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Has the EMU lost its “optimality“?
Business Cycle Synchronization and Correlation of Shocks in the Euro Area in the light of the Financial Crisis

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1. Introduction

Since the onset of the current economic crisis, numerous EMU skeptics have attacked the concept of the European Monetary Union (EMU). They argue that countries like Greece or Spain that were hard hit by the crisis could have reacted in a more efficient way, if they would have disposed of their own monetary and exchange rate policy as instruments to combat the crisis; e.g. Greece could have devalued its currency in order to stimulate its economy. In the aftermath of the crisis, major European policy makers expressed opposition to a break-up of the EMU, fearing that a collapse of the EMU would lead to massive economic and legal turmoil and consequently social unrest. However, especially after the left wing Greek party *Syriza* has come into power in the last Greek election with the promise to end the austerity programs in its crisis-ridden homeland, politicians and journalists once more discuss a collapse of the EMU or at least the exclusion of Greece from the EMU. (cf. Hofrichter, 2012). The reelection of David Cameron as Prime Minister of Great Britain and his promise to hold a referendum on UK's membership of the European Union ("Brexit") further fuels the discussion.

But is the EMU in such a poor condition that a break-up is reasonable or even advisable? To answer this question, this study tries to assess the current status of the EMU based on the optimal currency area (OCA) theory, which Mundell (1961), Kenen (1969) and McKinnon (1963) developed. Basically, the OCA theory evaluates the "optimality" of a currency union based on the similarity of the member states with respect to certain criteria (e.g. price and wage flexibility, high labor mobility, high diversification of production and consumption etc.). Since this kind of similarity ensures that a common monetary policy fits the needs of all member states and the likelihood of asymmetric shocks hitting the currency union (CU) is decreased. As a meta-criterion of these criteria I use in the current study the synchronization of business cycles as well as the correlation of shocks. Based on the OCA theory and the above mentioned similarity criterion the current study addresses the following research questions:

- Has the financial crisis led to a reduction or a reinforcement of imbalances among the EMU member states?

- Is a Grexit or even a break-up of the EMU reasonable?
- Are there signs of a recovery of the EMU like there were after other crisis such as the burst of the dot-com bubble?
- Are other currency union constructions in Europe advisable such as the introduction of a North and South Euro?
- What are the gains and costs of the exclusion of certain countries in terms of business cycle synchronization?

The contribution of this study to the literature is twofold. Firstly, considering the numerous countermeasures against the crisis in the EMU, a reassessment of the effects of the financial crisis on the EMU is relevant to complement the few existing studies on this topic. Secondly, seven years after the financial crisis hit Europe, the time has come to closely examine the recovery phase of the EMU and draw some cautious conclusions on how the future of the EMU could/should look like (e.g. "Grexit", North/South Euro). The structure of this study is as follows: The theoretical background and the general idea of this study is explained in the second chapter. The third chapter provides the methodology of the study and gives a description of the used data. The fourth chapter presents the results on business cycle (de)synchronization, while the fifth chapter reports the correlation of shocks within the EMU. The sixth chapter delivers the analysis of costs and gains of the exclusion of certain countries from the EMU. The paper ends with a conclusion.

2. Theoretical background

2.1. The classical Optimal Currency Area theory and its evolution

In 1961, Robert A. Mundell developed the optimal currency area theory. An OCA is defined as "the optimal geographic domain of a single currency, or of several currencies, whose exchange rates are irrevocably pegged and might be unified" (Mongelli, 2002). Mundell and other pioneers of the OCA theory such as McKinnon (1963) and Kenen (1969) tried to answer the question under which conditions it would be beneficial for a country to join a CU.

The obvious downsides of joining a monetary union are the loss of an independent monetary and exchange rate policy. As long as the countries forming a monetary union display similar characteristics (e.g. preferences for inflation, labor market institutions, legal system, growth rates), the loss of the ability to conduct a national monetary policy should not pose much of a problem, since the currency union can react appropriately to a symmetric shock by modifying its monetary, respectively, exchange rate policy (cf. De Grauwe, 2003). However, if there is a greater dissimilarity between the member countries of a CU, the exposure to asymmetric shocks within a CU rises and conflicts of interest can no longer be ruled out, as they have arisen within the EMU during the recent financial crisis. According to the classic OCA theory, the similarity of countries within a CU is not sufficient to cope with asymmetric shocks. In addition to that, there is the need for some kind of insurance scheme among the participating countries that allows for income transfers from unaffected countries to those countries that were hit by a shock. But such insurance mechanisms may induce moral hazard.

The direct benefits of joining a CU are financial, institutional and political integration – in other words a trend towards convergence among economies within a CU – price transparency, the elimination of transaction costs and of exchange rate volatility. Indirect gains of forming a CU are price level convergence via increased competition, a lower, growth stimulating interest rate due to the elimination of exchange rate risk and a rise

in trade and foreign direct investment (FDI), which also boosts growth within a CU. Moreover, if the common currency in a CU evolves to a globally important currency, benefits in the form of seignorage revenues will arise as well as in form of an expansion of the financial industry in the CU (cf. De Grauwe, 2003).
According to the OCA theory, countries will profit more from joining a CU if they display the following characteristics:

- A high degree of labor mobility
- A high degree of wage and price flexibility
- A high degree of capital mobility
- A high level of diversification of products and exports
- A small size
- A high level of openness

Wage flexibility and labor mobility are crucial elements when it comes to the decision whether a country should join a CU or not, since they are alternative tools to cope with asymmetric shocks within a monetary union. A high level of diversification of products and exports is of importance for the proper functioning of a CU, since, as Krugman (1993) pointed out, a unification might lead to regional concentration of industrial activities due to economies of scale, which would increase the risk for asymmetric shocks. If countries that are willing to form a CU have these characteristics, the benefits of adopting a common currency outweigh the costs of a unification, as the likelihood of the occurrence of asymmetric shocks, respectively the adjustment costs to them, are minimized (cf. De Grauwe, 2003). As a degree of the similarity, respectively convergence, among certain countries, numerous studies examined the degree of the synchronization of their business cycles as well as the correlation of supply and demand shocks across these countries. This is because these factors ensure that a common monetary policy will fit the interests of the members of a CU (cf. for example Cuaresma & Fernández-Amador, 2013, Bayoumi and Eichengreen, 1992, Fidrmuc & Korhonen, 2003, Gächter et al., 2013).
The classical OCA theory has received much attention among scholars since the 1960s. Economists, who have adopted a critical attitude towards the OCA theory, criticized the criteria used, pointing out that they are problematic to measure (cf. Robson, 1987).

Moreover, that they are either closely related or pointing in different directions and are inconsistent. For example, small countries are usually open, but not diversified in products and exports (cf. Tavlas, 1994). Moreover, the lack of a political and historical dimension brought criticism upon the OCA theory (cf. Handler, 2013).
The breakdown of the Bretton Woods system brought a halt to the discussion of monetary unions until the 1980s. A renewed interest in monetary integration, especially in Europe after the Maastricht treaty in 1992, brought about the evolution of a "new" OCA theory, which incorporated modern macroeconomic theories taking into account new concepts such as endogeneity, credibility and forward-looking expectations. Following the Lucas Critique the advocates of the "new" OCA theory pointed out that assessing the suitability of countries to join a CU based on historical data is insufficient, since the accession to a CU is likely to change their economic structure (cf. Handler, 2013). The concept of endogeneity is closely linked to the Lucas Critique, but the focus here is on causality. Frankel and Rose (1998) tackled the question whether a unification is only feasible if homogeneity among the potential member states of a CU *ex ante* exists, or if the unification itself leads to sufficient adjustment to justify the creation of a union *ex post*. They distinguish four different areas of endogeneity: endogeneity of economic integration (trade and prices), endogeneity of financial integration, endogeneity of symmetric shocks and the synchronization of outputs and endogeneity of product and labor markets. Frankel and Rose (1998) find that endogeneities unfold in all areas within a CU but with a different intensity and speed. Especially with respect to economic integration, they detect a significant rise in trade linkages between the participating countries of a CU that cannot be solely attributed to the elimination of exchange rate volatility (cf. Handler, 2013). The estimations of the so called "Rose effect" vary between 30 % and more than 90% for different CUs. But Rose and Stanley (2005) also find evidence for an publication bias. According to most recent research findings, the introduction of the Euro resulted in a more realistic rise in trade of about 5% to 15% (cf. Baldwin, 2006).

2.2. The OCA theory and the endogeneity hypothesis: Empirical evidence for the EMU

Most researchers argue that the EMU does not qualify as an OCA (cf. De Lucia, 2011, Bayoumi & Eichengreen, 1992 etc.) and even before the crisis many economists, especially from the US, emphasized the fragility of the stability of the EMU (cf. for a

comprehensive summary of US economists' views Jonung & Drea, 2010). They underpin their opinion with the heterogeneous economic structures of the participating countries, the rigidity of labor markets, the limitations to labor mobility, the absence of a lender of last resort and of a central authority to supervise the financial systems, the lack of democratic control and accountability of the ECB, the missing central coordination of fiscal policies within the EMU, the intransparent, inconsistent and badly designed policy directives for the ECB (cf. Bordo and Jonung, 1999) and the lack of credible sanctions in the Stability and Growth Pact (cf. Handler, 2013). The effects of the recent financial crisis on the EMU seem to confirm their objections to a certain extent.

To sum up, there is a consensus that the EMU cannot be regarded as an OCA. However, whether there has been a convergence tendency within the EMU that have boosted the "optimality" of the EMU and following the endogeneity hypothesis of Frankel and Rose (1998) justifies(d) the formation of the EMU *ex post* is another question. Many studies have been conducted on this topic, especially for the EMU. The empirical evidence is mixed, since a wide range of estimation methods was applied and time frames, countries and identification methods of business cycles (for a comprehensive study cf. Haan et al., 2008) differ. In most recent studies, this ambiguity prevails. Most researchers agree on the synchronization of business cycles in Europe in the mid-1980s, the run-up phase to the EMU and the time of the great moderation (cf. Lee, 2012, Crespo Cuaresma et al., 2013, Saiki and Kim, 2014, Giannone et al., 2008), but after the introduction of the EMU empirical results diverge. Lee (2013) applying a dynamic latent factor model finds no evidence that EMU has contributed to an alignment of economic activity between the member states of the CU. Using a model of dynamic interactions (VAR) on yearly output per capita data of EMU12 countries, Giannone et al. (2008) come to the same conclusion. In contrast to this, Saiki and Kim (2014) detect a higher cross-country correlation of business cycles in the Eurozone after the adoption of the Euro due to intra-industry trade and financial integration. On the basis of a synchronization index Gächter and Riedl (2013) also discover a significant positive impact of the introduction of a common currency on the correlation of business cycles among EMU member states beyond the impact of trade integration. Moreover, Crespo-Cuaresma and Fernandéz-Amador (2013) find a stable and slightly higher level of business cycle synchronization since 1993 compared to the beginning of the 1990s based on supply and demand shocks recovered by a SVAR. However, Lehwald's research findings (2012) suggest an increase in business cycle synchronization among the core countries of the

EMU after the introduction of the Euro, mainly due to worldwide developments, but a decrease in alignment for the periphery countries.[1]
In spite of the unclear research results, more recent studies examining the EMU are in favor of Frankel's and Rose's endogeneity hypothesis. New empirical evidence seems to indicate a synchronization of business cycles within the EMU after the introduction of the Euro, but periods of more and less synchronization take turns (cf. Haan et al., 2008).

2.3. The "optimality" of the EMU in the light of the financial crisis

The current difficult economic situation in Europe in the aftermath of the financial crisis of 2008 raises the question, whether this event has caused a decoupling or a further synchronization of business cycles among the EMU countries or, in terms of shocks, a decorrelation or a further correlation of shocks. It is not evident, which trend prevailed in the aftermath of the financial crisis. On the one hand, the crisis is said to have reinforced fiscal and trade imbalances among the EMU countries. Following this line of argumentation, the crisis would have hit the member states of the EMU in an asymmetric manner, resulting in a decoupling of business cycles. On the other hand, the degree of synchronization could also have increased as a consequence of the financial crisis, since all EMU countries experienced a recession at the same time (cf. Gächter et al., 2012).
Probably due to the short timespan since the onset of the crisis, this topic has not received much attention among scholars. So far only three studies on this issue exist. Two of these were conducted by Gächter et al. (2012 and 2013). In 2012, Gächter, Riedl and Ritzberger-Gründwald investigated the impact of the financial crisis on business cycle synchronization in the Euro Area by examining the dispersion of business cycles and the temporal correlation coefficient of business cycles before and after the crisis. In 2013, they applied the same methodology to analyze convergence or decoupling trends since the crisis between the EMU and the Central, Eastern and Southeastern European (CESEE) countries. Their research findings indicate that the crisis period led to a pronounced decoupling of business cycles in the Euro Area, both with respect to the dispersion as well as the correlation of business cycles. Moreover, the early recovery phase is accompanied by desynchronization of business cycles, since the member countries differed in

[1] The core countries are usually defined as Belgium, France, Germany, Luxembourg and the Netherlands (cf. Crespo-Cuaresma et al., 2013).

their economic situation and chose different policies to cope with the crisis and its consequences. This is in line with the order of events following times of crisis. For the end of the examined timespan, 2010 Q1, their results indicate a trend towards synchronization, respectively correlation, but due to end-of-sample problem of the HP-filter, which they used to retrieve the output gap from data on GDP and industrial production, these findings are not credible (cf. Gächter et al. 2012). With respect to CESEE countries they detect a discernible desynchronization of business cycles of CESEE countries and the EA since the outbreak of the financial crisis. However, according to their research findings there is a tendency of decoupling of business cycles of CESEE countries and the Euro Area in 2011/2012, continuing the increased convergence tendency since the accession of certain CESSEE countries to the EMU in 2004. This research finding is in agreement with recent empirical evidence stating a decoupling of global emerging market economies (EMEs) from industrialized countries since the onset of crisis (cf. Gächter et al,. 2013).

Using a cross-wavelet coherence measure Bekrios et al. (2014) analyze the scale-dependent time-varying synchronization effects between the business cycles of EMU members and EU members before and after the financial crisis. They find a higher synchronization during the crisis period, however, as they point out, convergence and (de)synchronization are sensitive to different time horizons and frequency bands. The results of Bekrios et al. (2014) are not really comparable to those of Gächter et al. (2012), since Bekrios et al. (2014) base their results on the examination of only few representative EMU and EU countries. Moreover, (de)synchronization tendencies within the EMU and between the EMU and the EU are detected only by analyzing the correlation relationship with respect to Germany, as they perceive Germany as the representative of the Eurozone (cf. Bekiros et al., 2014).

However, the data used for examination might have a sizable impact on the result and conclusion that can be drawn from the calculations, as Haan et al. (2008) have pointed out. Since several measures were taken to counteract the effects of the crisis on the EMU level as well as on the country specific level since 2011 (e.g. on EMU level: the introduction of new long-term refinancing operations to provide financing to Eurozone banks in 2012, on individual country level: fiscal consolidation measures, structural reforms in Greece since 2012), more appropriate conclusions on the (de)synchronization of business cycles in the aftermath of the crisis can be drawn if recent data is used. This paper tries to provide such an analysis, since seven years after the Euro area was hit by the financial crisis, a more profound analysis of the recovery phase of EMU countries

can be conducted. As Gayer (2007) stated, shortly after the dot-com bubble burst in 2000 in an early recovery phase the correlation of Euro area countries' business cycles declined strongly, but started to reinforce again after 2004. He therefore concludes that the early recovery phase after a recession is characterized by a decline in the synchronization of business cycles that is later reversed. On the assumption that the Euro area is currently in a later stage of recovery than it was at the end of 2010, an examination of the business cycles synchronization is therefore fruitful to clarify whether this pattern is repeated after the financial crisis.

3. Methodology

3.1. General idea and economic background

As in many studies on this topic (see chapter 2) demand shocks are regarded as an indicator of business cycles. As explained in the introduction, the synchronization of business cycles and the correlation of demand and supply shocks are used as a tool to assess the well-being of the EMU (cf. Fidrmuc and Korhonen, 2003). To recover supply and demand shocks, I apply the procedure of Eichengreen and Bayoumi (1992) (see also Crespo-Cuaresam et al., 2013, Fidrmuc & Korhonen, 2003). They employed the identification scheme developed by Blanchard and Quah (1989) to recover supply and demand shocks in a bivariate structural vector autoregression model (SVAR) of output and prices. Both long term as well as short term restrictions are used for the identification of shocks in this procedure. The general idea of this model is that the dynamics of output and prices depend on unknown unobserved supply and demand shocks. Furthermore, it is assumed that a supply shock decreases prices and increases output permanently, whereas a demand shocks only leads to a short time rise in output, but a long term rise in prices. These assumptions are sufficient to identify supply and demand shocks (cf. Bayoumi & Eichengreen, 1992).
These identification assumptions are based on the aggregate supply and aggregate demand model (AD-AS model). This New Keynesian model depicts the relationship between output and prices, both in the short and in the long run. The aggregate supply relation is derived from wage determination and price determination in the labor market, whereas the aggregate demand relation originates from the equilibrium conditions in the goods and financial markets (IS-LM model).
In the AD-AS model, the aggregate demand curve (AD) is downward sloping reflecting the negative effect of a rise in the price level on output. This is the case because a rise in the price level decreases the real money stock, which leads to a rise in the interest rate at a given output. A higher interest rate decreases the demand for goods and therefore output.

The short run AS curve (SRAS) on the other hand, is upward sloping representing the positive effect of a rise in output on prices (see figure A.1.). The reason for this is that an increase in output leads to a higher employment rate (respectively to a lower unemployment rate) and as a result to higher nominal wages, which forces firms to charge higher prices (cf. Blanchard, 2006).
The long run equilibrium is attained when output is equal to the natural level of output and the price level is in accordance with the expected price level. This is reflected in the verticality of the long run supply curve (cf. Bayoumi & Eichengreen et al., 1992).
In figure A.2. the effects of a positive demand shock on the price level and output are shown. In the initial situation the output level corresponds to the natural level of output. The long run equilibrium is denoted as E. A positive demand shock could be for example an expansionary monetary policy. In the AS-AD model such a policy leads to an increase of nominal money and for a given price level to an increase in real money stock. This results in the short run in a higher output. Therefore, in figure A.2. the AD curve shifts upwards to AD'. A new short time equilibrium is reached at D', output increased from Y to Y' and prices rose from P to P'. As output exceeds the natural level of output in this new equilibrium, wage setters adapt their price expectations letting the price level rise. The SRAS curve is therefore shifting upwards, getting more and more vertical (LRAS). The adaption process stops, when output has returned to the natural level of output and the price level corresponds to the expected price level in the new long run equilibrium D". At D" output is equivalent to its initial value, whereas prices do not return to their initial level. This reflects the transitory effect of demand shocks on output and their permanent effect on prices. These dynamics are also summarized under the concept *the neutrality of money* (c.f. Blanchard, 2006).
Figure A.3. depicts the effects of a positive supply shock on output and prices. An example for such a positive supply shock is technological progress. The introduction of new machines increases the effectivity of labor. This allows firms to produce larger quantities of output with the given capital and labor input (cf. Blanchard, 2006). Overall, the natural level of output rises. As depicted in figure A.3. in the short run the positive supply shock results in a rightwards shift of the SRAS curve. The new short run equilibrium is at S', output increase from Y to Y' and prices fall from P to P'. As the output is below the new natural level of output, wage setters adapt their price expectations. Over time the SRAS curve gets more and more vertical, shifting the equilibrium to the new long run equilibrium S". At S the price level is lower and the output level is higher than in S', reflecting the permanent long run effect of supply shocks on prices

and output (cf. Eichengreen & Bayoumi, 1992).
Figure A.4. and A.5. display the accumulated impulse response functions of GDP and prices to a positive demand and supply shock for Germany. As in the underlying AD-AS model, a demand shock has a positive long run effect on prices and the effect reaches its long run level after approximately 18 quarters (see figure A.4.). In contrast to this, it has only a temporary positive effect on GDP, the effect fades out after approximately 23 quarters. On the other hand, the supply shock in figure A.5. has a positive long run effect on GDP and a negative one on prices. The long run level of the effect of a positive supply shock on GDP is reached at approximately 18 quarters, whereas the long run effect on prices attains its maximum only after about 22 quarters.

