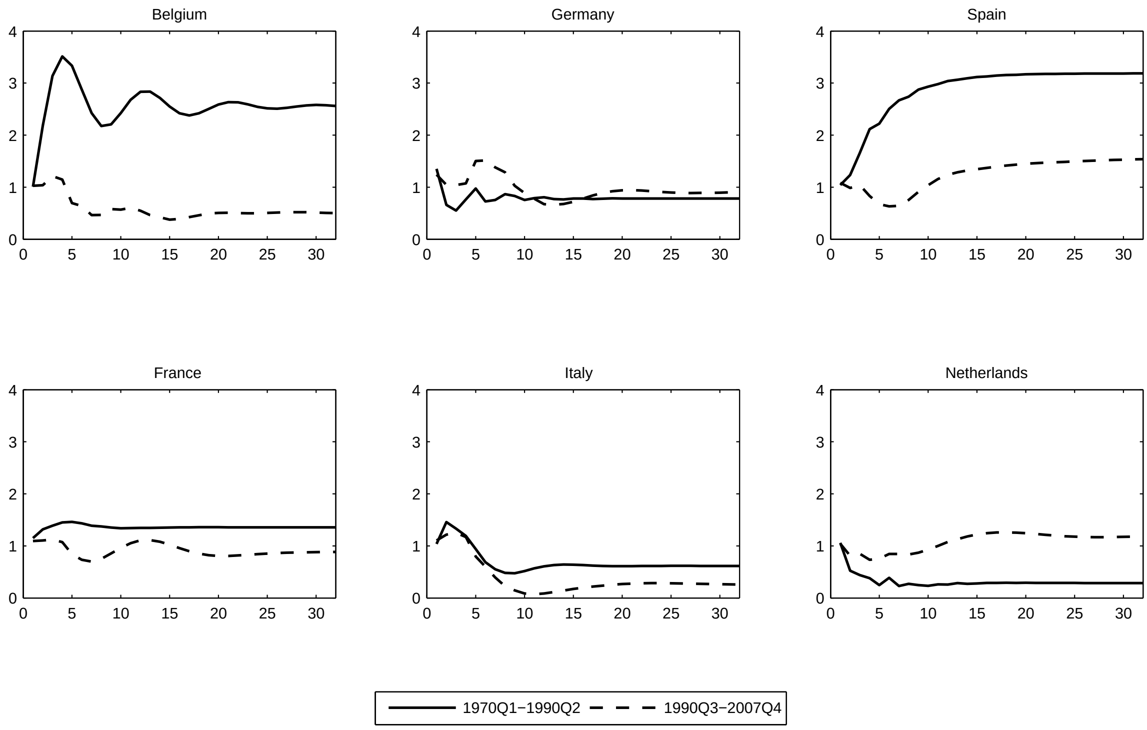

Figure 3c: Response to country-specific shock

suggested by Stock and Watson (2005). We write the variance of the output gap of a country at period p, with $p = 1, 2$ corresponding to the first (1970Q1–1990Q2) and second (1990Q3–2007Q4) sub-periods, as

$$V_p = V_{p1} + V_{p2} + V_{p3}, \tag{12}$$

where V_{pl} is the variance of output gap at period p with respect to the shock l, i.e. the variance that would have been observed if only the shock l took place. (12) is obviously analogous to (8). Note that the variance V_{pl} is given by $b_{pl}\sigma^2_{pl}$, b_{pl} being a quadratic term and σ^2_{pl} the variance of the shock l in period p. We are interested in explaining the change – decline – in the variance of output gap in each euro area country. The linear structure allows us to write the change in the contribution of the shock l as

$$V_{2l} - V_{1l} = \left(\frac{b_{1l} + b_{2l}}{2}\right)\left(\sigma^2_{2l} - \sigma^2_{1l}\right) + \left(\frac{\sigma^2_{1l} + \sigma^2_{2l}}{2}\right)\left(b_{2l} - b_{1l}\right) \tag{13}$$

following Stock and Watson (2005). The first term on the right-hand side of (13) measures the contribution of the change in the standard deviation of shock l, while the second term measures the contribution of the change in the propagation of the same shock.

The first box in the upper panel of Table 8 shows the absolute change in output gap volatility of the euro area countries from the first to the second sub-period derived from the estimated business cycle generating process given in (7) for each country. The decline in output gap volality, the so-called Great Moderation, in every euro area country is obvious. The left and right boxes of the lower panel in Table 8 respectively show the relative, i.e. percentage, contributions of changes in shock variance as well as shock propagation to the output gap volatility decline. A positive (negative) value in these two boxes indicates that the corresponding factor has led to a decline (increase) in the corresponding output gap volatility.