3.2. The model

As it is assumed in the model that the dynamics of GDP and prices are driven by supply and demand their joint process can be written as an infinitely moving average representation of supply and demand shocks,

$$X_t = A_0\epsilon_t + A_1\epsilon_{t-1} + A_2\epsilon_{t-2} + A_3\epsilon_{t-3} + ... = \sum_{i=0}^{\infty} A_i L^i \epsilon_t \tag{3.1}$$

where X_t represent a vector of the first difference of the logarithm of output and of the logarithm of prices $[\Delta y_t, \Delta p_t]'$, ϵ_t stands for a vector of supply and demand shocks $[\epsilon_{dt}, \epsilon_{st}]'$, A_i are transmission matrices of the dimension 2x2 and L^i stands for the lag operator. Let $a_{jk,i}$ denote the (j,k) element of the matrix A_i.

The aforementioned assumption that demand shocks have only a transitory effect on output implies that in the long run the cumulative effect of demand shocks on the output change is zero, i.e. $\sum_{i=0}^{\infty} a_{11,i} = 0$. Furthermore, supply and demand shocks are assumed to be uncorrelated and their variance is normalized to unity, i.e. $Var(\epsilon) = 1$. In order to recover the shocks, a finite vector autoregression model (VAR) has to be first estimated,

$$X_t = G_1X_{t-1} + G_2X_{t-2} + G_3X_{t-3} + ... + G_nX_{t-n} + e_t = [I - G(L)]^{-1}e_t \tag{3.2}$$

where the G_i matrices capture the dynamics between output change and inflation, $G(L)$ stands for the lag polynomial, e.g. $G_1L + G_2L^2 + ... + G_nL^n$ and $e_t = [e_{dt}, e_{st}]'$ denotes the

residuals of the bivariate VAR estimation. As X_t is stationary, the VAR representation can be inverted to a Wold moving average representation by simply using the properties of geometric series.[1]

$$X_t = e_t + C_1 e_{t-1} + C_2 e_{t-2} + ... = \sum_{i=0}^{\infty} C_i L^i e_t \tag{3.3}$$

The variance-covariance matrix of the residuals is denoted as $Var(e) = \Omega$. From equation (3.1) and (3.3) it follows that:

$$e_t = A_0 \epsilon_t \tag{3.4}$$

$$A_i = C_i A_0 \tag{3.5}$$

$$\sum_{i=0}^{\infty} A_i = \sum_{i=0}^{\infty} C_i A_0 \tag{3.6}$$

Moreover, from the normalization of the variances of the shocks to unity as well as from the orthogonal relationship between the shocks, the following relationship is derived:

$$A_0 A_0' = \Omega \tag{3.7}$$

Equation (3.6) and (3.7) yield the four restrictions that are needed to identify the matrix A_0 uniquely[2],

$$a_{11,0}^2 + a_{12,0}^2 = Var(e_{1,t}) \tag{3.8}$$

$$a_{21,0}^2 + a_{22,0}^2 = Var(e_{2,t}) \tag{3.9}$$

$$a_{11,0} a_{21,0} + a_{12,0} a_{22,0} = Cov(e_{1,t}, e_{2,t}) \tag{3.10}$$

$$c_{1,1}(L) a_{11,0} + c_{1,2}(L) a_{21,0} = 0 \tag{3.11}$$

[1] An exemplary calculation of the C_i matrices for a VAR model with two lags is displayed in the appendix part C.

[2] See the appendix part C for the derivation of the elements of A_0.

After obtaining the A_0 matrix supply and demand shocks can be retrieved from the residuals of the VAR estimation (cf. Eichengreen & Bayoumi, 1992).

As a measurement of synchronization, respectively of dispersion between the business cycles of different groups of countries, such as the EMU countries or the OECD countries, I apply the weighted cross-country standard deviation time series that Crespo-Cuaresma and Fernández-Amador suggest in their paper *Business cycle convergence in EMU: A second look at the second moment* (2013),

$$\hat{S}_t = \sqrt{\frac{\sum_{j=1}^{N} \omega_{jt}(\hat{\phi}_{jt} - \sum_{k=1}^{N} \omega_{k(-j)t}\hat{\phi}_{kt})^2}{1 - \sum_{j=1}^{N} \omega_{jt}^2}} \tag{3.12}$$

where $\hat{\phi}_{jt}$ denotes the demand shocks of GDP of a country j among the group of N countries, for which the time varying dispersion measurement is calculated. ω_{jt} stands for the time varying weights given to country j in the group of N countries, the subscript k indicates the group of N countries excluding the country j and $\omega_{k(-j)t} = 0$ when $k = j$.

The assessment of the costs/gains of exclusion of country j from a group of countries Ω, e.g. the EMU, is also based on a measurement tool Crespo-Cuaresma and Fernández-Amador (2013) developed. The costs or gains of exclusion are measured in the increase respectively in the reduction of dispersion within the business cycles of the group of countries.

$$coe_{t,j}|\Omega = \frac{\hat{S}_t|\Omega_{-j} - \hat{S}_t|\Omega}{\hat{S}_t|\Omega} \tag{3.13}$$

where $\hat{S}_t|\Omega$ denotes the above mentioned weighted cross-country standard deviation time series of the group of countries Ω, whereas $\hat{S}_t|\Omega_{-j}$ stands for the same time varying measurement but without the country j.

3.3. Data description

The examined time frame ranges from 1991Q1 until 2014Q4.[3] The CPI data had to be seasonally adjusted before the estimation. Since most European countries use the

[3]The data sources can be found in the appendix part B.

TRAMO/SEATS procedure to seasonally adjust their GDP data (cf. Eurostat), the same procedure was applied to the CPI data. The data on GDP and CPI was clearly not stationary in levels as indicated by augmented Dickey-Fuller-tests. The first difference of both variables was therefore taken in order to render the time series stationary. ADF-tests gave evidence for the stationarity of the individual time series, which is crucial for the stability of the VAR estimation.

For the estimation of business cycle synchronization the CPI was used as a measurement of inflation, whereas, in accordance with the established approach for the estimation of the correlation of shocks, the GDP deflator was adopted. In order to determine how many lags to include in the VAR estimation the Akaike criterion was consulted. The maximum lag length was chosen on the basis of the data frequency and the number of observations. For the estimation of the dispersion measure a maximum lag length of 12 seemed appropriate, since the examined timespan was from 1991Q1 to 2014Q4, whereas for the estimation of the correlation coefficients only 10 lags were included, since the analyzed timespan only lasted from 1995Q1 until 2014Q4.[4] Based on the Akaike criterion between one and five lags were chosen for the estimation of the VARs.

The financial crisis in 2008 most likely has interfered with model stability. There is no clearcut approach to deal with this problem as Blanchard and Quah (1989) pointed out, when dealing with a similar data problem, namely the first OPEC oil shock in 1974. Therefore, as proposed by Blanchard and Quah, two version of the model were estimated: a baseline model that does not take the model stability problem into account and an alternative version that does. The first approach seems to be the more popular one among scholars, since model stability is often not addressed in research papers (cf. Crespo-Cuaresma et al. 2013, Fidrmuc and Korhonen, 2003, Eichengreen & Bayoumi, 1992, etc.). In the second version, it is assumed that the financial crisis influenced both mean and the trend of the CPI and GDP time series. An inspection of the data confirms this assumption for many countries. For example, the mean of the German GDP growth rate before the crisis was 0.0036, whereas after the crisis it was 0.0015. The same is true for inflation, whose mean was before the crisis 0.0051 and the crisis 0.0031. Moreover the inflation time series of Germany is trending, suggesting a quadratic trend in prices in levels. The stability of the time series was assessed with a Chow- test for a known breakpoint at 2008Q3, the assumed date when the crisis hit Europe.[5] The conducted

[4] It is common to set at least four lags as the maximum lag length, if quarterly data is used (cf. Lütkepohl, 2004).

[5] For the Chow-test a dummy variable for the time period after 2008Q2 and the interactions terms of

Chow-tests confirm the assumed break in the data after the crisis for a number of European countries, usually in the GDP time series of crisis-ridden countries, at a significance level of 5%.[6] If necessary, the individual time series were therefore adjusted for a changing mean and trend, before the estimation of the VAR (cf. Lütkepohl, 2004). By doing so, we implicitly assume that the crisis did affect the deterministic but not the stochastic terms of the data structure, i.e. the growth rates of the GDP and the prices, but not the dynamic relation between them. In the further analysis, the differences and similarities of the two versions will be described and results of both versions will be presented.

the lagged dependent variable and the dummy variable was included in the regression. After the estimation the joint significance of the coefficients of the dummy variable and of the interaction terms was tested with an F-test (cf. Stock & Watson, 2012).

[6] For example, Spain exhibits a break at 2008Q3 in both the GDP and CPI time series (AR(3) process $F(4, 85) = 7.47^{***}$, respectively AR(2) process $F(3, 88) = 3.79^{**}$). The mean of the Spanish GDP growth rate before the crisis was 0.0076, whereas after the crisis it was -0.0023. The same holds for inflation, whose mean was before the crisis 0.0088 and the crisis 0.0031. As for Germany, the inflation time series of Spain is trending in first difference.

4. Business Cycle (De)Synchronization

4.1. Preface

In order to answer which country groups induced or reduced synchronization in the EMU, respectively whether the EMU should split in different subareas with own currencies, I calculated the dispersion of certain groups within the EMU separately (cf. Crespo-Cuaresma et al., 2013). The EMU18 aggregate represents the borders of the EMU in 2014; i.e. it includes the eleven original EMU countries[1] and Greece (from here on referred to as EMU12) and the enlargement countries (Estonia, Latvia, Malta, Slovenia, Slovakia, Cyprus) that joined the EMU from 2007 onwards.[2] The EU comparison group is composed of the EMU18 countries and the EU countries Czech Republic, Hungary, Poland, UK, Sweden and Denmark. Since the enlargement countries joined the EMU and Hungary, Poland and the Czech Republic the EU only in the 2000s, they enter the calculation of the dispersion not before the year 2000. In this way the adapting phase of these countries to the EMU, respectively the EU (cf. Gächter et al., 2013) in the run-up to their accession can also be captured, but they do not interfere with (de)synchronization tendencies prior to their catch-up phase.
Furthermore, a core, a periphery and an enlargement country group was formed to analyze the dispersion tendency of different groups within the EMU. The group assignment is based on the grouping of the EMU countries in a vast number of scientific publications (e.g. cf. Lehwald, 2012). Germany, Luxembourg, the Netherlands, France and Belgium form the core group. Greece, Ireland, Italy, Portugal and Spain constitute the famous *Giips* group that has received considerable media attention in the years since the crisis. The enlargement group consists of the above mentioned countries that joined the EMU since 2007. As four out of these six countries are regarded as CEE countries and

[1] The term "original EMU countries" refers to Germany, France, Finland, Belgium, the Netherlands, Italy, Ireland, Austria, Luxembourg, Portugal and Spain.

[2] Since the available data on GDP and CPI for Lithuania was limited and Lithuania joined the EMU only in 2015, it was omitted in the estimation of the dispersion of EMU business cycles. With a GDP of $45.93 billion in 2013 (cf. Worldbank database) Lithuania belongs to the group of the smallest EMU countries, an inclusion would therefore not make much of a difference.

Slovakia, Slovenia and Latvia are by far the biggest countries in this group one could perceive this group as a substitute of the CEE countries, which allows the comparison of business cycle synchronization in Eastern Europe and Western Europe. To examine whether the synchronization or decoupling tendencies within the EU and the EMU are a regional or a global phenomenon, a group of OECD countries was formed as a control group, consisting of Australia, Japan, South Korea, Canada, USA, Mexico, Switzerland, Turkey, New Zealand and the three EU countries Denmark, UK and Sweden, which are not members of the EMU.
The dispersion measures $\hat{S}_t$ shown in figure A.6.to A.18. are weighted time series. The weighting is dynamic throughout the observed time horizon and is based on real GDP relative to the aggregated real GDP of the whole examined group. The vertical red lines in these figures indicate the "crisis" quarters 2000Q1 and 2008Q3. 2000Q1 marks the date when the dot-com bubble burst. 2008Q3 refers to the bankruptcy of Lehman Brothers and is usually considered as the date when the financial crisis reached Europe. The trend lines that are shown in figure A.13. to A.18. are retrieved from the Hodrick-Prescott business cycle decomposition.[3]

4.2. Comparison of the baseline model and the crisis adjusted version

Figures A.6. to A.12. depict the difference in dispersion of the baseline version (V I) and the alternative crisis adjusted version (V II) from 1994Q1 up to 2014Q3 for the different country groups. For all these groups the difference between the results of the baseline and the alternative version are small. The absolute cross-country-group mean difference as well as the maximum and minimum difference are shown in table 4.1. The crisis adjusted version, i.e. the one that allows for a changing deterministic component, seems to induce slightly more dispersion within the country aggregates. The general mean difference across country aggregates amounts to approximately 0.2 standard deviations. The general cross country group maximum difference is at about 0.8 standard deviations, whereas the minimum is at about 0.004 standard deviations. The biggest differences between the two versions can be found for the *Giips* country group, the smallest difference can be found for the EU 25 aggregate. The peaks and

[3] As usual for quarterly data, the smoothing factor (lambda) was chosen to be 1600 (cf. Favero, 2001).

lows seem to be more pronounced for the version allowing for a break than for the baseline version. For the enlargement countries as well as the OECD aggregate the time series with a break and without one seem to be especially in times of high dispersion in line with each other, whereas the opposite holds for the *Giips* countries, the core countries and the EMU12, the EMU18 and the EU25 aggregates. Since the difference between the two versions is not very pronounced, the focus of the upcoming analyses will be on the baseline model.[4]

Table 4.1.: Comparison of Version I and II: Absolute value of difference of the dispersion measures: mean, minimum, maximum

	Core	EMU 18	EU 25	OECD	EMU 12	Enlargement	*Giips*	Cross-Country-Mean
mean	0.157	0.124	0.095	0.209	0.126	0.156	0.296	0.166
max	0.673	0.680	0.353	1.105	0.703	0.654	1.608	0.825
min	0.003	0.004	0.001	0.005	0.004	0.006	0.005	0.004

4.3. Business cycle synchronization in the EMU

Figure A.14. depicts the dispersion time series of the EMU12 and the EMU18 groups from 1994Q1 to 2014Q4. The accession of the enlargement countries to the EMU seems to have triggered no further desynchronization of business cycles within the EMU, as the differences between the two time series are hardly perceivable. This is also indicated by the coinciding trends of the two time series. Only in 2009, the subsequent year of the financial crisis, the inclusion of the enlargement countries seems to have induced a slightly higher dispersion of about 0.05 standard deviations. The increased value of the EMU18 dispersion time series around 2002 still belongs to the above mentioned catch-up phase and therefore did not actually affect the synchronization of business cycles in the EMU. The rise in dispersion in the aftermath of the financial crisis due to these countries is in line with the findings of Gächter et al. (2013) concerning the enlargement countries.[5]

When looking at the dispersion development within the EMU throughout the observed timespan (see figure A.14.), it can be seen that the era from 1994 to 2000 can be characterized as a period of growing synchronization of business cycles within the EMU.

[4] Blanchard and Quah (1989) came to the same conclusion for their model with respect to a potential break due to the OPEC oil price shock.

[5] The peak in dispersion in 2002 was caused by an exceptionally high GDP growth rate in Slovakia, the largest country in this group (cf. OECD Data).

The synchronization process seems to have come to a halt with the burst of the dot-com bubble in March 2000. The timespan from 2000 until 2006 exhibits a nearly constant value of dispersion, while in 2007 a period of high and short lasting divergence starts that reaches its peak in 2008Q1. At that point, dispersion is approximately 0.4 standard deviations higher than it was in mid-2000. This episode of high dispersion is followed by a massive and harsh drop in dispersion in 2008Q2. This trough at 0.65 standard deviations can be interpreted as a first synchronous reaction of the EMU countries to the financial crisis. However, these results suggest that the crisis has already reached the EMU in 2008Q2 and not one quarter later. After this trough in dispersion a period of extremely high divergence can be detected with a maximum of 1.5 standard deviations that gradually decreases ever since to a pre-crisis level. The high divergence pattern in 2009 may have been triggered by the imbalances between the economies of the EMU member states that manifested itself in the aftermath of the crisis and led to differences in the way and speed of adjustment to the crisis (cf. Gayer, 2007). At least since 2010 convergence between EMU business cycles pattern seems to set in. This pattern would be in line with the post-crisis pattern that was observed after the burst of the dot-com bubble, namely that the early recovery phase exhibited a high divergence pattern, while an increased convergence tendency only arose in a later phase of recovery (cf. Gayer, 2007). This specific dynamics are also underpinned by the trend line. The results until 2010, where the sample of previous studies ended, are in line with recent research findings (Gächter et al., 2012, Gächter et al., 2013).

4.3.1. The statistical properties of the dispersion time series: Significant changes and break tests

To test the statistical significance of changes in the dispersion time series of the EMU12, similarly to Crespo-Cuaresma et al. (2013) I conducted the Carree and Klomp's T_2 test (1997). The test statistic is as follows:

$$T_{2,t,\tau} = (N - 2.5)log[\frac{1 + 0.25(\hat{S}_t^2 - \hat{S}_{t+\tau}^2)^2}{\hat{S}_t^2 \hat{S}_{t+\tau}^2 - \hat{S}_{t,t+\tau}^2}] \tag{4.1}$$

where $\hat{S}_t$ refers to the standard deviation of business cycles at time t in (3.12), $\hat{S}_{t+\tau}$ stands for their standard deviation at period $t + \tau$ and $\hat{S}_{t,t+\tau}$ is the covariance of the

business cycles at times t and $t + \tau$. Under the null hypothesis of no change in size between period t and $t + \tau$ $T_{2,t,\tau}$ is distributed as $\chi^2(1)$. In figure A.19., significant changes in the dispersion time series at a 5% significance level are depicted for different time horizons (one to eight years). Significant changes can be detected in the convergence period in 1993 and in the divergence period from the onset of the financial crisis until 2010. To a lesser extent significant changes can be identified at the end of the sample and during the relatively stable period from 1995 until 2005. The year-to-year changes seem to be predominantly significant at the end of the sample, whereas in the rest of the sample changes of different time horizons are significantly different from zero.[6]

In order to assess the properties and the stability of the dispersion time series of the EMU12, the EU25 and the OECD, a series of tests were conducted. For the EMU12 and the EU25 time series the partial autocorrelation function suggested modeling an AR(1) process. The residuals of these AR(1) processes showed no sign of autocorrelation at any conventional significance level. The partial autocorrelation function and the autocorrelation function suggested that the OECD time series is a white noise process. The detrended OCED time series displays some evidence of autocorrelation at the first lag, but only at a 10% significance level. In addition to that, the Jarque-Bera-tests suggests that the detrended OECD time series exhibits no normality at a 1% significance level (see table 4.3.).

The augmented Dickey-Fuller test with an intercept rejected the null hypotheses of a unit root for all three time series at least at a 5% significance level (see table 4.2.). This result is also underpinned by the KPSS-test. When a specification of the Dickey-Fuller-test with an intercept and a trend is chosen, the null hypothesis can be rejected at least at a 10% significance level, with the exception of the time series for the EU25 countries, for which the null hypothesis cannot be rejected even at a 10% significance level. However, it has to be noted that the linear trends were in none of the ADF-test regressions significant at a conventional significance level. The KPSS-test including a trend and an intercept reports conflicting results, since the null hypothesis of no unit root cannot be rejected at any conventional significance level.

Different break tests were conducted on the autoregressive processes to test the model stability. In table 4.3. the estimation results of the AR(1) and white noise processes are shown in the specification of the BIC criterion and the CUSUM test, along with the test

[6] The first four periods from 1993Q1 to 1993Q4 of the dispersion time series are not shown in figure A.6. to A.18. due to their high values, since this would have impeded a proper graphical presentation of the crisis period, which is of most interest in the present study. They represent the end of a decline pattern in dispersion from a very high level in the aftermath of the German reunification.

statistics of the Ljung-Box test for autocorrelation of the residuals and the Jarque-Bera test for normality of the residuals.[7] For all three time series a recursive CUSUM test on the empirical fluctuation processes did not show any significant model instability at a 5% significance level. Moreover, according to the Bayesian Information Criterion, the number of breaks amounts for all three time series to zero. The Chow-test for unknown change points also finds no significant breaks for the OECD and the EMU12 time series at a 5% significance level, but some evidence for a break in the EU25 time series for 2005Q2.[8]

Table 4.2.: Unit root tests for selected weighted dispersion time series

	ADF-test			KPSS-test	
	lags	intercept	intercept + trend	intercept	intercept + trend
oecd	3	-4.237***	-4.277***	0.138	0.073
emu12	3	-3.507**	-3.478**	0.073	0.076
eu25	3	-3.078**	-3.010	0.152	0.101

Note:***,**,* stands for significance at the 1, 5 and 10% level.

4.3.2. Robustness check: The average bilateral cyclical correlations in the EMU

As a robustness check a second method that is often used to evaluate the co-movement of business cycles in a certain region was calculated: the average bilateral cyclical correlations between the output gaps of a group of countries (e.g. cf. Saiki & Kim, 2014). There are many different decomposition methods available to extract the output gap from output data. The most frequently used extraction methods in this research field are the Hodrick-Prescott filter, the Baxter-King band-pass filter, the phase-average trend and the Christiano-Fitzgerald band-pass filter. Typically, they lead to similar results (cf. Haan et al., 2008, for a comparison of results using different filters cf. Massmann & Mitchell, 2003).

For the sake of comparability with the above presented results, the Hodrick-Prescott filter was once more used with the same smoothing factor ($\lambda = 1600$). In this case to

[7] The test statistic of the Chow-test for unknown change points has an asymptotic $\chi^2(k)$ distribution, where k refers to the number of regressors in the model (cf. Zeileis et al. 2012). For a 5% significance level stability is rejected by the CUSUM-test if the cumulated sum of recursive residuals trespasses the lines $\pm 0.948[\sqrt{T-K} + \frac{2(\tau-K)}{\sqrt{T-K}}]$, where τ refers to the time horizon of subsamples and is plotted in figure A.23. to A.24. for $\tau = K+1, ..., T$, K is the number of coefficients and T refers to the whole sample size (cf. Lütkepohl, 2004).

[8] The figures A.20. to A.25. refer to the breaks tests and can be found in the appendix part A.

Table 4.3.: AR(1) and white noise processes of selected weighted dispersion time series

	OECD	EMU12	EU 25
coeff. intercept	0.925***	0.529 ***	0.403***
	(0.059)	(0.0754)	(0.0666)
coeff. 1.lag	-	0.265***	0.439***
	-	(0.100)	(0.091)
LjungBox(1)	3.541*	0.182	0.219
LjungBox(4)	4.780	2.583	5.622
JB test	1531.268***	2.619	1.105
Fstats	no break: 4.682	no break: 7.302	break in 2005Q2: 13.439**
BIC	no break: 165.164	no break: -4.685	no break: -50.009
Efp	no break: 0.487	no break: 0.510	no break: 0.438

Note:***,**,* stands for significance at the 1, 5 and 10% level. The standard deviation of the coefficients is given in the brackets. JB refers to the Jarque-Bera test. LjungBox stands for the Ljung-Box test at the first up to the fourth lag. Fstats symbolizes the Chow-test for unknown change point. BIC stands for the Bayesian information criterion. Efp refers to the recursive CUSUM test on the empirical fluctuation processes. The test statistics for the different break tests are given in the corresponding row. For the Bayesian information criterion the lowest criterion value is displayed.

extract the output gap from the real GDP data of the EMU12 countries from 1995Q1 to 2014Q4. The correlation was measured in a rolling window of eight quarters, following preceding studies (cf. Gächter et al., 2013). The resulting evolution of the average correlation coefficient from 2000Q1 to 2014Q4 is depicted in figure A.26. As before, the vertical red line marks 2008Q3.

After the crisis the results seem to be more in accordance with those of the dispersion time series in A.14. The correlation coefficient graph in A.26. also suggests that the crisis hit the EMU in 2008Q2, since the high correlation coefficients of approximately 0.9 at that time mimics the low dispersion level in figure A.14. Moreover, the high correlation among the individual business cycles within the EMU12 in 2008Q2 is followed by a decline in correlation in the next period. This trend is subsequently reversed and from 2009 until 2013 the correlation coefficients more or less mimic the reversed dispersion path for the EMU12. Only the last three quarters of the sample in the post-crisis period do not reflect the previous results, since theses indicate a massive and seemingly unlimited downturn in correlation in 2014. But it is well known that the Hodrick-Prescott filter exhibits an end-of-sample-problem (e.g. cf. Gerlach, 2011), which concerns in the above

case approximately the last four observations.[9] This end-of-sample-problem should be taken into account, when analyzing the correlation graph. Therefore the values of the last correlation coefficients in the sample are not credible.
At least for the post-crisis era the conclusions drawn from the dispersion time series on the (de)synchronization among the EMU countries are underpinned by the results of the average bilateral cyclical correlations in the EMU. As Gächter et al. (2013) pointed out, correlation coefficient and dispersion time series may capture different aspects of synchronization.[10] Moreover, it has to be mentioned that the structure of the dynamic correlation coefficients crucially depends on the filter used, the chosen parameters for a certain filter, the length of the rolling window and the calculation method used.

4.4. Business cycle synchronization in subgroups

In figures A.13. to A.18. the dispersion from 1994Q1 up to 2014Q4 of the EMU12 aggregate are compared with the dispersion for the above mentioned subgroups. A comparison of the dispersion time series of the core countries and of the EMU12 contradicts the widespread perception that the core countries are more synchronized than the EMU12 countries (see figure A.13.). Although the core country dispersion follows the dynamics of dispersion of the EMU12 quite closely, from 1996 onwards until 2008 the core countries seem to be for most of the periods less correlated than the EMU 12 countries by about 0.25 to 0.35 standard deviations. This pattern seems to have changed after the financial crisis hit Europe. Since 2009, the synchronization among the core countries has increased compared to the EMU, especially in the last observed year 2014. Considering the deep recessions into which some of Southern European countries slid in the aftermath of the financial crisis this result is reasonable. However, it is questionable if this results supports the constitution of a Northern Euro Area based on the OCA theory, since the involved countries share obviously similar business cycles in times of crisis, but did do so to a lesser extent in quieter times.
The assumption that the *Giips* countries are more synchronized due to their similar exposure to the crisis has to be also negated. Throughout the observed time span the

[9] Other filters exhibit the same end-of-sample problems. For example, the calculation of the Baxter-King band-pass filter implies loosing observations at the end and the beginning of the sample (cf. De Lucia, 2011).
[10] Dispersion between the business cycles of two countries may be low due to the similar size of the output gaps, although the directions of the business cycles may differ (cf. Gächter et al., 2012).

business cycles of the individual *Giips* countries were less synchronized than those of the EMU12 countries (see figure A.17). In the pre-crisis period the dispersion within the *Giips* countries was often twice as high as the one of the EMU12 countries (e.g in 1995Q1 or in 2005Q3). Only in the short time span of 2002Q2 to 2005Q1 the dispersion within the *Giips* countries coincided with the dispersion of the EMU12 countries. Already with the onset of the financial crisis in 2008Q1 the dispersion within the core countries once more doubled the dispersion in the EMU. At the height of the financial crisis in Europe, 1.7 standard deviations separated the two dispersion time series. Since the second half of 2010, the dispersion time series have approached each other once again, but 2013Q2/2014Q2 meant another huge disparity between the level of synchronization of business cycles within the EMU12 and the *Giips* countries. Due to the high level of decoupling of the business cycles among the *Giips* countries it seems not advisable to form a Southern Europe currency union from the OCA theory perspective.
A similar picture emerges when assessing the business cycle synchronization within the enlargement countries (see figure A. 15.). Since their accession to the EMU, they only shared a similar level of business cycle synchronization between the second half of 2003 until the beginning of 2008. With the onset of the crisis until the first half of 2010, the synchronization level between the two aggregates diverged extremely, resulting in a maximum difference of 1.7 standard deviations at the peak of the crisis. In contrast to the development of the *Giips* countries, since the second half of 2010 the divergence between business cycles for the enlargement countries has reached a low, pre-crisis level that is even lower than the one for the whole EMU12. Both the increased divergence among business cycles of the enlargement countries since the onset of the crisis as well as increased convergence in the recovery phase since the financial crisis are in consonance with Gächter et al. (2013). In normal times the business cycles of the enlargement countries seem to be as correlated as the ones in the EMU12 during normal times. In spite of this, these countries do not fulfill the OCA criteria to form a CU, since the shock in 2008 has shown that times of crisis induce extremely high divergence to this country group. But the conditions are good for further CEE countries to join the EMU. As pointed out before, the enlargement group can be considered as a representative of the CEE countries. Gächter et al. (2013) found that the decoupling of business cycles in CEE countries was mainly driven by small countries. Based on experience with the enlargement countries, even in a crisis period a further inclusion of CEE countries would not disrupt synchronization trends to a large extent, since the countries that induce dispersion would have only a small weight in the EMU.

The dispersion pattern for the EU25 aggregate displays the same dynamics as the one for the EMU12 (see figure A. 16.). With the exception of the first three quarters of 2004 and the first three quarters of 2011 the synchronization of business cycles in the EU25 aggregate was constantly slightly higher than that of the EMU12. This result is in line with a convergence tendency of recent EU countries in the direction of the EMU that a number of studies observed (e.g. cf. Crespo-Cuaresma et al., 2013) . Since the difference in dispersion did not rise between theses aggregates in the light of the crisis, a further enlargement of the EMU on the basis of the OCA theory might be feasible.
Throughout the observed timespan the EMU12 countries exhibited far more synchronization than the OECD countries, especially during the financial crisis, when the difference rose to 3 standard deviations in 2008Q2 (see figure A.18.). Only in 2003/2004 and 2012/13 the level of dispersion between these two aggregates converged. Interestingly, the dispersion pattern differ notably from 1995 until 2002, whereas the dispersion pattern of the EMU mimics the one of the OECD countries during the crisis. This result indicates that "regional" aspects dominated the business cycles in the EMU from 1995 until 2002, whereas since 2002 worldwide phenomena dictate business cycle movements in the EMU. This result is in agreement with the research findings of Lehwald (2012), who detected that the synchronization trend among the EMU core countries after 2000 was mainly caused by worldwide forces.
Overall the results of this subchapter confirm previous research findings up to 2010. The late recovery phase from 2010 onwards is dominated by a higher synchronization of business cycles among core countries and among enlargement countries than for the whole EMU12. In contrast to this, the dispersion of business cycles among the *Giips* countries is even after 2010 considerably higher than for whole EMU. Divergence tendencies within the EMU after 2010 are therefore most likely to stem from the *Giips* countries. A comparison of the different dispersion time series of the subgroups for the estimation version allowing for a break basically leads to similar results, although the difference between the OECD dispersion time series and the EMU12 time series is slightly smaller for the crisis adjusted version.

5. The correlation of supply and demand shocks in the EMU

As pointed out in chapter 2, the correlation of supply and demand shocks in a CU is crucial for its proper functioning, since only a common monetary policy exists to counteract shocks. If the shocks are hugely asymmetric, a conflict of interest arises. Therefore, in addition to examining (de)synchronization trends in a CU based on business cycles, the correlation of supply and demand shocks of individual countries with those of an EMU aggregate also deserves attention. In this study the Pearson correlations of demand and supply shocks for the countries of the EMU of the borders of 2015 were calculated for a period from 1995Q1 to 2014Q4. Following a great number of studies, the GDP deflator was used here as a measurement of price dynamics (cf. De Lucia, 2011, Fidrmuc & Korhonen, 2003, Bayoumi & Eichengreen, 1992, Gilson & Labondance, 2013).
Calculating the correlation between the shocks of an individual country and the shocks of an EMU aggregate is critical from a methodological point of view, since the supply and demand shocks of bigger countries are obviously higher correlated with the shocks of the EMU aggregate due to the fact that they make up a bigger part of the monetary union. Omitting the examined country from the aggregate, on the other hand, implies not properly representing the EMU and its specific shocks. In some studies the authors try to circumvent this problem by fixing one of the bigger countries, usually Germany or France, as the representative of the EMU and solely calculating correlations of the shocks of EMU member states with the shocks of the representative country. But especially in times of crisis, where business cycles diverge heavily due to different responses to the crisis, it is not easy to defend the representative position of a certain country, as also Fidrmuc & Korhonen (2003) emphasize. The size of a country compared to the other EMU member states has therefore to be taken into account, when interpreting the results that are depicted in figure A.28. It portrays the correlation of supply and demand shocks of individual EMU countries with the shocks of the EMU19 aggregate

for the whole sample.[1]

A comparison with the findings of Fidrmuc & Korhonen (2003), who applied the same approach to a number of EMU/EU and CEE countries for the timespan of 1991Q4 to 2000Q4, provides support for the endogeneity hypothesis, since the correlation of supply shocks within the EMU seems to have significantly risen, especially for the enlargement countries (see table 5.1.). But it has to be noted that the impulse response functions of the SVAR estimations for some countries differed to a sizable extent from the expected shape, which may limit the validity of the correlation coefficients of these countries. This might be due to the shorter time span used for the calculation of the correlation of the shocks.[2]

However, in figure A.28. three different correlation groups can be identified that seem to mimic the country groups from chapter 4. The first group, which shares a high correlation of supply and demand shocks with the EMU19 aggregate, consists mainly of the members of the core country group and Italy. Taking into account the size of Austria and the consequently small contribution to the EA aggregate it also belongs to this first group. The *Giips* countries without Spain but including Slovenia seem to constitute a second group with a medium level of correlation with the Euro Area. The third group contains mostly the enlargement countries that exhibit a low level of correlation with the EMU. If the size of the countries in the last group is taken into account, their level of correlation should somehow resemble the one of the second group.

Luxembourg, Belgium and Spain do not really fit in any of these groups or at least do not seem to belong to the group they are next to from a theoretical point of view. With respect to demand shocks, Spain exhibits the same correlation level as the first group, but not with respect to the supply shock side, especially when the size of Spain is taken into account. But from a demand shock perspective Spain does not belong to the second group either, although the correlation of supply shocks with the Euro Area corresponds to the level of the second group. De Lucia (2011) pointed out that demand shocks are less important for the assessment of the wellbeing of a CU than the supply shocks because supply shocks have a long lasting effect on an economy. Therefore it is probably advisable to regard Spain as a part of the second group.

Luxembourg exhibits the same level of correlation as Austria in terms of supply shocks, but in terms of demand shocks it is even slightly negatively correlated with the Euro Area. This is a surprising result, but it is in line with recent results of Gilson & Labon-

[1] Lithuania was once more omitted due to data availability.

[2] The impulse response functions for Cyprus, Greece, Ireland, Italy, Latvia, Netherlands, Portugal and Spain had a somehow unexpected shape.

dance (2013), who find a correlation coefficient of zero for the demand shocks of Luxembourg and an EMU11 aggregate for the period 2000Q4 to 2010Q2. Probably the size of Luxembourg or its economic orientation towards the financial sector make it prone to different demand shocks than the rest of the EMU. Similarly, Belgium exhibits a small correlation coefficient of demand shocks with the EMU, but a high one in terms of supply shocks. But it has to be noted that Fidrmuc & Korhonen (2003) find an even smaller demand correlation coefficient for Belgium (see table 5.1.).
Although these static correlation coefficients between individual EMU countries and an EMU aggregate have to be interpreted with caution due to the above mentioned imprecisions, they reflect in some way the (de)synchronization dynamics within the EMU: The core group is here too highly correlated with the EMU area, whereas the *Giips* group and the enlargement group exhibit less correlation with the EMU.
Moreover, when interpreting figure A.26. one has to keep in mind that it depicts only a static relationship for a timespan of nearly 20 years. Haan et al. (2007) emphasized the sensitivity of such an analysis concerning the chosen time frame. In a recent study Gilson and Labondance (2013) using a rolling window of four years showed that with the onset of the financial crisis the correlation of demand shocks as well as of supply shocks of individual EMU countries with an EMU11 aggregate have risen dramatically and subsequently declined. The calculation of the shock correlations for a pre- and a post-crisis period with the given sample leads to the same results. Their research findings once more underpin the findings concerning a desynchronization pattern in the EMU in the early recovery phase.
In the light of these findings, it seems recommendable to not use this static approach for a short time span, since it is too sensitive to the timespan used. Whereas if data for a longer time span is used, this approach may detect a long run relation.

Table 5.1.: Comparison of correlation coefficients of shocks of individual countries with the shocks of the EU19 aggregate

	Own Results: 1995Q1-2014Q4		Fidrmuc & Korhonen (2003): 1991Q4-200Q4	
	Supply Shocks	Demand Shocks	Supply Shocks	Demand Shocks
Austria	0.46***	0.35**	0.38	0.08
Belgium	0.51***	0.12	0.53	0
Cyprus	0.23	-0.03		
Estonia	0.38**	-0.06	0.25	0.12
Finland	0.56**	0.14	0.3	0.06
France	0.71***	0.66***	0.69	0.3
Germany	0.83***	0.44***	0.66	0.18
Greece	0.51***	0.13	0.05	-0.01
Ireland	0.44***	0.14	-0.14	0.13
Italy	0.68***	0.41***	0.52	0.57
Latvia	0.04	0.02	0.3	-0.49
Luxembourg	0.45***	-0.09		
Malta	0.28*	-0.22		
Netherlands	0.66***	0.53***	0.47	0.04
Portugal	0.35**	0.17	0.45	0.09
Slovakia	0.19	0.05	0.05	-0.05
Slovenia	0.56***	0.19	0.15	-0.18
Spain	0.43***	0.53***	0.22	0.16

Note:***,**,* stands for significance at the 1, 5 and 10% level.

6. Analysis of costs and gains of exclusion of a country

6.1. Contribution of individual countries and groups to dispersion with a special focus on the crisis

The aims of this chapter is to determine which countries contributed the most to the dispersion among the business cycles of EMU member states. The costs respectively gains of exclusion $coe_{t,j}$ in (3.13.) in this context are measured as the rise respectively the reduction in dispersion, if a country had not been in the EMU. The costs are measured in standard deviations of the dispersion time series. In figure A.29. the cost/gains of exclusion for all EMU18 countries are depicted. A negative percentage value here refers to a reduction in dispersion, whereas a positive one signals the reverse. A comparison of figure A.14. and figure A.29. shows that the highly positive percentages in figure A.29. correspond to troughs in the dispersion of business cycles in the EMU.[1]
In the time horizon from 1993 up to the onset of the financial crisis, as expected, the biggest European countries induced the most dispersion of business cycles. Given their size compared to the other EMU countries, this is not surprising. Over the timespan from 1993 to 1995, Germany seems to have caused the most dispersion, which can be traced back to the German reunification. The dispersion in the period from 1995 to 1998 can be characterized as dominated by Italy and Spain. The following era from 1998 to approximately 2003 saw all four big countries and, interestingly, partly the relatively small Netherlands contributing to dispersion. From 2003 until 2006 France seems to have had the biggest influence on the dispersion of business cycles in the EMU, whereas in the onset of the financial crisis (2007) Germany seems to have triggered the most decorrelation within the EMU. Until 2009, the four biggest EMU countries still dominated the dispersion in the EMU and even triggered the convergence patent in 2008Q4/2009Q1.

[1] The costs/gains of exclusion figures for the individual countries can be found in figure A.33. to A.50. in the appendix part A.

Considering their size also the Netherlands and Belgium contributed to the dispersion in 2008 and 2009. This implies that the first convergence reaction to the crisis as well as the divergence pattern in the early recovery phase can be mainly traced back to the biggest EMU countries. This result is also underpinned by the dynamics of the output gaps of the EMU12 countries in figure A.27.
However, in the aftermath of the financial crisis, figure A.29. gets more colorful, meaning that smaller countries that did not cause or caused only to a negligible extent divergence before the crisis, suddenly played a significant part in the dispersion of the EMU business cycles.
Figure A.30. to A.32. displays the impact of certain country groups on the (de)synchronization within the EMU from the onset of the financial crisis to its aftermath. By far the most interesting chart is figure A.30. Here the countries with the highest gains of exclusion for the pre- and post-crisis period (Germany, Italy, France, Spain, Portugal and Greece) are depicted with their contribution to divergence.[2] Together they were responsible for up to 70% of the dispersion in the EMU in the observed era. As stated before, until the first year of the crisis the four biggest EMU countries induced most of the dispersion within the EMU. The - in relation to their size - immense negative effect of small countries, above all of Greece, on the synchronization within the EMU started in 2010, when Greece alone caused dispersion to rise by 17%, (2010Q1) respectively 28% (2010Q2). Portugal alone triggered an increase in dispersion by 11% in 201Q3 and by 17% in 2012Q2. Interestingly, this is the phase, in which first convergence tendencies are perceivable within the EMU (see chapter 4), which is also depicted by the synchronization of output gap dynamics in figure A.27.[3] Until the end of the sample the small countries Portugal and Greece take a big part in divergence among EMU business cycles. Most recently, in 2014Q3, when dispersion rose by 13% due to Greece or in 2014Q2 by 11% due to Portugal. Overall, in the period from 2012 until the end of 2014 Italy and to some extent also France and Spain have caused the most dispersion of business cycles in the EMU, whereas Germany only played a secondary role in this time period.
This divergence pattern that the *Giips* countries – all above Greece and Portugal – induce to the EMU can also be detected in figure A.27. Although Germany, France and Italy display by far the largest negative output gaps, their business cycle are in sync

[2] For Ireland this is not exactly true. It was put in this group simply because it belongs to the group of countries that were hit by the crisis the most. Moreover, it has to be noted that these countries caused the most dispersion considering the whole crisis period. However, in some quarters of this era they even contributed to the synchronization of business cycles within the EMU.