We had reported in Table 7 that the magnitude of global and euro area shocks had declined in the second sub-period. This is reflected in the first two columns (that correspond to global and euro area shocks) of the first box of the lower panel of Table 8 as a positive contribution to the decline in output gap volatility. In Belgium, changes in the size own shocks contributed negatively to the Great Moderation, but the total contribution of the change in shock variance is positive. The second box in the lower panel of Table 8 shows the contribution of the change in shock propagation to the decline in output gap volatility. It is interesting that the change in the propagation of shocks led in many cases to an increase of the output gap volatility. Hence, we can conclude that the Great Moderation is owed rather to a decrease in the size of shocks, while the contribution of change in shock propagation is either small or even negative.

In the left box in the upper panel of Table 8, we present the total contribution from global, euro area and country-specific shocks, i.e. the total of the contributions of changes in the magnitude of shocks and their propagation. The picture that arises is that the Great Moderation is caused mainly by changes related to global and country-specific shocks in the euro area, while common euro area shocks did generally have less or no significant effect on the output gap volatility decline in the member countries. This finding is in line with the previous finding that the share of euro area shocks in output gap volatility has increased in the second sub-period as reported in Table 4. The contribution of global shocks to the Great Moderation is highest in largest economies of the euro area – Germany and France– while country-specific shocks dominate the scene from this perspective in the rest of the euro area countries.

4.3.4. Moderation of Output Gap Differentials

Table 9 is analogous to Table 8 and shows the decomposition of change in output gap differential variance into change in size of shocks and change in shock propagation. We have seen that global shocks and country-specific shocks were together the main contributors to the Great Moderation in output gap variances. According to Table 9, however, country-specific shocks clearly dominate the Great Moderation of each output gap differetials in the euro area, global or euro area shocks being of import in only few cases. Except in Belgium, the main contribution generally comes from the decline in size of shocks rather than from changes in shocks propagation as in the case of the Great Moderation of output gap volatility. However, with the exception of the Netherlands, the total weight of change in size of shocks in the output gap differential moderation is lower relative to the case of output gap volatility decline.

Table 8: Decomposition of change in output gap variance into change in size of shocks and change in propagation

	Variances			Total contribution from shocks		
	1970–1990	1991–2007	Change	Global	Euro Area	Own
bel	1.62	0.62	-1.00	0.25	0.26	0.49
deu	1.28	0.50	-0.78	0.91	0.24	-0.14
esp	1.69	0.27	-1.42	0.09	-0.01	0.92
fra	0.92	0.45	-0.47	0.44	0.25	0.32
ita	2.24	0.56	-1.68	0.37	0.07	0.56
nld	1.51	0.54	-0.98	0.39	0.10	0.51

	Contribution of change in shock variance				Contribution of change in shock propagation			
	Global	Euro Area	Own	Total	Global	Euro Area	Own	Total
bel	0.30	0.71	-0.18	0.82	-0.05	-0.45	0.68	0.18
deu	0.49	0.69	0.30	1.47	0.42	-0.45	-0.44	-0.47
esp	0.11	0.20	0.49	0.80	-0.03	-0.21	0.43	0.20
fra	0.91	1.01	0.17	2.10	-0.48	-0.77	0.14	-1.10
ita	0.20	0.22	0.65	1.08	0.17	-0.15	-0.10	-0.08
nld	0.60	0.44	0.58	1.62	-0.21	-0.33	-0.07	-0.62

Note: See Table 1 for abbreviations.

Table 9: Decomposition of change in output gap differential variance into change in size of shocks and change in propagation

	Variances			Total contribution from shocks		
	1970–1990	1991–2007	Change	Global	Euro Area	Own
bel	0.41	0.12	-0.29	0.01	0.33	0.65
deu	0.21	0.09	-0.13	0.26	0.29	0.46
esp	1.14	0.11	-1.03	0.12	0.20	0.68
fra	0.18	0.08	-0.10	0.32	-0.02	0.70
ita	0.72	0.11	-0.61	0.10	0.09	0.81
nld	0.46	0.25	-0.21	-0.17	-0.31	1.49

	Contribution of change in shock variance				Contribution of change in shock propagation			
	Global	Euro Area	Own	Total	Global	Euro Area	Own	Total
bel	0.22	0.27	-0.24	0.25	-0.21	0.06	0.90	0.75
deu	0.24	0.19	0.70	1.13	0.01	0.09	-0.24	-0.13
esp	0.16	0.12	0.35	0.63	-0.03	0.07	0.33	0.37
fra	0.30	0.25	0.42	0.97	0.03	-0.27	0.28	0.03
ita	0.07	0.07	0.60	0.74	0.03	0.02	0.21	0.26
nld	0.73	0.42	2.55	3.70	-0.91	-0.73	-1.06	-2.70

Note: See Table 1 for abbreviations.