[3] The effect of Ireland on the desynchronization within the EMU amounts up to a maximum of 6% in 2012Q1.

with those of the other EMU12 countries, whereas Portugal, Greece and to a far lesser extent Spain exhibit an almost reversed business cycle pattern compared to the rest of the EMU since 2008. Since Italy's business cycle seems to be in accordance with the rest of the EMU, Italy's high contribution to dispersion in the EMU since 2012 can be traced back to its high weight within the EMU relative to the less synchronized countries. Gächter el al. (2012) make a similar observation for Italy. In this way, Italy's dominance in dispersion at the end of the sample can be interpreted to some degree as a sign of recovery of the EMU after the financial crisis.
With respect to the enlargement countries, figure A.31. reveals that their contribution to dispersion within the EMU amounted to a maximum of 0.6% in the period from 2005 until 2014 with a peak in 2010Q1. This value has to be interpreted in the light of the small size of the group members. Not surprisingly, Slovakia, the largest country in this subgroup, is responsible for the most dispersion, followed by the second and third largest countries in this group Slovenia and Latvia. Considering its size Cyprus having strong links to Greece triggered a high level of dispersion in 2010 compared to the larger countries in this group.
The group of the other EMU countries, whose gains of exclusion are depicted in figure A.32., is also, not surprisingly, dominated by its largest countries: the Netherlands and Belgium. When omitting the outlier in 2006Q2, their effect on the dispersion within the EMU amounts to a maximum of 32% in 2011Q1. It should, however, be noted that this group already induced quite some dispersion during the crisis and in the first recovery phase.

6.2. The future of the EMU: Is a Grexit or even a break-up of the EMU reasonable?

Summing up the results of the previous chapters, on the grounds of the OCA theory a break-up of the EMU does not seem reasonable. The dispersion among the business cycles of the EMU member is shrinking and approaching a pre-crisis level. The latter also applies for average bilateral cyclical correlations between the output gaps of the EMU member states. Moreover, in terms of the correlation of supply shocks with the Euro Area, most member states seem to have reached an appropriate level. In addition to that, figure A.27. indicates a shrinking of the negative output gaps and a further synchronization of the individual output gaps among the EMU countries. Based on

these results, the EMU seems to be returning to its pre-crisis path. But in order to prevent a future shock from hitting the EMU in the way the financial crisis did, the ties between the EMU countries have to become even closer, as was already suggested by the traditional OCA theory ("insurance scheme"). A possibility to do so might be to also form a fiscal union. But it is highly questionable if the political will to form such a construction is sufficient in the light of the financial crisis and its drastic consequences. It remains to decide whether the frequently discussed Grexit is reasonable from the perspective of the OCA theory. Comparing the cost of exclusion of Greece with those of an EMU country that is a bit smaller, namely Finland, and one that is a bit bigger, namely Belgium (see figures A.34.,A.37. and A.40.), reveals that before the crisis, Greece contributed as much to dispersion within the EMU as Belgium and Finland did, when omitting the outlier from 2002Q1. Especially, from the period of 2002 to 2008 Greece did partly undercut the low dispersion contribution of Finland. On the other hand, it has to be noted that if Rose's and Frankel's (1998) endogeneity assumption is correct – as many empirical studies suggest (see chapter 2) – the high synchronization of the Greek business cycle with those of the other EMU countries before the crisis was caused by its accession to the EMU. Due to this endogeneity problem figure A.40. only presents a lower bound of the gains of Greece leaving the EMU. The actual gains of an exclusion are therefore higher. From 2010 onwards the mean gains of an exclusion of Greece amount to 5% of dispersion (lower bound!), whereas the gains of exclusion amount to approximately 1% to 2% for countries of a comparable size, like Belgium, Finland and Austria (see table 6.1.). Even the gains of exclusion of Italy, which has induced the most divergence to the EMU since 2010, would amount only to about 2%, if it was scaled down to Greece's weight within the EMU. Moreover, figure A.27. shows that the Greek business cycle still is out of sync with the business cycles of the other EMU countries.[4] This implies that whereas the rest of the EMU countries shows signs of a recovery from the crisis, Greece is still far away from reaching this point.
The high (compared to the size of Greece) reduction in dispersion within the EMU and the fact that it is highly questionable if the Greece business cycle will reach a high level of synchronization with the EMU member business cycles in the near future suggests from an OCA theory perspective an exclusion of Greece from the EMU.

[4] As stated before the last quarters depicted in this figure are not credible, since they were derived from the Hodrick-Prescott business cycle decomposition.

Table 6.1.: Average reduction in dispersion due to exclusion of a country vs. average weight of the country in the EMU in % 2010Q1-2014Q4

Country	Average reduction in dispersion in %	Average weights in EMU in % from 2010Q1 to 2014Q4
Austria	-2.38	3.06
Belgium	-1.36	3.63
Cyprus	-0.27	0.19
Estland	-0.18	0.24
Finland	-1.61	1.70
France	-8.51	19.80
Germany	-4.69	28.21
Greece	-5.25	2.34
Ireland	-1.14	1.66
Italy	-12.81	16.15
Latvia	-0.21	0.32
Luxembourg	-0.52	0.36
Malta	-0.19	0.07
Netherlands	-4.29	6.30
Potugal	-4.06	2.17
Slovakia	-0.28	1.11
Slovenia	-0.53	0.50
Spain	-4.75	12.18

7. Discussion of results

Although the bigger timespan since the crisis has allowed to gain further insight in the dynamics within a crisis ridden currency union compared to earlier studies, the time span since the crisis is still too short as for allowing a thorough econometric analysis of the dynamic behavior after the crisis. If more data were available, I could have estimated a model with a sample before and one after the crisis. This would allow different dynamic behavior before and after the crisis. I tried to circumvent the data availability problem by working with monthly data, i.e. with data on industrial production instead of data on GDP. However, an estimation of SVAR with monthly data was not meaningful, since the data on industrial production are more volatile than the data on GDP and do not reflect the economic relationships within the EMU/EU as good as data on GDP. This is probably due to the fact that industrial production only accounts for 20% of GDP in Europe (cf. Haan et al. 2008). Moreover, the idea of demand shocks serving as an indicator of business cycle ceases to be valid when monthly data on industrial production are used.

The short time span since the crisis is connected with a further potential limitation of the current study, namely the model instability. Model stability always is a concern when analyzing time series data. In the present case, the financial crisis that hit Europe approximately in the third quarter of 2008 is highly likely to interfere with the model stability. In the current study, I attempted to circumvent or at least to alleviate this problem. The two separately measured versions - one assuming stability, the other allowing for some instability – led to similar results. For the estimated dispersion time series, the CUSUM- and the Chow-test for unknown change points did not detect model instability during the financial crisis for the OECD and the EMU12, but at least the Chow-test discovered a break for the EU25 time series at 2005Q2.

Not only model stability raises concerns, but also the identification method of the SVAR. The results of a SVAR analysis are typically sensitive to the identification assumptions. As an additional robustness check other identification assumptions could have been applied as well. However, since the classical Blanchard & Quah (1989) identification

procedure, tracing back to the AS-AD model, is well-accepted among scholars, this is not further proceeded here.

An obvious and potential conceptual issue of the current study is endogeneity. That is to say that the membership in the EMU has already increased the correlation of the business cycle of an individual country with the business cycles of the other EMU countries. Hence, the estimated costs, respectively gains of a country like Greece leaving the EMU are underestimated in this study. The results of the costs and gains analysis can therefore only be regarded as a lower bound and a conservative measurement of the actual effect of an exclusion of a certain country on the EMU business cycle. Therefore the actual costs/gains might be even higher.

8. Conclusion

Since the outbreak of the current crisis, EMU critics call the prevalence of the EMU into question. Recently, the coming to office of the left wing Greek party *Syriza* has fueled the discussion about an exclusion of Greece from the EMU. In the current study the well-being of the EMU in the light of the financial crisis is assessed on the basis of the OCA theory. The OCA theory evaluates the "optimality" of a currency union by the means of certain characteristics of its member states such as openness and flexibility of labor markets. This is because these characteristics guarantee that a currency union is immune to asymmetric shocks, respectively the likelihood of an asymmetric shock to occur, is reduced. Therefore the common monetary policy is sufficient for the needs of the whole currency union. As a meta-criterion for these characteristics, this study examines the synchronization of business cycles among the state members. For this purpose I use a dispersion measure based on the weighted demand shocks of the member states, which were retrieved from the estimation of a bivariate SVAR of output and prices.

Only few studies exist so far on the effect of the financial crisis on the business cycle synchronization within the EMU (cf. Gächter et al., 2013, Gächter et al., 2014, Bekiros et al., 2014). Due to the short time span since the crisis these studies examine the first reaction to the shock within the EMU. The current study can complement these studies, since it puts an emphasis on the recovery phase of the EMU from the financial crisis until the end of 2014. The evaluation of the full recovery phase until 2014 has the advantage that it allows to identify certain post-crisis patterns, we have seen before, such as after the burst of the dot-com bubble.

This study has shown that the financial crisis led in the first place to a period of high synchronization among the business cycles of the member states, as all countries were hit by the crisis. This short period was followed by a period of great divergence, which was most likely caused by the economic imbalances between the economies of the member states and their different ways and speed of adjustment to the crisis. These results are in line with the above mentioned early studies on the effect of the crisis on the EMU (cf. Gächter et al., 2013, Gächter et al., 2014, Bekiros et al., 2014). However, since 2010, a

tendency of higher synchronization is noticeable that approaches the pre-crisis level of synchronization. This tendency is also confirmed by the average bilateral cyclical correlations between the output gaps of the EMU member states, which were retrieved from output data by the HP-filter, as well as the shrinking of the negative output gaps to pre-crisis levels and a further synchronization of the individual output gaps among the EMU countries. This particular post-crisis pattern resembles the de- and convergence tendencies within the EMU after burst of the dot-com bubble (cf. Gayer 2007).
On the basis of the OCA theory the formation of another currency union construction is not advisable, since the core countries, the periphery countries and the new enlargement countries individually exhibit a higher divergence than the EMU as a whole. A further enlargement of the EMU towards Eastern Europe is by the means of the OCA theory feasible, since the inclusion of the enlargement countries did not lead to a higher dispersion level within the EMU during *normal times*. The core countries are more correlated with the EMU than the periphery and the enlargement countries, as the pattern of correlation of shocks of individual countries with the EMU shocks has shown. Moreover, the results of this study suggest that since 2002 global phenomena seem to dictate business cycle movements within the EMU, whereas before 2002 regional aspects prevailed.
With respect to the individual contributions of member states to the dispersion pattern during and after the financial crisis, it was shown that the crisis phase and the early recovery phase was mainly dominated by the convergence and subsequently the divergence among the four biggest member states. In contrast to this, in the later recovery phase, especially small member states like Greece and Portugal, played a decisive role in the divergence pattern the EMU displayed.
In the light of these results and on the basis of the OCA theory, a break-up of the EMU seems to be not advisable, since there are some strong signs that the EMU is returning to its pre-crisis path. But in order to prevent future shocks from hitting the EMU to such a large extent, the ties between the EMU countries have to become even closer, for example via forming also a fiscal union. Since an exclusion of Greece in 2010 would have led to a mean decrease of dispersion within the EMU of at least 5% and, further, it does not seem that the Greek business cycle will be in sync with the business cycles of the other countries in the near future, an exclusion of Greece from the EMU seems on the basis of the OCA theory reasonable.
However, the conclusions that are drawn in the current study are based on a vague and partly inconsistent theory (see chapter 2). The here presented perspective on the future of the EMU can only be seen as a very simple approach to a very complex issue, since

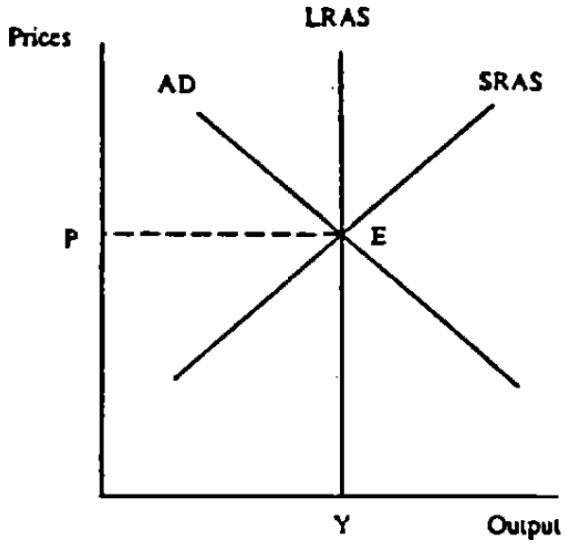
the actual consequences of a break of the EMU for the involved countries and the rest of the world are manifold, severe and thus cannot be predicted.

List of Figures

Appendices

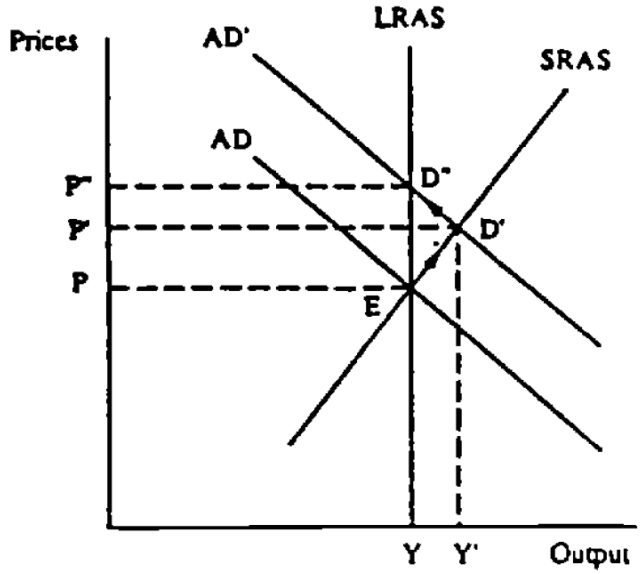
A. Figures

Figure A.1.: The aggregate demand and aggregate supply model (cf. Bayoumi & Eichengreen et al. 1992)



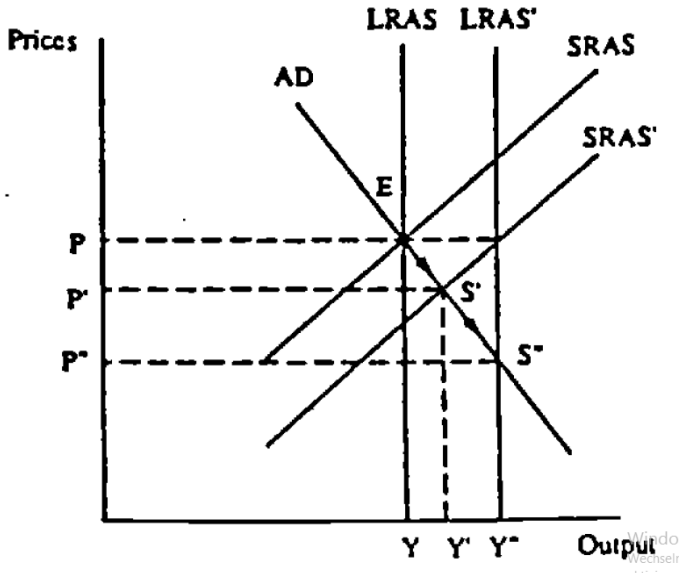
The intersection of the aggregate demand curve (AD) and the short run aggregate supply curve (SRAS) marks the equilibrium E in the markets. Since the vertical long run aggregate supply curve (LRAS) also intersects E, a long run equilibrium is reached, where output is equal to its natural level and the price level is in accordance with the expected price level.

Figure A.2.: A demand shock (cf. Bayoumi & Eichengreen et al. 1992)



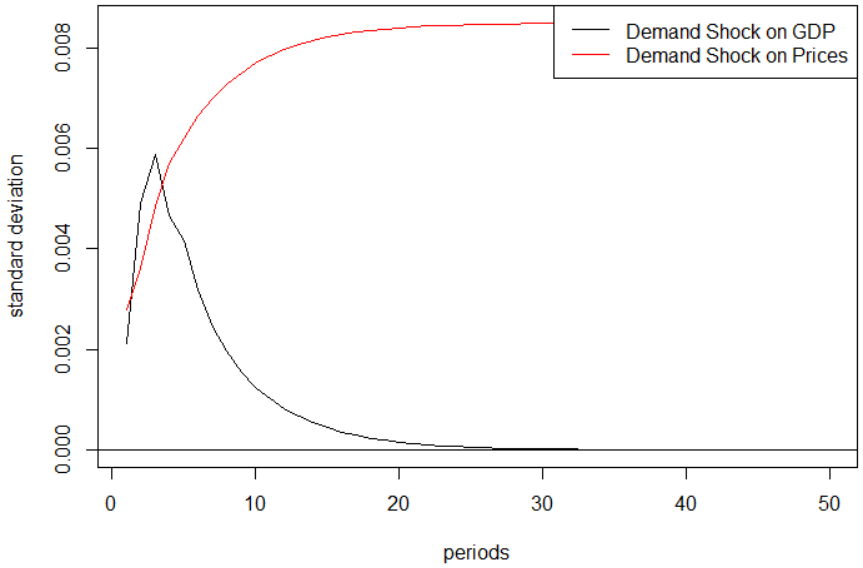
In the AD-AS model a positive demand shock shift the AD curve upwards and leads to a permanent rise in the price level, but only a temporary increase in output.

Figure A.3.: A supply shock (cf. Bayoumi & Eichengreen et al. 1992)



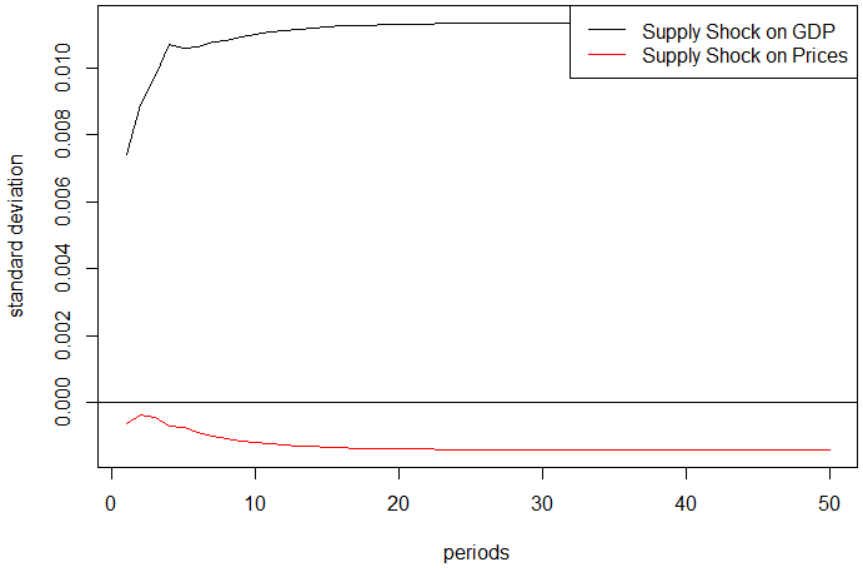
In the AD-AS model a positive supply shock shifts the short run AS curve upwards and the long run AS curve to the right. This implies a permanent rise in output, a higher natural level of output and a long run decrease in prices.

Figure A.4.: Accumulated Impulse Respone Functions of German GDP & prices to a positive demand shock



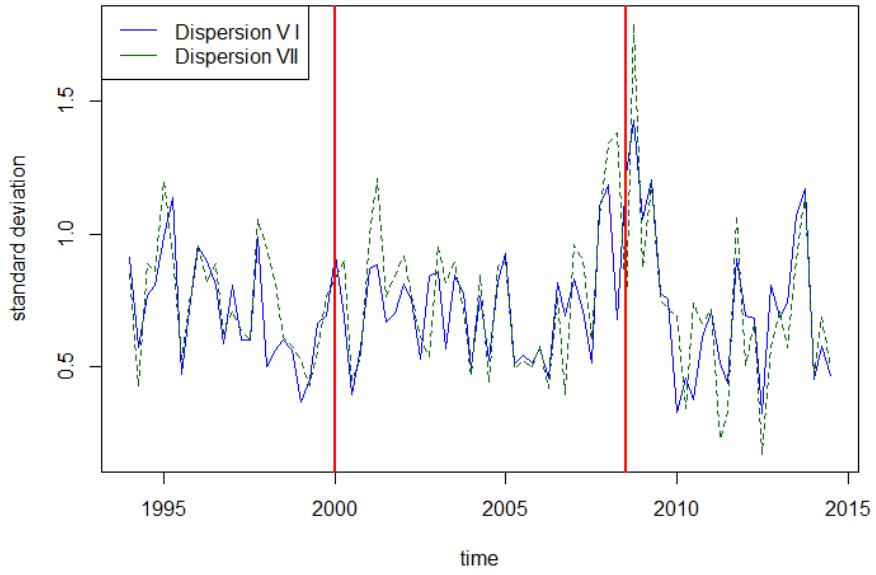
Note: Like in the underlying AD-AS model a positive demand shock introduced to the SVAR model causes prices to rise permanently and GDP to rise only temporary.