4.4. Sensitivity of the Results

We check the sensitivity of our findings with respect to a number of factors. Our conclusions are generally robust with respect to lower or higher lag orders and other measures of the business cycle such as the Baxter and King (1999) filter, Hodrick and Prescott (1997) filter and year-on-year growth.[8] There may be, however, some sensitivity with respect to the period the sample is split. As there may be arguments to split the sample in the mid-1980s, since the Great Moderation is often dated back to that time in many studies, there are also arguments to choose a later date, for example 1993Q4, after which the Maastricht Treaty came into effect. We try to find a more comprehensive to this problem by running regressions over rolling estimation windows, of which results are presented in the next section.

5. Results from Rolling Regressions

The hitherto presented results have been based on the assumption of a discrete break in the data in 1990Q2. Changing the break date in the data leads to changes in some of the results, but our previous conclusions generally hold. However, as reported in Section 2, each euro area member country possesses its own peculiarities. In order to capture these peculiarities we estimate in this section, following Blanchard and Gali (2008), rolling SVARs for each individual country model in moving windows of 15 years (60 quarters). Hence, the estimation windows cover the period from 1970Q1–1984Q4, from 1970Q2–1985Q1, etc., and the last estimation window covers the period from 1993Q1–2007Q4.

Figure 4 illustrates the standard deviations of global, euro area and country-specific shocks. It is seen that the standard deviation of global shocks have decreased steadily until roughly the middle of the sample period and stayed more or less constant around the same level after the middle of the sample period. Thus, the rolling regression estimations show that the moderation of the global shocks took indeed place in the first half of the sample period and the variance was steady in the second sample period. Therefore, we found in our afore discussed estimations reported in Table 7 based on a single break that the variance of

[8] Since the basic message of the paper does not change with respect to these modifications, we do not report the corresponding results within the paper in order to save space. For the interested reader, a supplement on these issues will soon be available from the author.

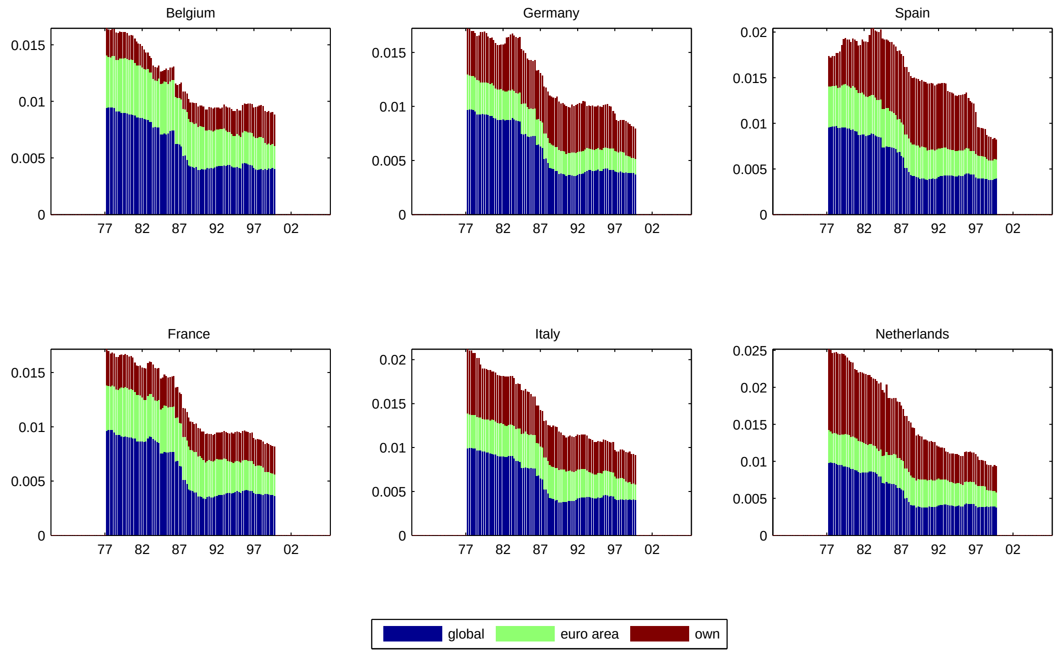

Figure 4: Standard deviation of shocks over 15-year rolling windows

global shocks have decreased in the second sub-period. It is harder to recognize from the graphs, but the standard deviation of euro area shocks was constant roughly in the first half of the sample period, while it decreased steadily in the second half. In line with the findings reported in Table 7, the standard deviation of the own shocks of Belgium became generally higher,while in all other countries it became lower in the second half of the sample period.

As before, we plot the impulse response functions in order to capture changes in the shock propagation. Figures 5a–5c illustrate three-dimensional shaded surface plots of the impulse response functions of the euro area countries with respect to global, euro area and country-specific shocks over rolling regression estimations. For the sake of better visual perception, we took the average of the impulse responses for each horizon over each calendar year. The first impulse response in the three-dimensional graphs of all three figures is, for example, the average of the impulse responses from the rolling regressions corresponding to the estimation windows 1970Q1–1984Q4 to 1970Q4–1985Q3 for each horizon. The second impulse response corresponds to averages from estimation windows 1971Q1–1985Q4 to 1971Q4–1986Q3, etc.

The responses to global shocks can be seen in Figure 5a. It is clear also from this picture

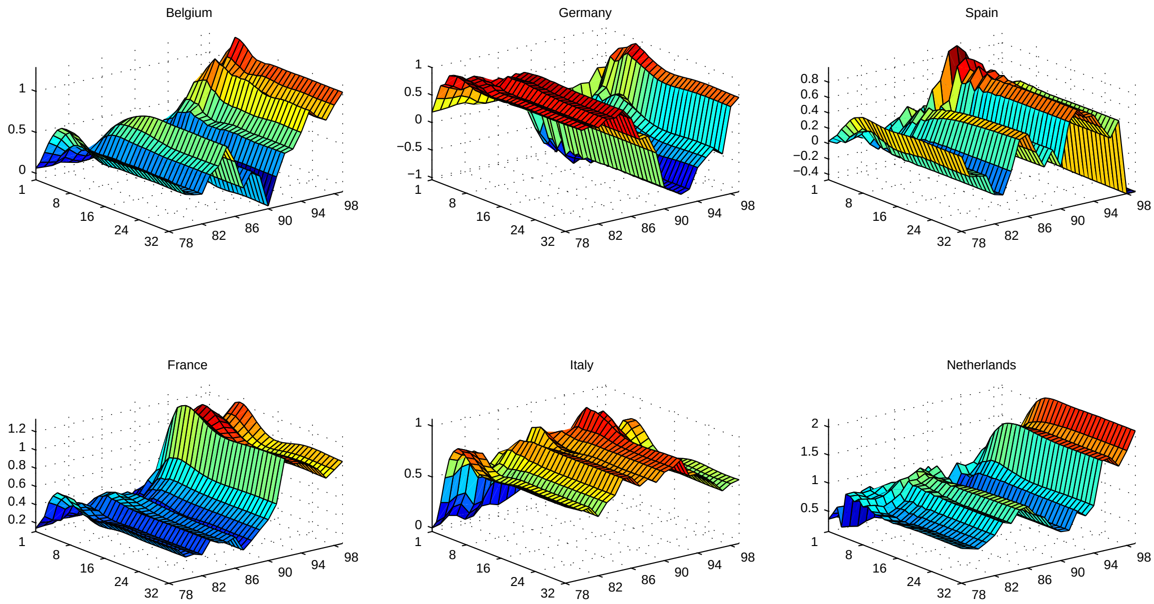

Figure 5a: Response to world shock over 15-year rolling windows

that the member countries underwent important changes throughout the sample period. For example, the output response to global shocks was very weak in France at the beginning of the sample period, but it became stronger in over time reaching a peak in the rolling regression of which centre is about 1990 and tapering off after that period. However, we can generally say that the response of output to global shocks was on average much stronger in the second half of the sample period than in the first half. Note that this is consistent with the negative contribution to the Great Moderation of the propagation of global shocks in France, see Table 8.

The contribution of changes in the shock propagation with respect to other shocks and countries reported in Table 8 can similarly be traced back to the changing dynamics seen in Figures 5a–5c. For example, the response of output to euro area shocks was not so strong at the beginning of the sample period in France, but became gradually stronger throughout the sample period. This is is reflected as a negative contribution of -0.77 to the Great Moderation of the change in the propagation of euro area shocks for France in Table 8.

It is out of scope of this study to interpret the changes in the impulse response functions over each rolling regression, for each country and with respect to each structural shock. It is clear that each euro area country has its own peculiar history of changing dynamics