Figure A.5.: Accumulated Impulse Respone Functions of German GDP & prices to a positive supply shock



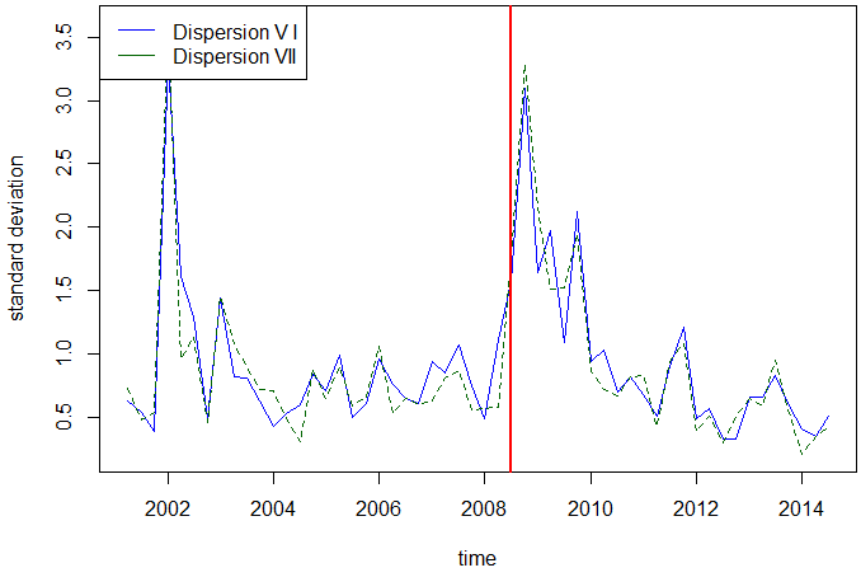
Note: Like in the underlying AD-AS model a positive supply shock introduced to the SVAR model causes prices to decrease permanently and GDP to rise permanently.

Figure A.6.: Comparison V I and V II: Dispersion in EMU12 countries



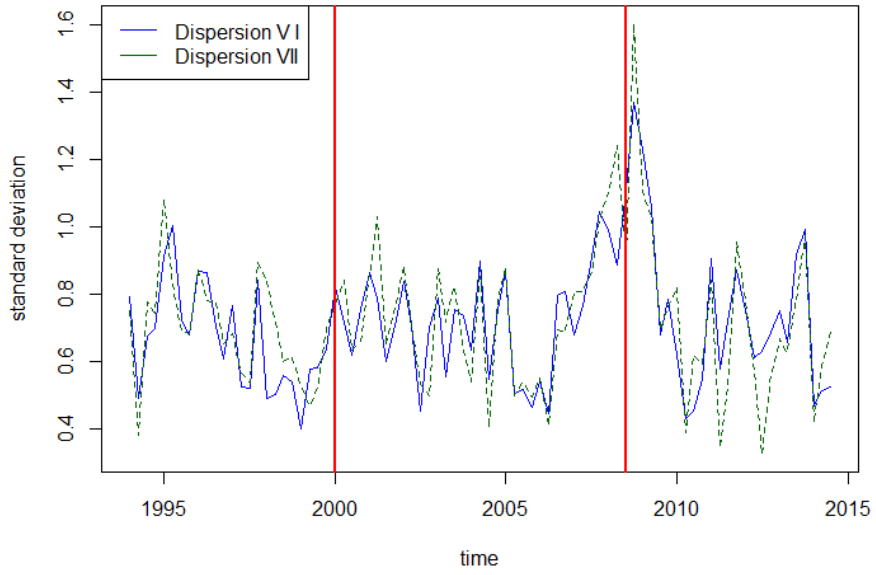
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the EMU12 countries in a version without a break (V I) and a version allowing for a break (V II). The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.7.: Comparison V I and V II: Dispersion in enlargement countries



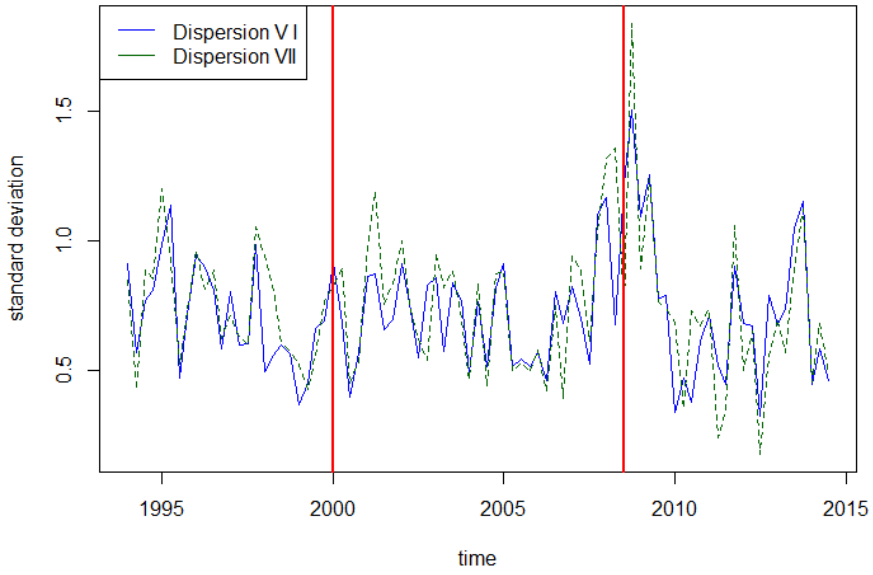
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the enlargement countries in a version without a break (V I) and a version allowing for a break (V II). The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.8.: Comparison V I and V II: Dispersion in EU25 countries



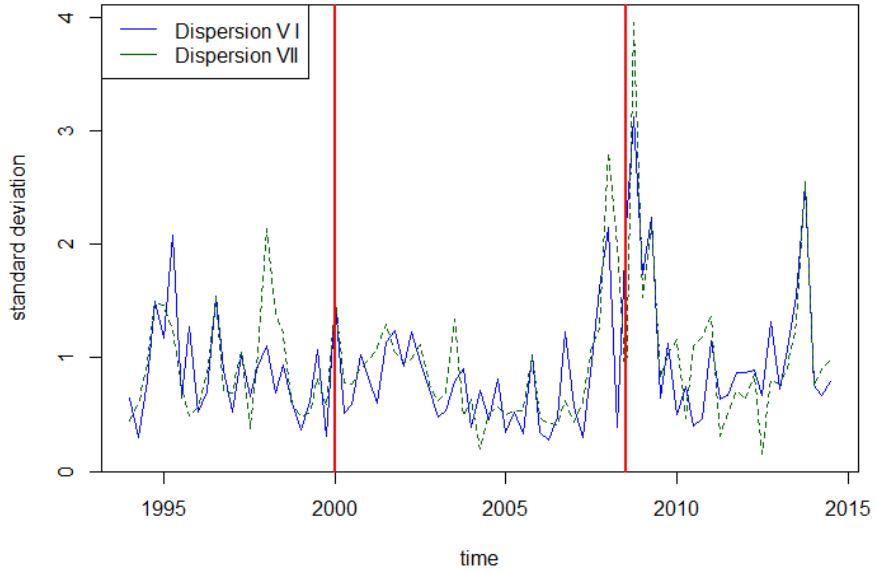
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the EU25 countries in a version without a break (V I) and a version allowing for a break (V II). The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.9.: Comparison V I and V II: Dispersion in EMU18 countries



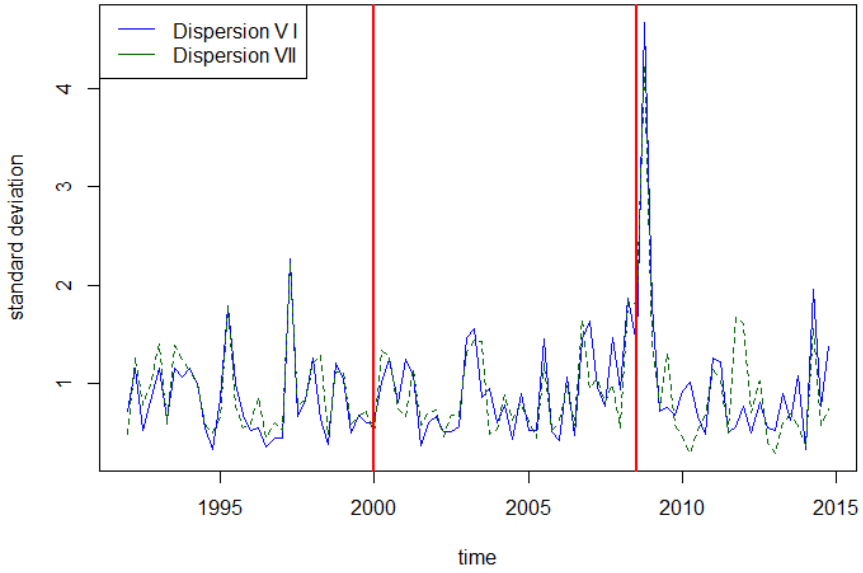
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the EMU18 countries in a version without a break (V I) and a version allowing for a break (V II). The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.10.: Comparison V I and V II: Dispersion in *Giips* countries



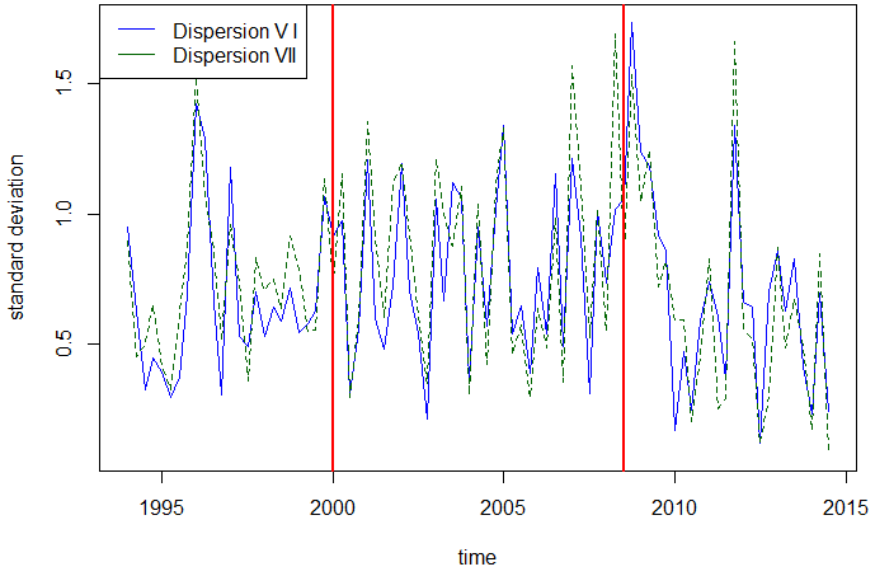
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the *Giips* countries in a version without a break (V I) and a version allowing for a break (V II). The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.11.: Comparison V I and V II: Dispersion in OECD countries



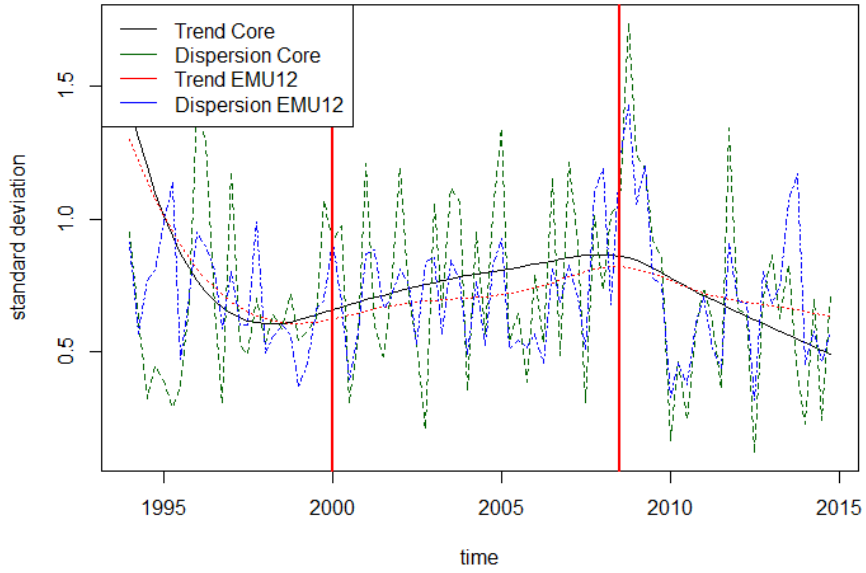
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the OECD countries in a version without a break (V I) and a version allowing for a break (V II). The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.12.: Comparison V I and V II: Dispersion in core countries



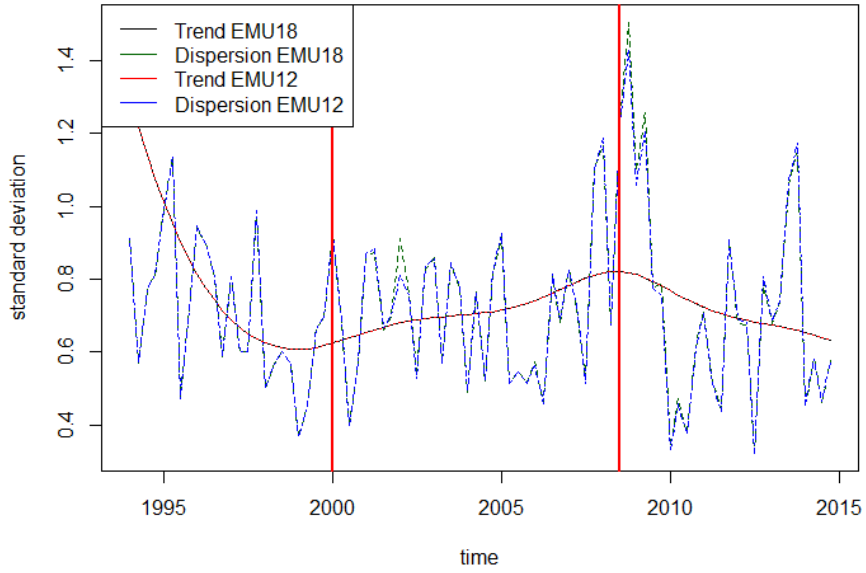
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the core countries in a version without a break (V I) and a version allowing for a break (V II). The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.13.: Comparison: Dispersion in EMU12 and core countries



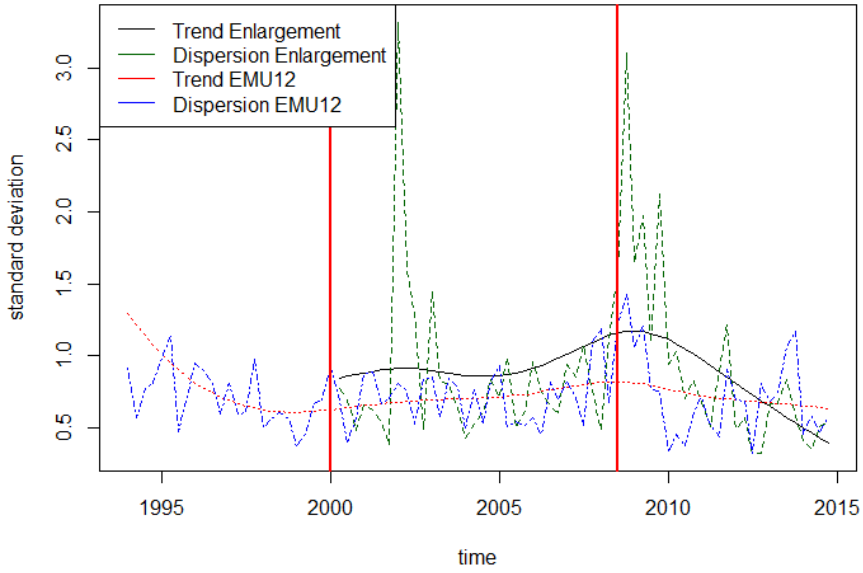
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the EMU12 and the core countries. The trend lines were derived from the Hodrick-Prescott business cycles decomposition. The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.14.: Comparison: Dispersion in EMU12 and EMU18 countries



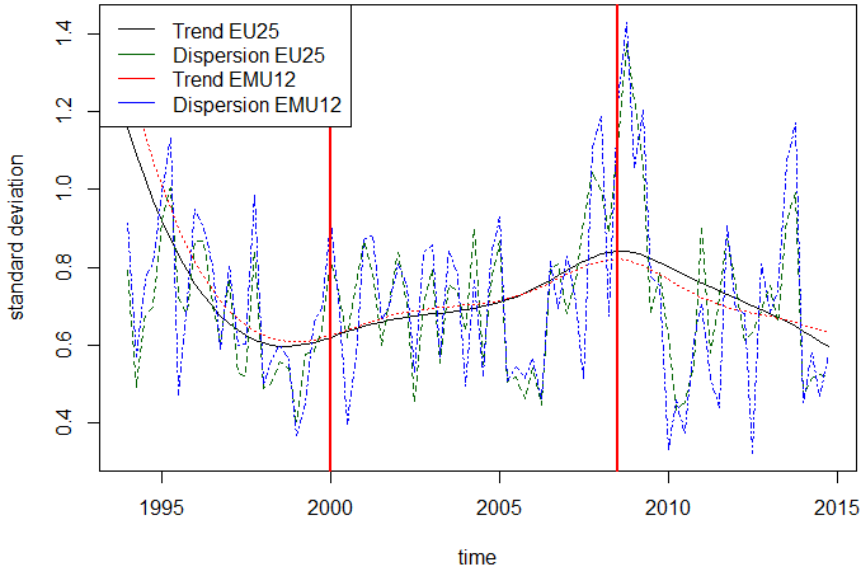
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the EMU12 and the EMU18 countries. The trend lines were derived from the Hodrick-Prescott business cycles decomposition. The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.15.: Comparison: Dispersion in EMU12 and enlargement countries



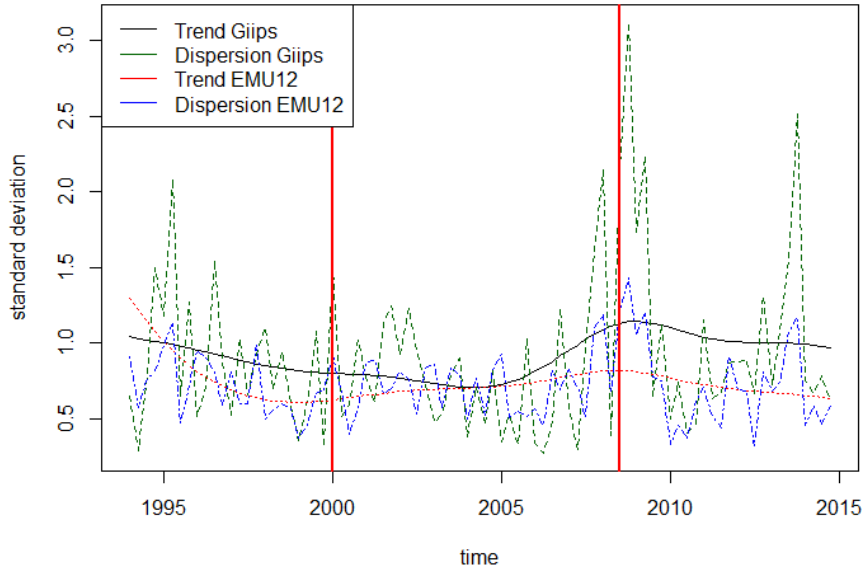
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the EMU12 and the enlargement countries. The trend lines were derived from the Hodrick-Prescott business cycles decomposition. The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.16.: Comparison: Dispersion in EMU12 and EU25 countries



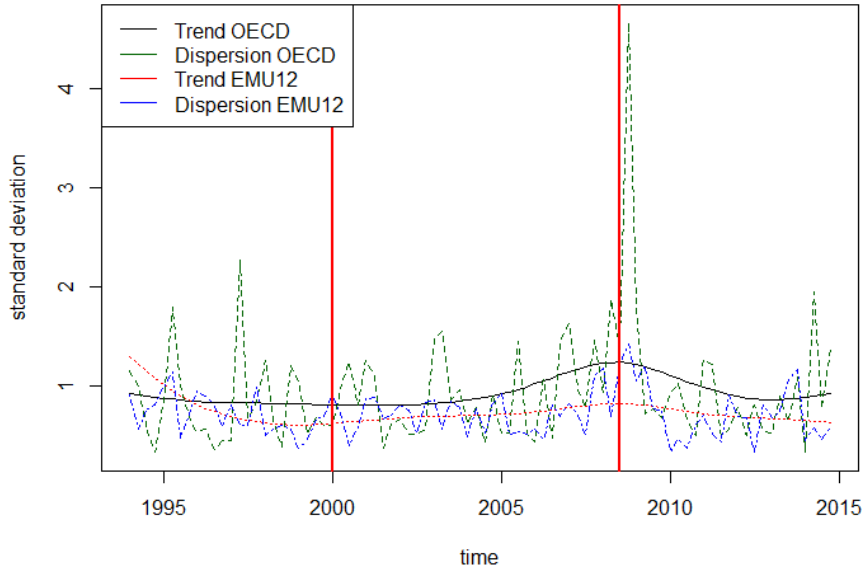
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the EMU12 and the EU25 countries. The trend lines were derived from the Hodrick-Prescott business cycles decomposition. The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.17.: Comparison: Dispersion in EMU12 and *Giips* countries



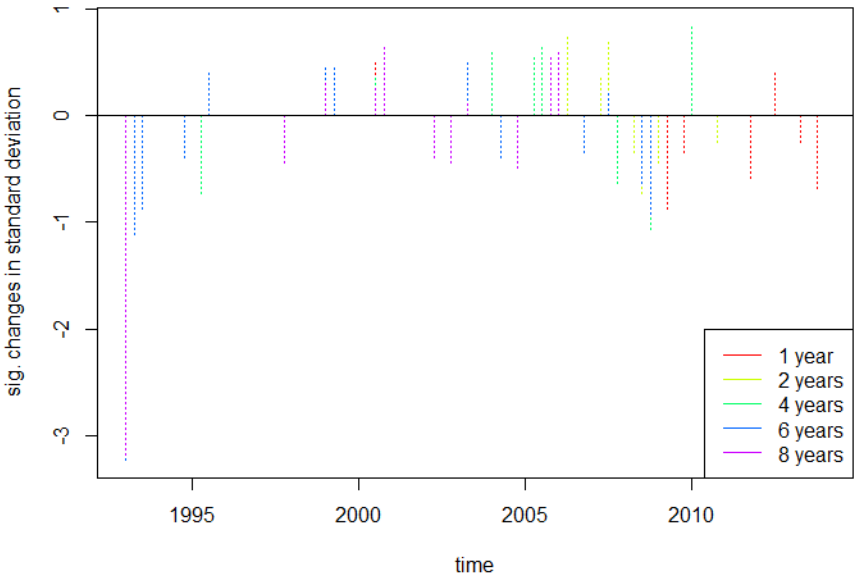
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the EMU12 and the *Giips* countries. The trend lines were derived from the Hodrick-Prescott business cycles decomposition. The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.18.: Comparison: Dispersion in EMU12 and OECD countries



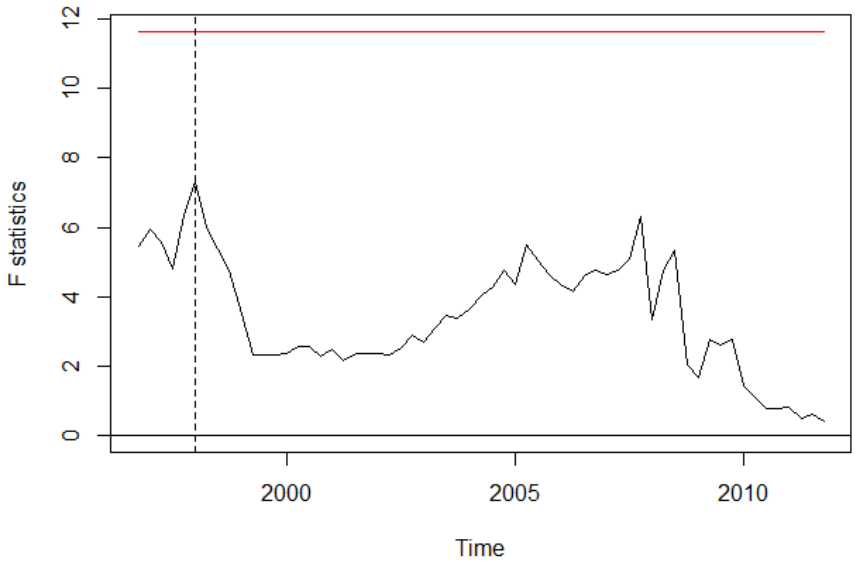
Note: The above figure shows a comparison of the weighted dispersion time series (measured in standard deviations) for the EMU12 and the OECD countries. The trend lines were derived from the Hodrick-Prescott business cycles decomposition. The vertical red lines indicate the crisis periods 2000Q1 and 2008Q3.

Figure A.19.: Significant changes in dispersion for the EMU12



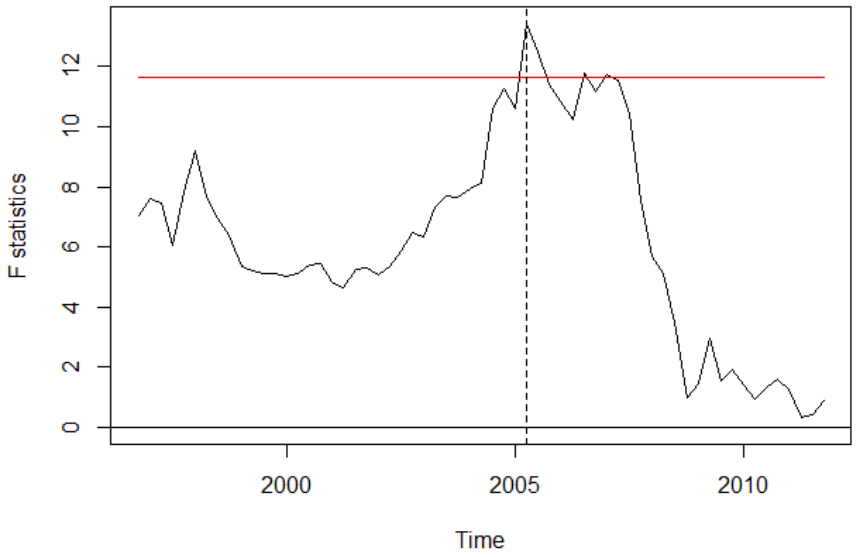
Note: The above figure depicts significant changes in the dispersion time series for the EMU12 countries at a 5% significance level. The significance of the changes was determined by using the Carree and Klomp's test (1997). The time horizons for the significant changes ranged from one year to eight years.

Figure A.20.: Chow-test EMU12



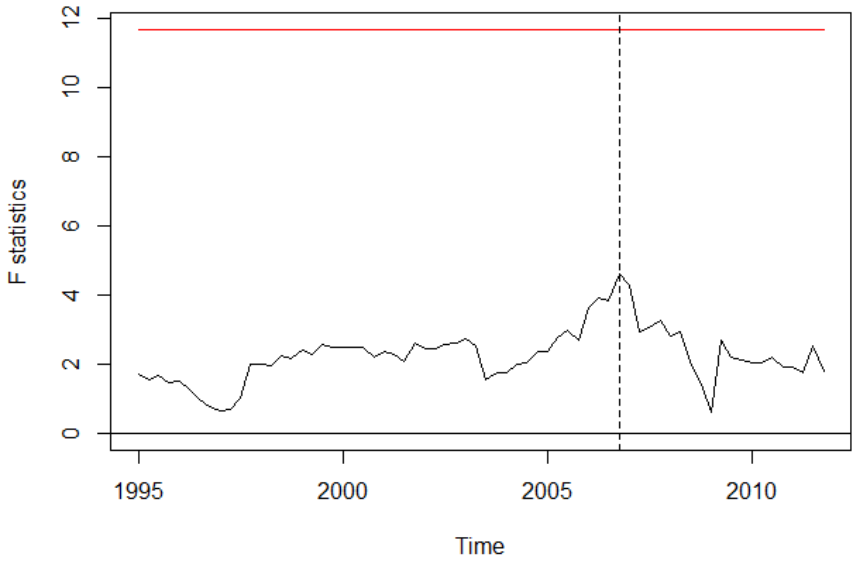
Note: Results of the Chow-test for unknown changes for the dispersion time series of the EMU12 countries at 5% significance level. The vertical dotted line indicates the potential break date. The red horizontal line stands for the critical values.

Figure A.21.: Chow-test EU25



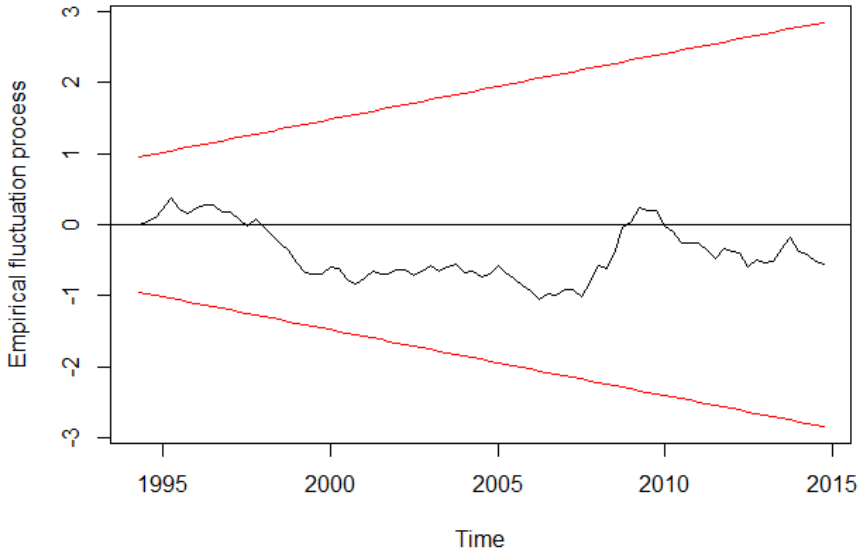
Note: Results of the Chow-test for unknown changes for the dispersion time series of the EU25 countries at 5% significance level. The vertical dotted line indicates the potential break date. The red horizontal line stands for the critical values.

Figure A.22.: Chow-test OECD



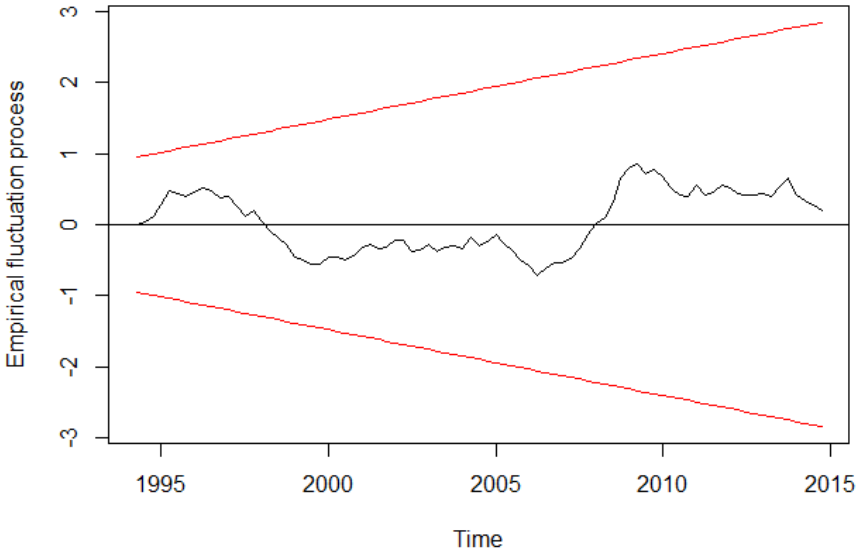
Note: Results of the Chow-test for unknown changes for the dispersion time series of the OECD countries at 5% significance level. The vertical dotted line indicates the potential break date. The red horizontal line stands for the critical values.

Figure A.23.: CUSUM-test EMU12



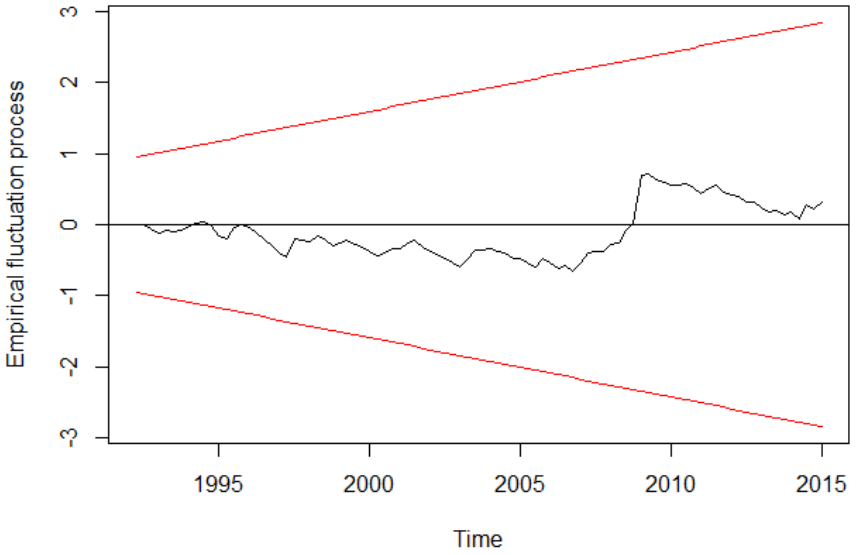
Note: Results of the CUSUM-test for stability of the EMU12 dispersion time series at a 5% significance level. The red increasing lines stand for the critical values.

Figure A.24.: CUSUM-test EU25



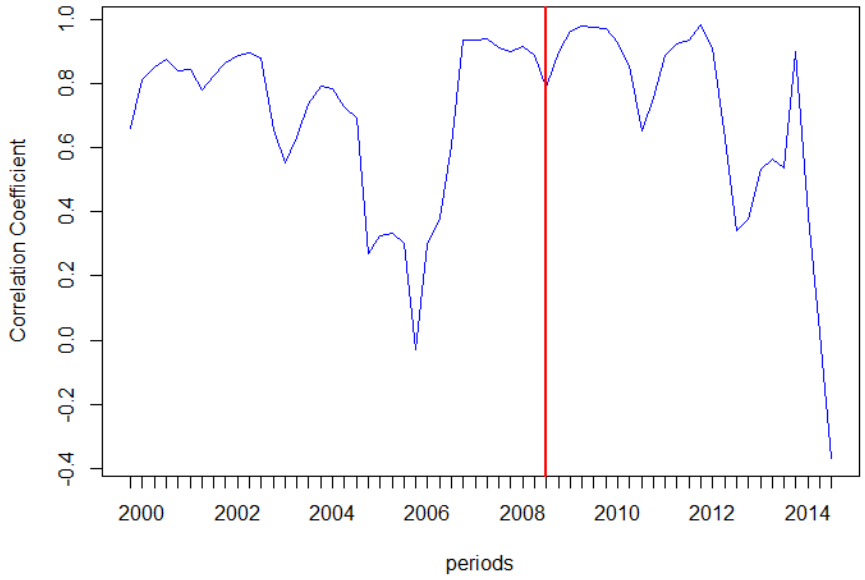
Note: Results of the CUSUM-test for stability of the EU25 dispersion time series at a 5% significance level. The red increasing lines stand for the critical values.

Figure A.25.: CUSUM-test OECD



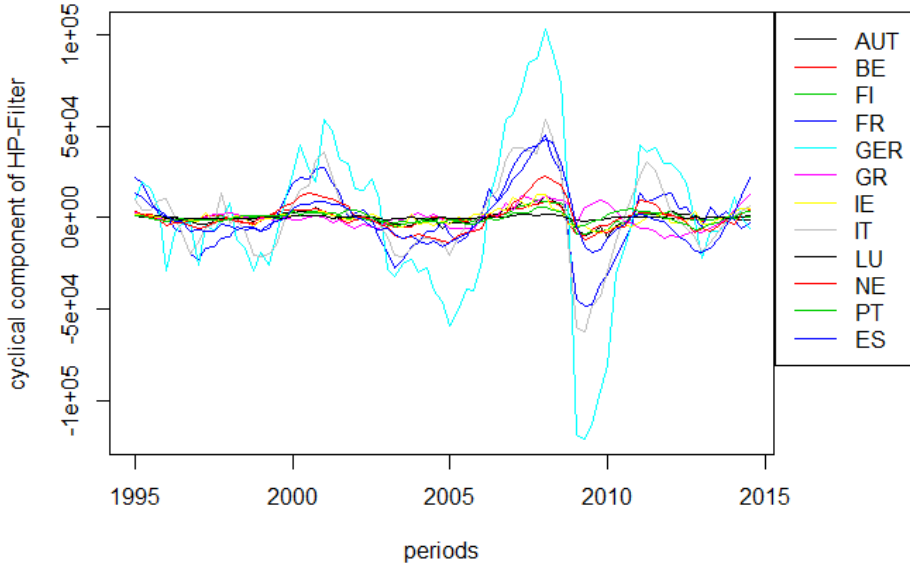
Note: Results of the CUSUM-test for stability of the OECD dispersion time series at a 5% significance level. The red increasing lines stand for the critical values.

Figure A.26.: Average of pairwise correlation of EMU12 country cycles



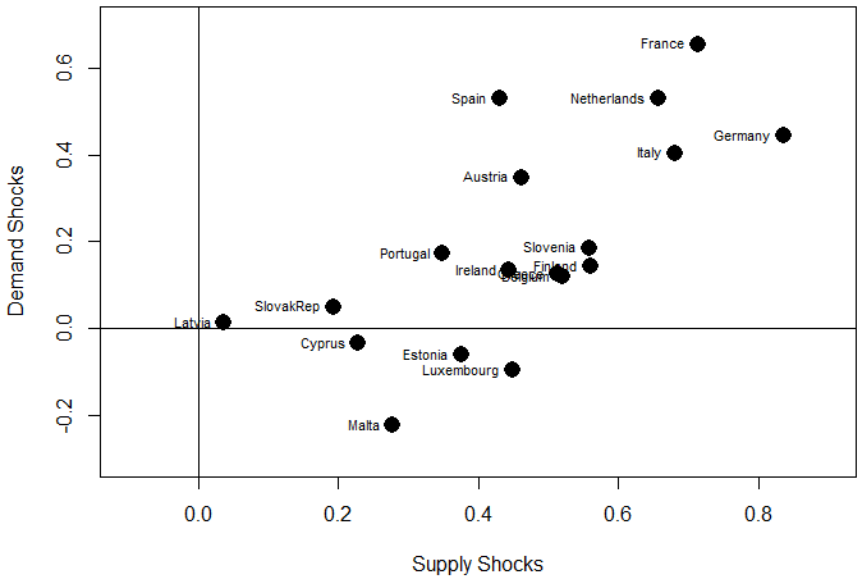
Note: The above figure shows the average of all pairwise correlation coefficients of EMU12 country cycles. The output gaps for the individual countries were derived from the Hodrick-Prescott business cycle decomposition. The vertical red lines indicate the crisis period in 2008Q3.