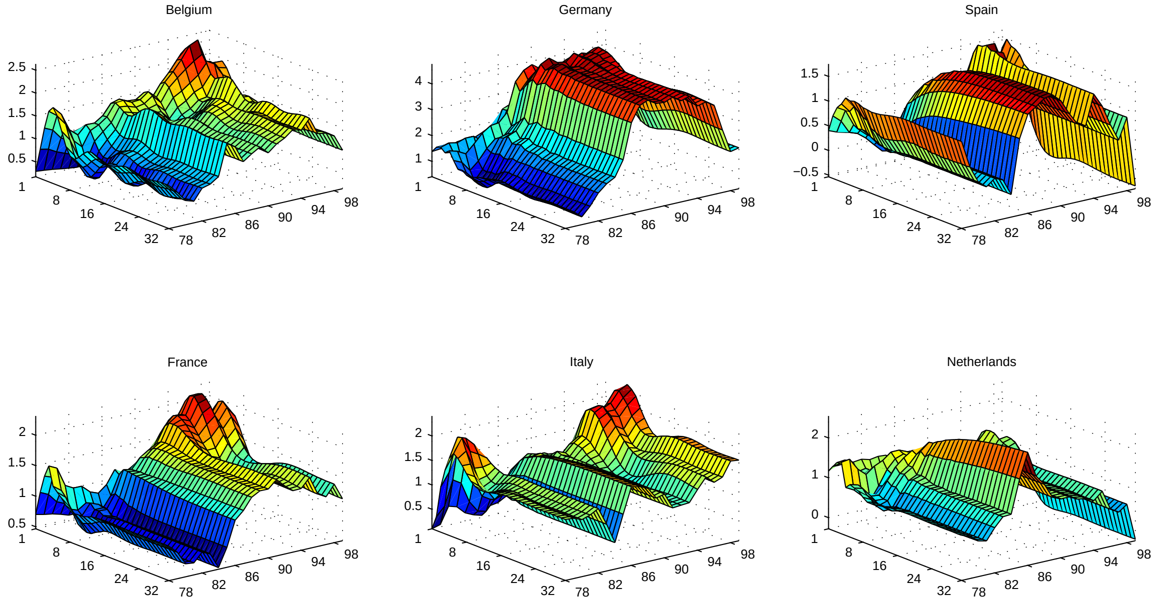

Figure 5b: Response to euro area shock over 15-year rolling windows

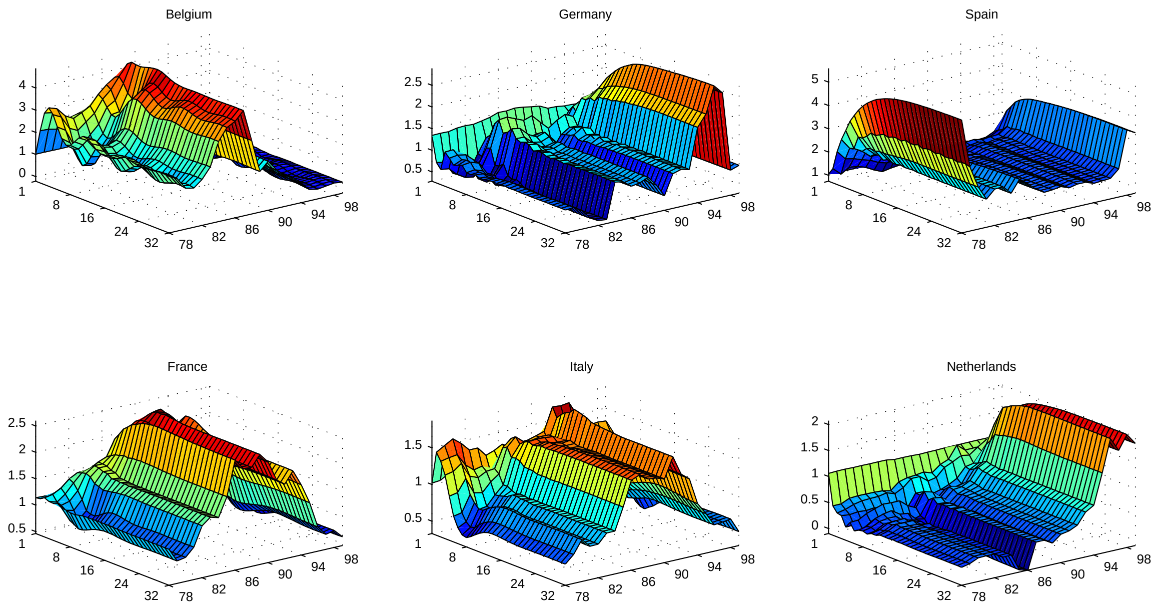

Figure 5c: Response to own shock over 15-year rolling windows

over time. We leave further interpretations to the interested reader along the lines of our afore given examples and turn our attention to the changing variance of output gaps in the euro area countries. Figure 6a shows the total variance of output gaps in the member countries as well as a decomposition of the total variance with respect to global, euro area and country-specific shocks in bar graphs. We had documented before that the variance of output gaps were higher in the first half of the sample period than in the second half. The rolling regression estimations reported in Figure 6a confirm this conclusion. However, it is not possible to recognize any country, where the variance of the output gap was roughly constant in the first half of the sample period and decreased to a lower constant level in the second half of the sample period. For example, Belgium and Italy saw important declines in their output gap variance at the beginning of the sample period, which then stayed roughly around a constant level and decreased further recently. A moderation in the output gap variance of Germany and France took place only recently, while formerly this variance was moving around some higher levels. The output gap variance of the Netherlands decreased gradually from the beginning until the middle of the sample period, after which it increased for a while and then stabilised around a constant level recently, which is still much lower than in the 1970s.

Figure 6b reports the business cycle variance decomposition results over rolling regressions, i.e. the shares of shocks in the variances reported in Figure 6a. The picture tells us that the output gap variance of Spain and Italy is mainly driven by their own shocks, in Italy, however, global and euro area shocks are also of some import. An increase in the share of euro area shocks in the second half of the sample period can be observed in Spain, while those still being less important than the own shocks in the cyclical fluctuations. The output gap variance of the Netherlands is mainly driven by global and euro area shocks, global shocks having a relatively larger share according to most of the rolling regression estimations. The euro area shocks are quite important in the output gap fluctuations of Belgium, Germany and France. Striking is the decline in the share of euro area shocks observed in recent rolling regression estimations of all countries, although it is generally possible to say that euro area shocks became relatively more important in the cyclical fluctuations of output in every member country in the second half of the sample period, as was also implied by

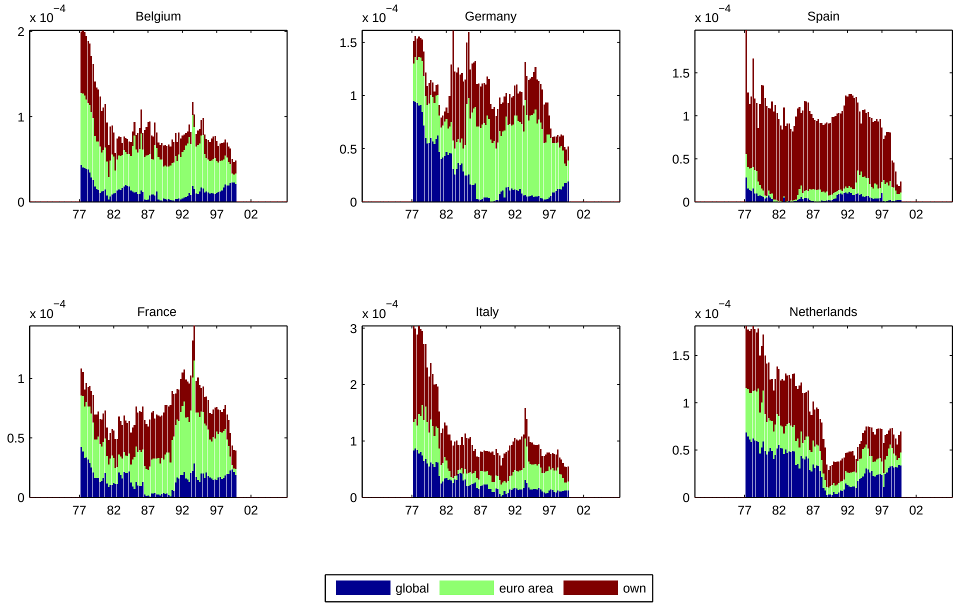

Figure 6a: Variance of output gap with respect to shocks over 15-year rolling windows

Table 4.

Figures 7a and 7b are analogous to Figures 6a and 6b showing the variance of the cyclical component of output gap differential and the variance decomposition of output gap differential in the member countries. It is seen from Figure 7a that the variance of output gap differential has been substantially lower than the sample average recently. Figure 7b confirms the previous finding that country-specific shocks are the main driving force of output gap differentials in the euro area. As noted before, this implies that heterogeneity in the euro area in terms of output gaps can be traced back to asymmetric shocks to a large extent. However, although this conclusion seems to hold for many of the rolling regressions across the member countries, there are also episodes where global or euro area shocks had also a relatively large share. In Belgium, Spain and the Netherlands, there are some rolling regressions here the total share of global and euro area shocks exceed 0.5. Particulary for Spain and the Netherlands, this is so according to the rolling regression estimations, of which sample center lie in the second half of the entire sample period. Note that this finding is in line with the previous finding following from Table 6 that shares of global and euro area shocks increased in output gap differential variance in the sample from 1990Q3–2007Q4. Yet, the