Figure A.27.: Output Gaps in EMU12 countries in Dollars



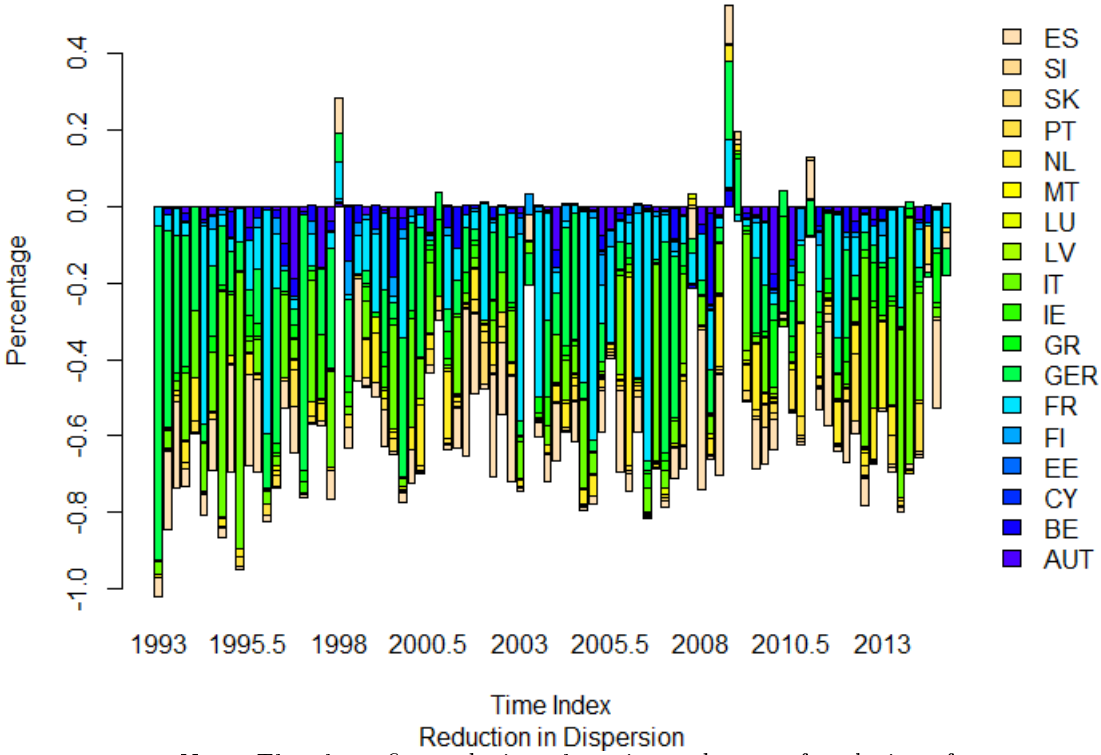
Note: The above shown output gaps for the individual EMU countries were derived from the Hodrick-Prescott business cycle decomposition.

Figure A.28.: Correlation of Supply and Demand Shocks with the Euro Area 1995Q1-2014Q4



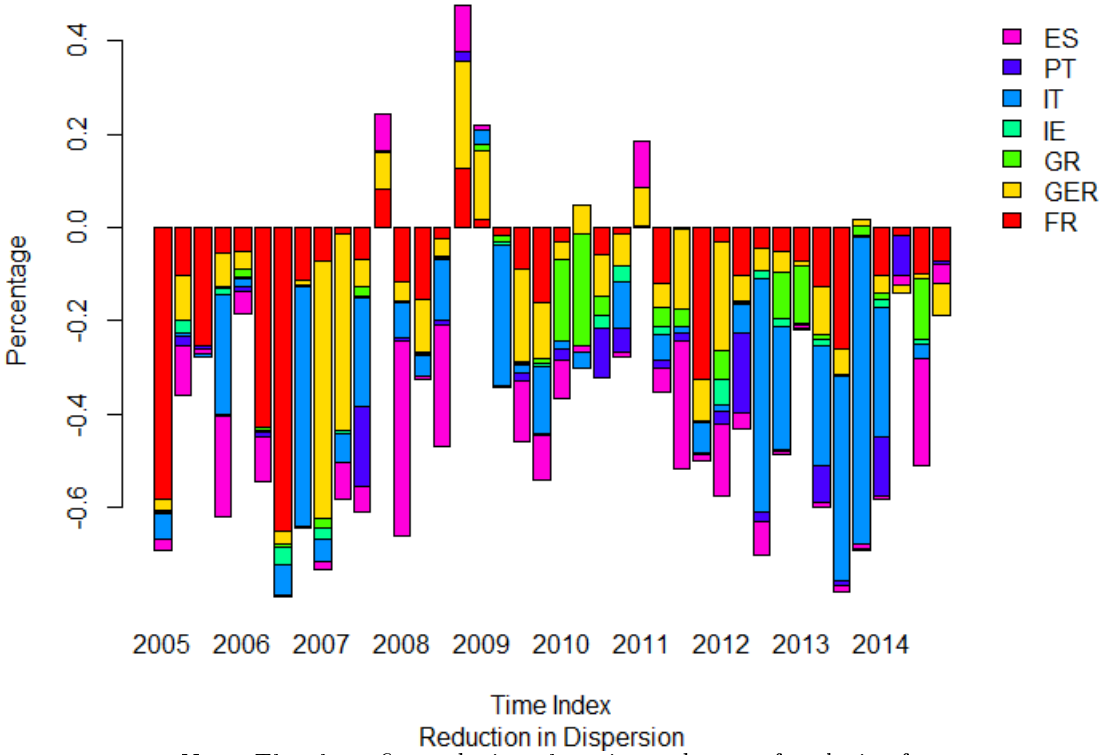
Note: The above shown correlations between the supply and demand shocks of individual EMU countries and the shocks of an EMU aggregate are Pearson correlations.

Figure A.29.: Gains and costs of exclusion: EMU18



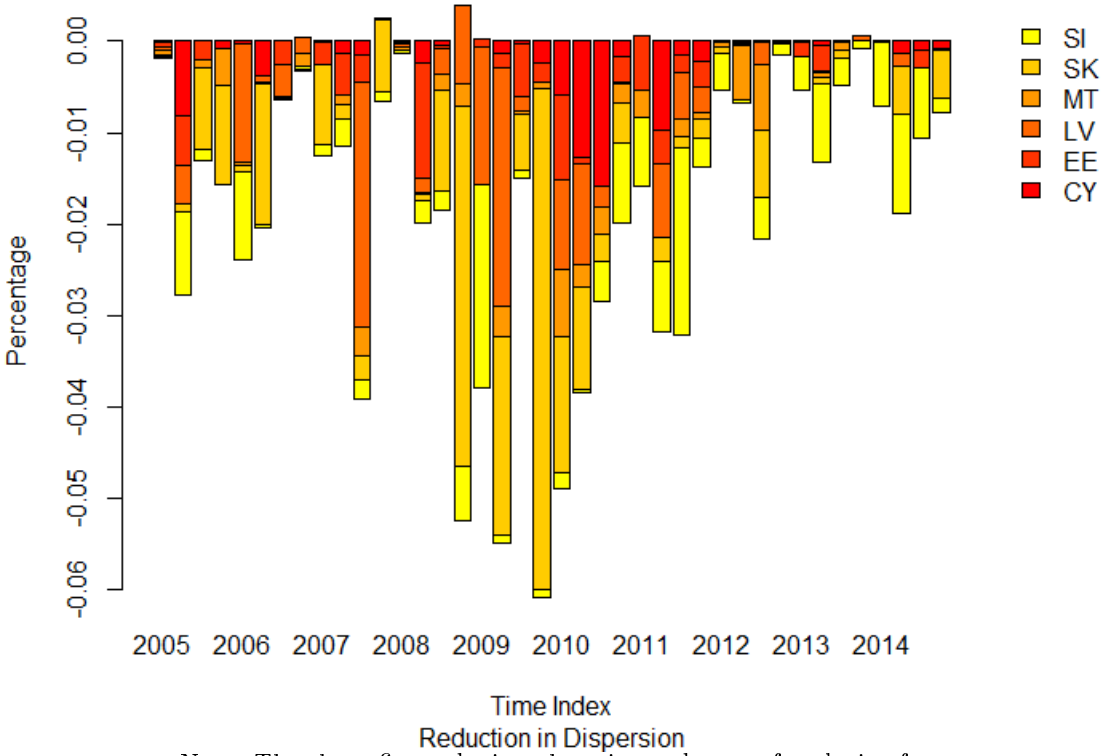
Note: The above figure depicts the gains and costs of exclusion of all EMU18 countries individually from the EMU from 1993Q1 until 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.30.: Gains and costs of exclusion EMU18: Top 7



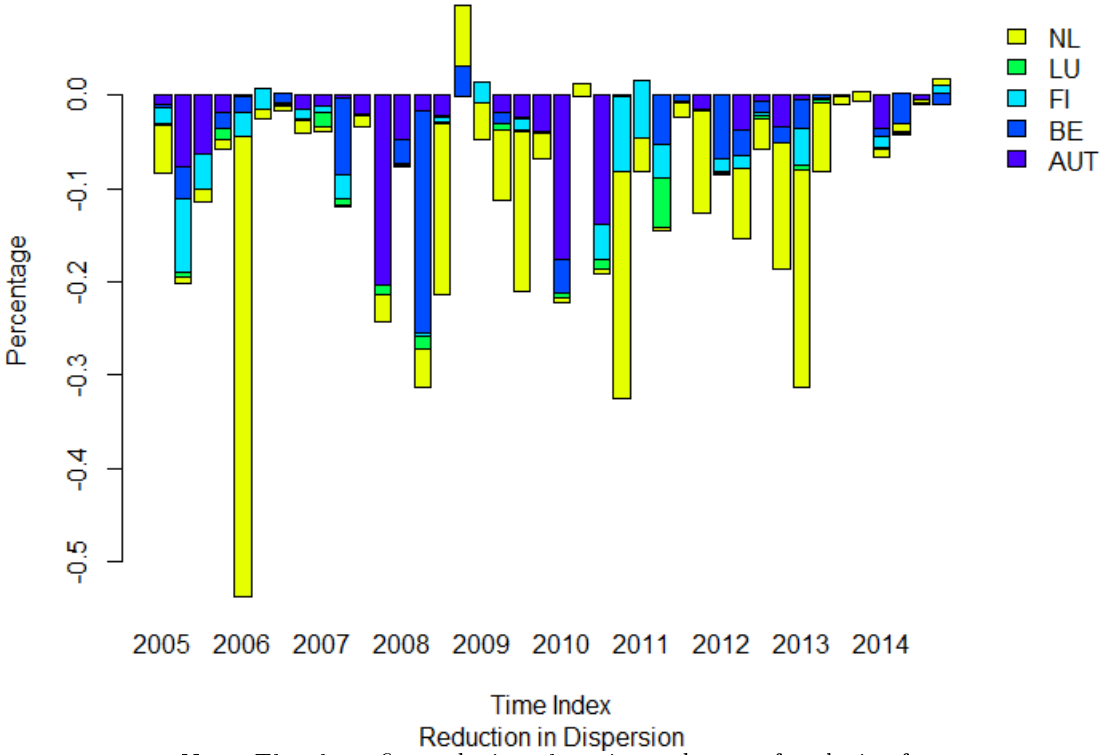
Note: The above figure depicts the gains and costs of exclusion from the EMU18 of those countries, who induced the most dispersion to the EMU18 group during the financial crisis . The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.31.: Gains and costs of exclusion EMU18: Enlargement countries



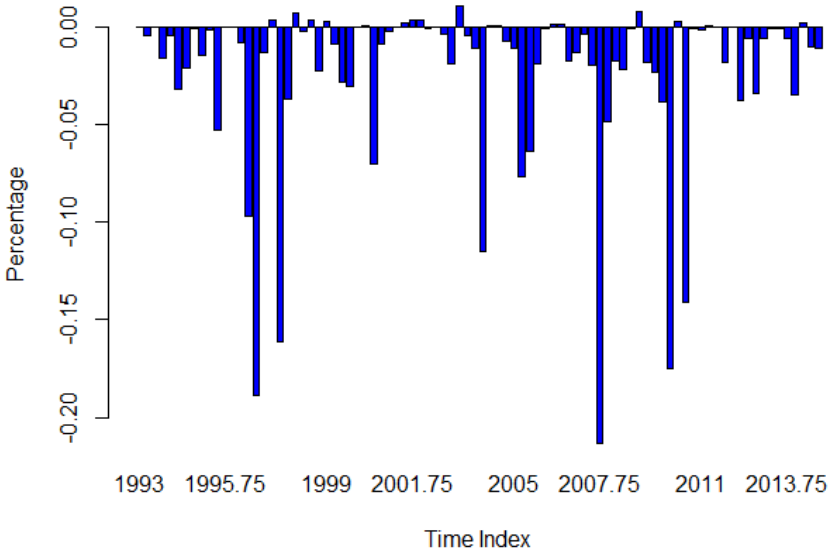
Note: The above figure depicts the gains and costs of exclusion from the EMU18 of the enlargement countries during the financial crisis. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.32.: Gains and costs of exclusion EMU18: Others



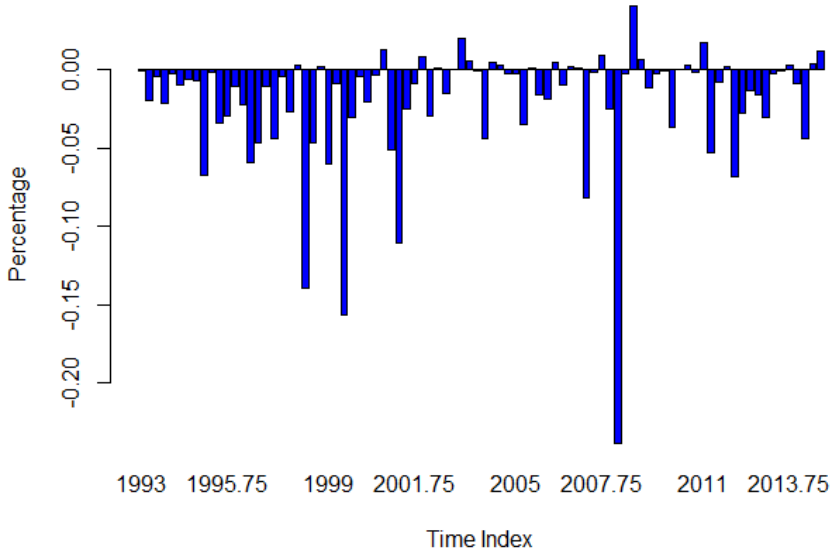
Note: The above figure depicts the gains and costs of exclusion from the EMU18 of the small and medium sized EMU countries during the financial crisis. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.33.: Gains and costs of exclusion EMU18: Austria



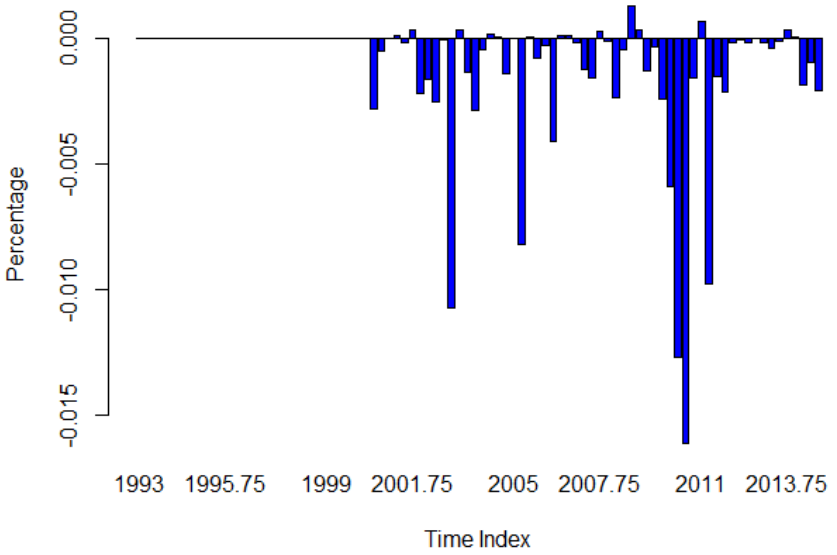
Note: The above figure depicts the gains and costs of exclusion of Austria from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.34.: Gains and costs of exclusion EMU18: Belgium



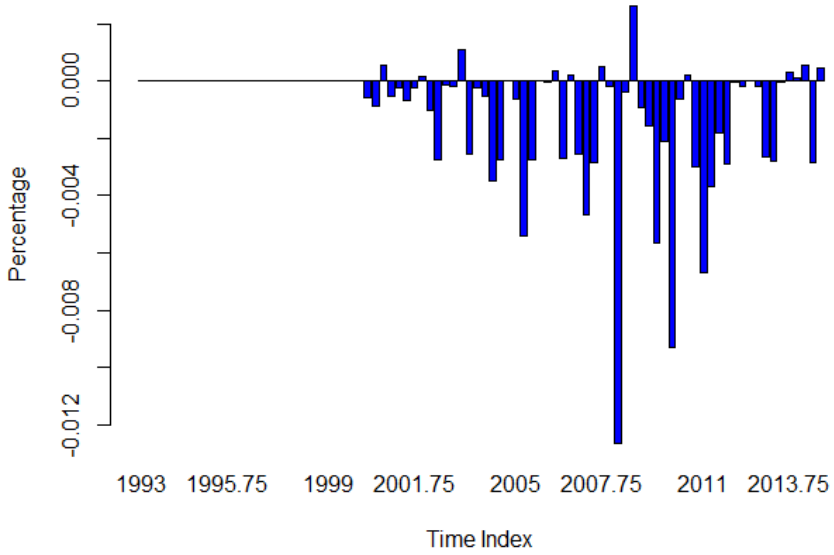
Note: The above figure depicts the gains and costs of exclusion of Belgium from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.35.: Gains and costs of exclusion EMU18:Cyprus



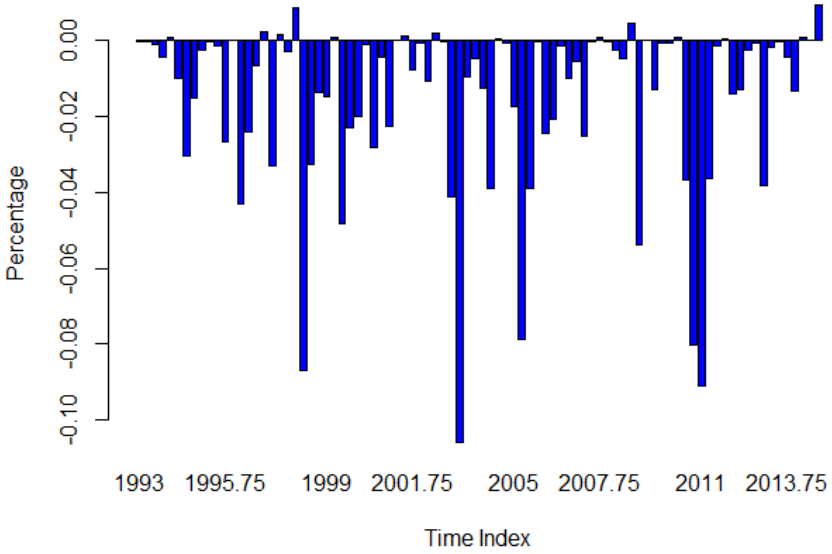
Note: The above figure depicts the gains and costs of exclusion of Cyprus from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.36.: Gains and costs of exclusion EMU18:Estonia



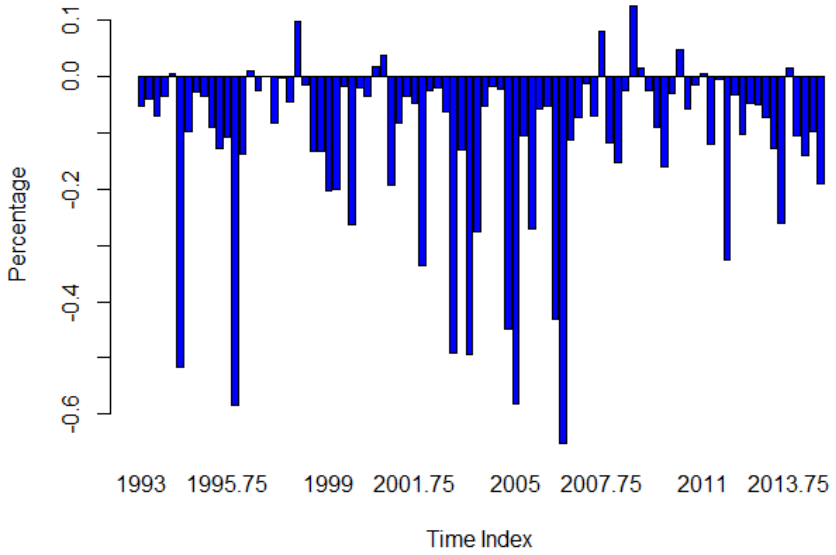
Note: The above figure depicts the gains and costs of exclusion of Estonia from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.37.: Gains and costs of exclusion EMU18:Finland