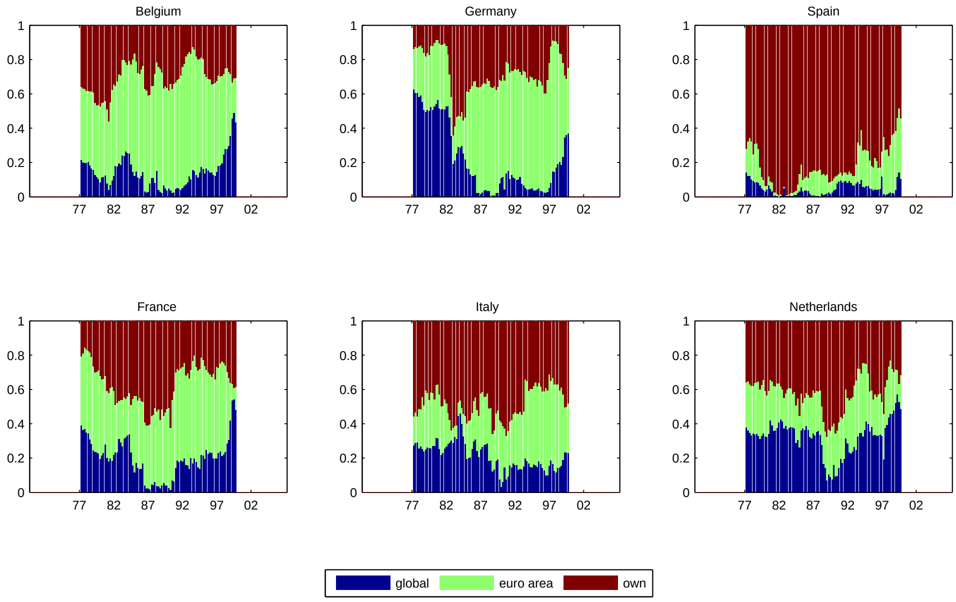

Figure 6b: Business cycle variance decomposition of output gap over 15-year rolling windows

finding does not point to a recent structural divergence of these two economies from the euro area economy. It is rather that relative role of these shocks in the output gap differential variance has increased, while their absolute contribution to the differential has not changed much.

6. Summary

We investigated the properties of business cycle dynamics in the euro area with the aid of structural VAR models. We first established the statistical properties of the cyclical fluctuations and then assessed the role of global, euro area and country-specific shocks in the fluctuations. We found that euro area shocks became a more important factor behind cyclical fluctuations euro area countries recently. Moreover, while the moderation of output gap variance in the euro area was found to be related to changes corresponding to global and country-specific shocks, it was found that euro area shocks did not play a significant role in this phenomenon. Finally, differentials between the output gaps of the euro area and member countries are driven mainly by country-specific shocks. Changes in the dynamics

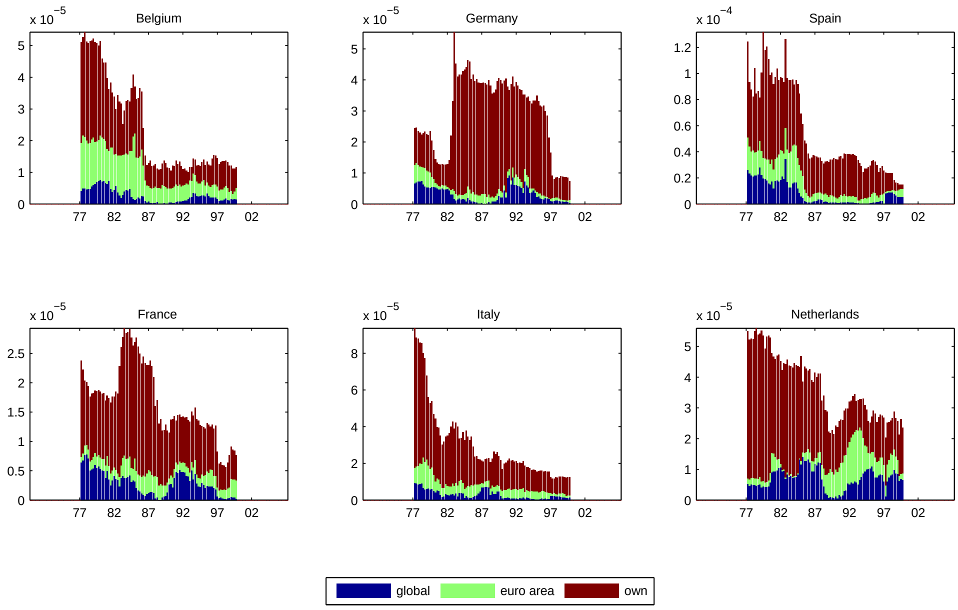

Figure 7a: Variance of output gap differential with respect to shocks over 15-year rolling windows

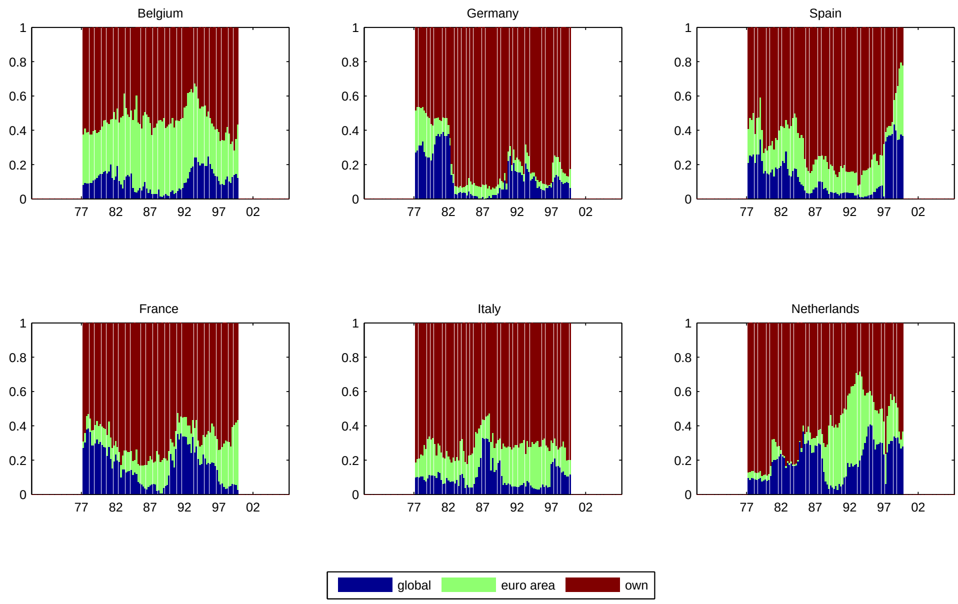

Figure 7b: Business cycle variance decomposition of output gap differential over 15-year rolling windows

related to these shocks did also mainly lead to the moderation of output gap differentials. While we came to these conclusions with a specific model specification and splitting the sample in the second quarter of 1990, our findings show that the results are robust with respect to lag order and various definitions of the business cycle. Findings from regressions run over rolling estimation windows are also in line with the findings that follow from two discrete sub-samples.

References

Artis, M., Krolzig, H-M. and J. Toro (2004) "The European Business Cycle," *Oxford Economic Papers*, Vol. 56, 1-44

Baxter, M. and R.G. King (1999) "Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series," *The Review of Economics and Statistics*, Vol. 81, No. 4, 575-593

Blanchard, O.J. and J. Gali (2008) "The Macroeconomic Effects of Oil Shocks: Why Are the 2000s So Different from the 1970s" *CEPR Discussion Paper*, No. 6631

Canova, F. (1998) "Detrending and Business Cycle Facts," *Journal of Monetary Economics*, Vol. 41, 475-512

Christiano, L.J. and T.J. Fitzgerald (2003) "The Band Pass Filter," *International Economic Review*, Vol. 44, No. 2, 435-465

Christiano, L.J., Eichenbaum, M. and C.L. Evans (1999) "Monetary Policy Shocks: What Have We Learned and to What End?" in *Handbook of Macroeconomics*, M. Woodford and J. Taylor, eds., Vol. 1A, Amsterdam: North Holland

Giannone D. and L. Reichlin (2005) "Euro Area and US Recessions, 1970-2003," in *Euro Area Business Cycle: Stylized Facts and Measurement Issues*, L. Reichlin, ed., CEPR, 83-93

Giannone D. and L. Reichlin (2006) "Trends and Cycles in the Euro Area: How Much Heterogeneity and Should We Worry about It?," *ECB Working Paper Series*, No. 595

Hodrick, R.J. and E.C. Prescott (1997) “Postwar U.S. Business Cycles: An Empirical Investigation,” *Journal of Money, Credit, and Banking*, Vol. 29, No. 1, 1-16

Krugman, P. (1991) *Geography and Trade*, MIT Press, Cambridge, MA

McKinnon, R.I. (1963) “Optimum Currency Areas,” *The American Economic Review*, Vol. 53, 717-725

Mundell, R.A. (1961) “A Theory of Optimum Currency Areas,” *The American Economic Review*, Vol. 51, 657-665

Perez, P.J., Osborn, D.R. and M. Artis (2006) “The International Business Cycle in a Changing World: Volatility and the Propagation of Shocks in the G-7,” *Open Economics Review*, No. 17, 255-279

Stock, J.H. and M.W. Watson (2005) “Understanding Changes in International Business Cycle Dynamics,” *Journal of the European Economic Association*, Vol. 3, No. 5, 968-1006