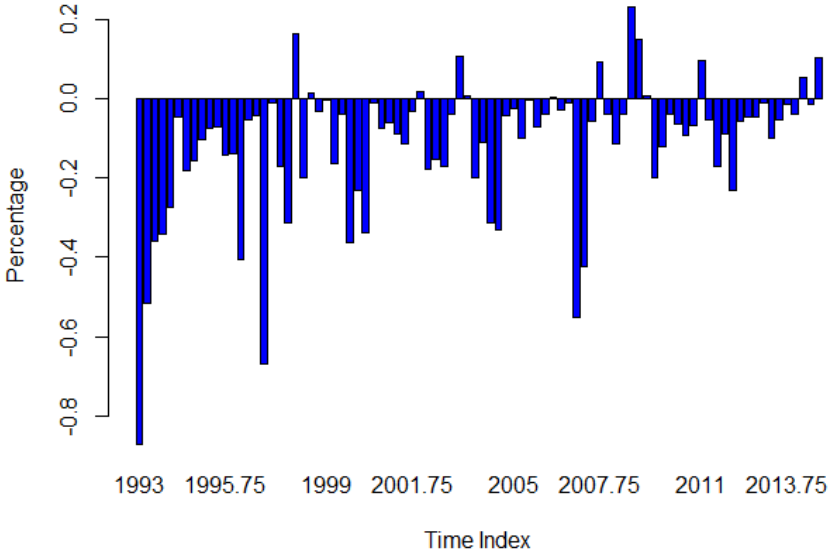
Note: The above figure depicts the gains and costs of exclusion of Finland from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.38.: Gains and costs of exclusion EMU18:France



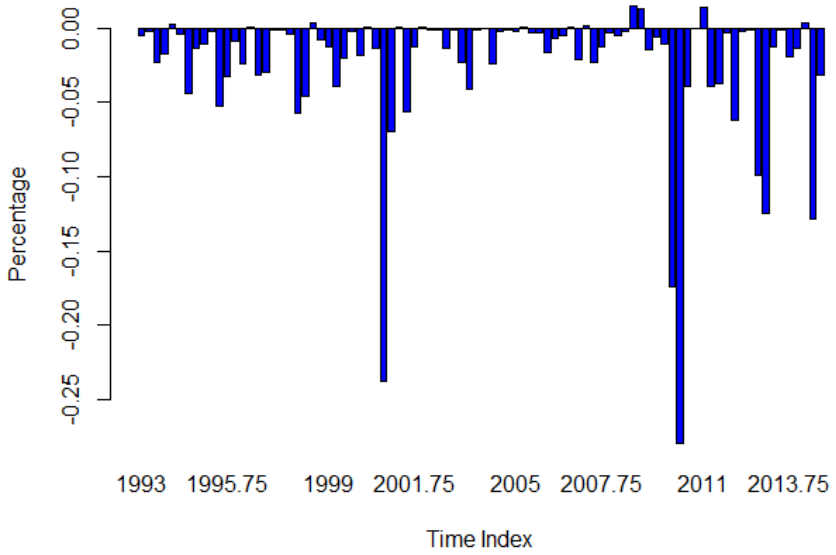
Note: The above figure depicts the gains and costs of exclusion of France from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.39.: Gains and costs of exclusion EMU18: Germany



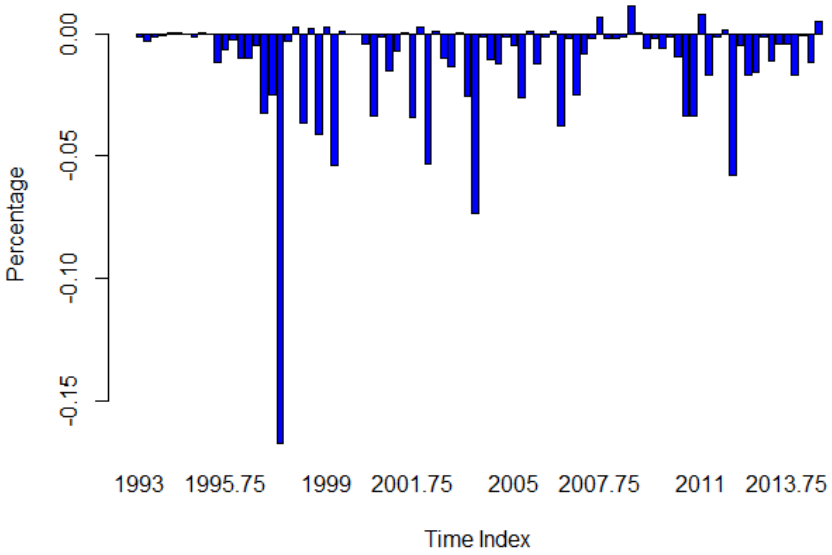
Note: The above figure depicts the gains and costs of exclusion of Germany from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.40.: Gains and costs of exclusion EMU18:Greece



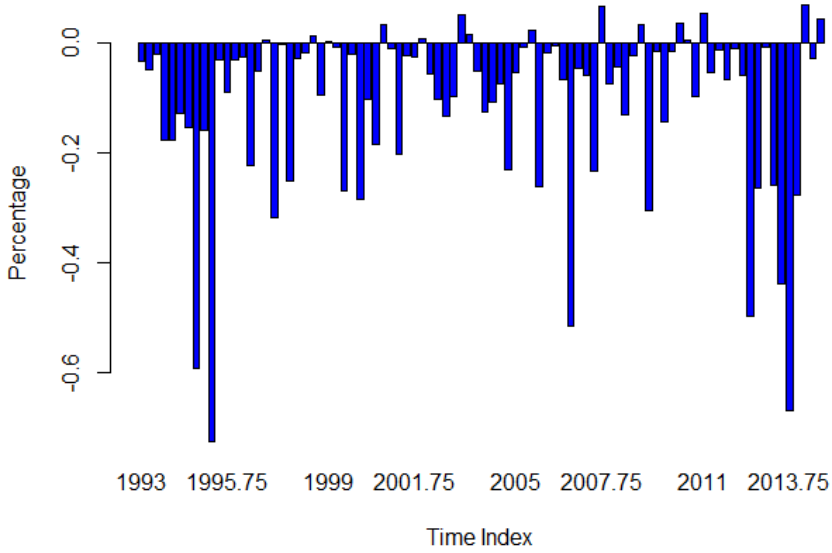
Note: The above figure depicts the gains and costs of exclusion of Greece from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.41.: Gains and costs of exclusion EMU18:Ireland



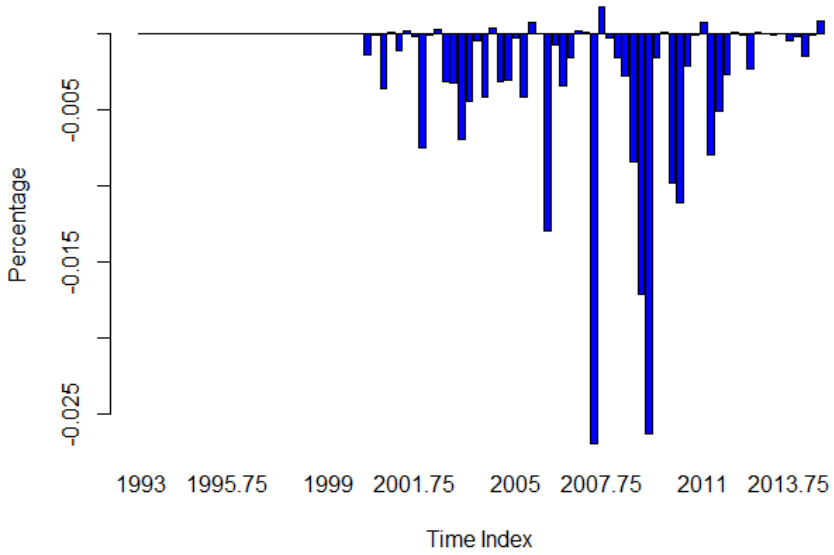
Note: The above figure depicts the gains and costs of exclusion of Ireland from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.42.: Gains and costs of exclusion EMU18:Italy



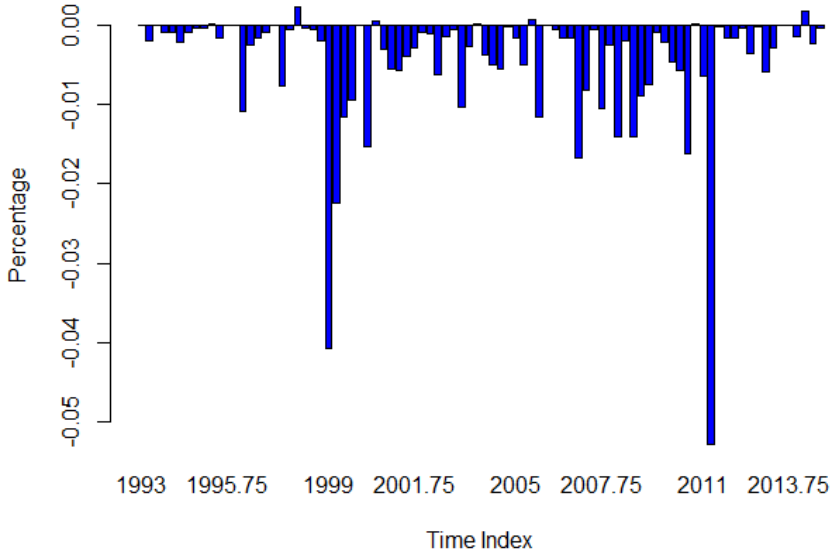
Note: The above figure depicts the gains and costs of exclusion of Italy from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.43.: Gains and costs of exclusion EMU18: Latvia



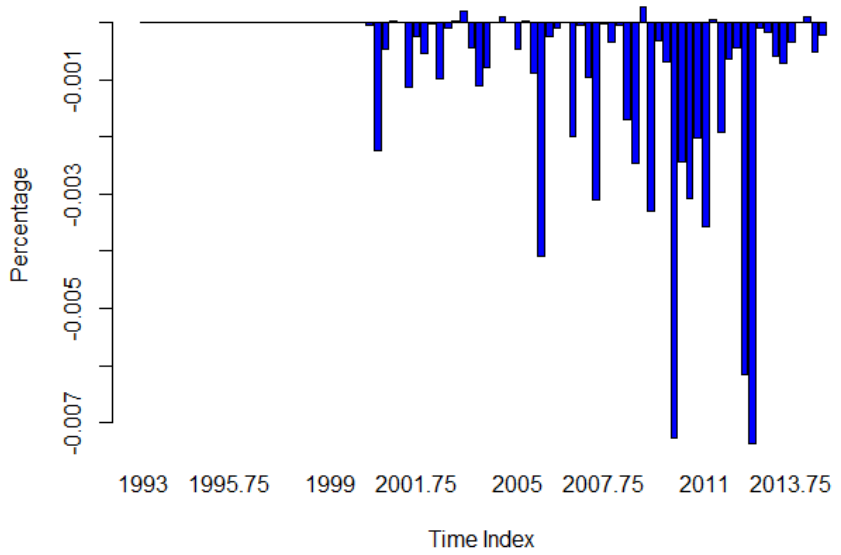
Note: The above figure depicts the gains and costs of exclusion of Latvia from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.44.: Gains and costs of exclusion EMU18: Luxembourg



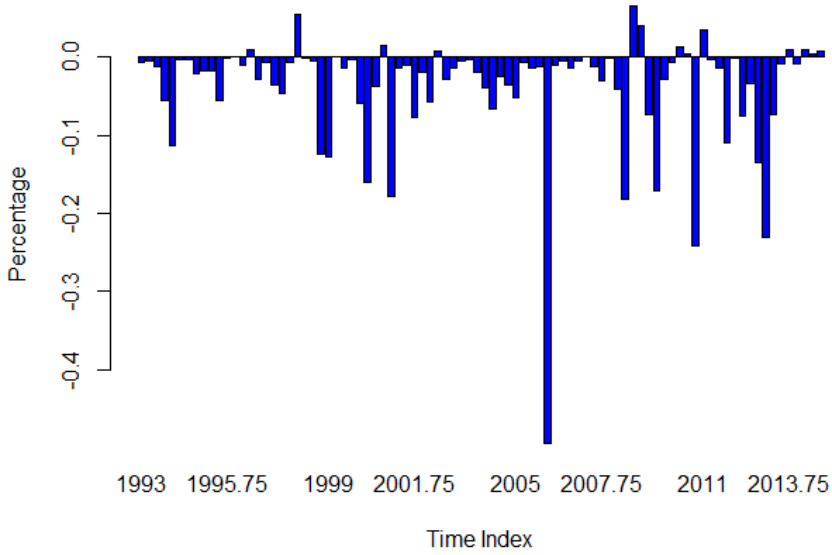
Note: The above figure depicts the gains and costs of exclusion of Luxembourg from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.45.: Gains and costs of exclusion EMU18: Malta



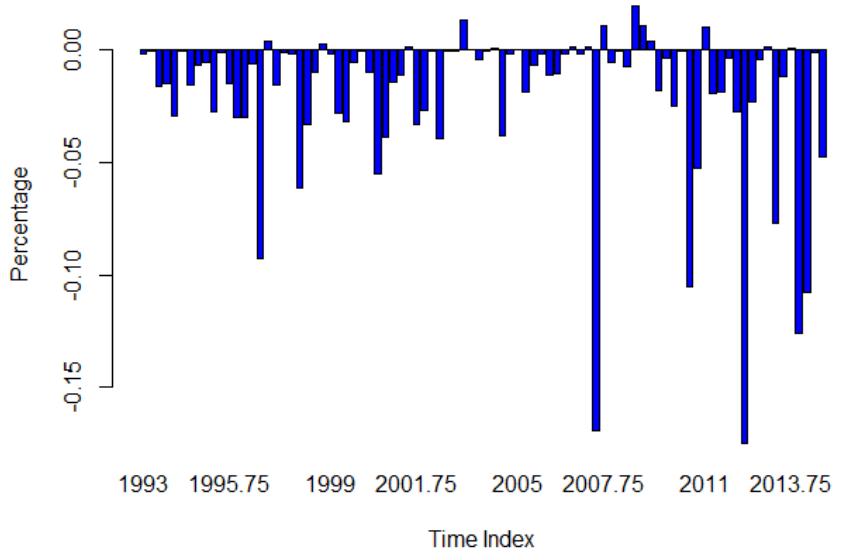
Note: The above figure depicts the gains and costs of exclusion of Malta from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.46.: Gains and costs of exclusion EMU18: Netherlands



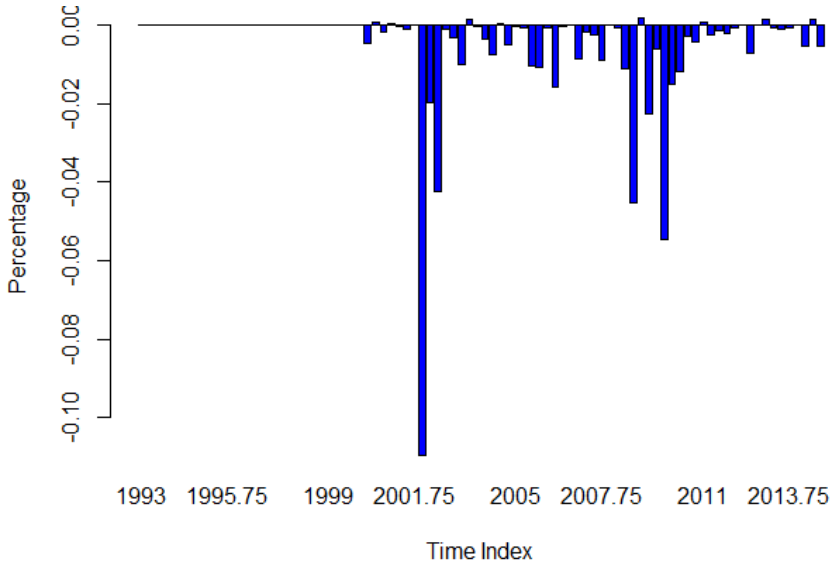
Note: The above figure depicts the gains and costs of exclusion of the Netherlands from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.47.: Gains and costs of exclusion EMU18: Portugal



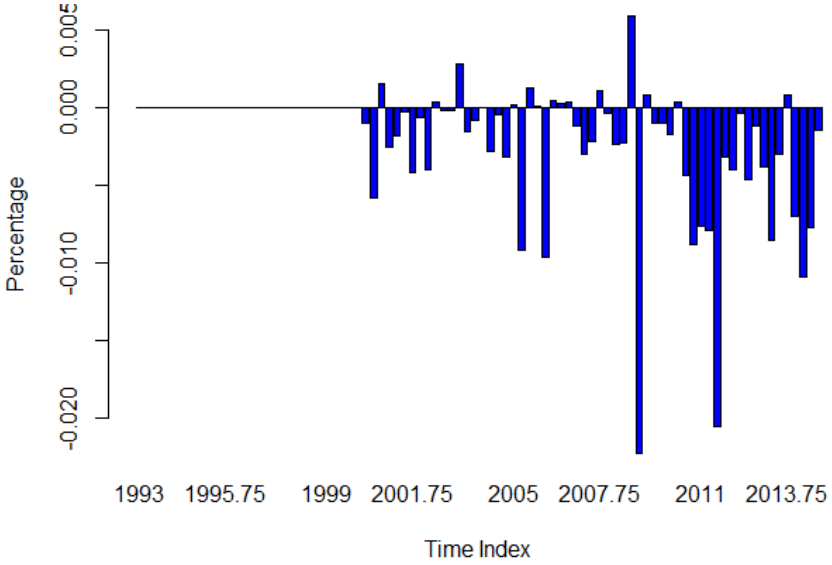
Note: The above figure depicts the gains and costs of exclusion of Portugal from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.48.: Gains and costs of exclusion EMU18:Slovakia



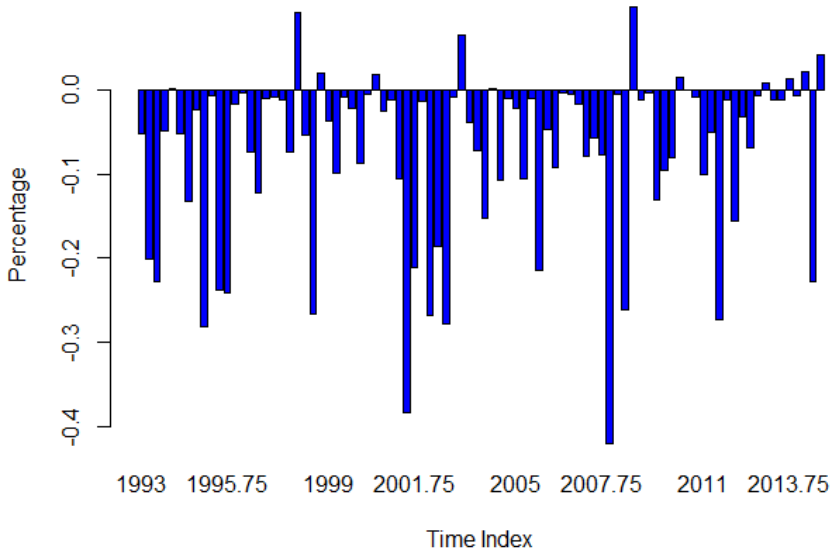
Note: The above figure depicts the gains and costs of exclusion of Slovakia from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.49.: Gains and costs of exclusion EMU18: Slovenia



Note: The above figure depicts the gains and costs of exclusion of Slovenia from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

Figure A.50.: Gains and costs of exclusion EMU18: Spain



Note: The above figure depicts the gains and costs of exclusion of Spain from the EMU18 from 1993Q1 to 2014Q4. The gains, respectively costs, of exclusion of an individual country here are measured as the rise, respectively the reduction, in the dispersion time series of the EMU18 group, if a country had not been in the EMU. The costs/gains are measured in standard deviation. A negative percentage value refers to reduction in dispersion due to the exclusion of a certain country, a positive percentage signals the reverse.

B. Data sources

Table B.1.: Datasets and Sources

Country	Sample period CPI	Sample period real GDP	Sample period nominal GDP	Source
Australia	1991Q1-2014Q4	1991Q1-2014Q4		OECD
Austria	1991Q1-2014Q4	1991Q1-2014Q4/1995Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
Belgium	1991Q1-2014Q4	1991Q1-2014Q4/1995Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
Canada	1991Q1-2014Q4	1991Q1-2014Q4		OECD
Cyprus	1996Q1-2014Q4	1996Q1-2014Q4	1995Q1-2014Q4	Eurostat
Czech Republic	1991Q1-2014Q4	1995Q1-2014Q4		OECD
Denmark	1991Q1-2014Q4	1991Q1-2014Q4		OECD
Estonia	1998Q1-2014Q4	1995Q1-2014Q4		OECD
Finland	1991Q1-2014Q4	1991Q1-2014Q4/1995Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
France	1991Q1-2014Q4	1991Q1-2014Q4/1995Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
Germany	1991Q1-2014Q4	1991Q1-2014Q4/1995Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
Greece	1991Q1-2014Q4	1991Q1-2014Q4/1995Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
Hungary	1991Q1-2014Q4	1995Q1-2014Q4		OECD
Ireland	1991Q1-2014Q4	1991Q1-2014Q4		OECD
Italy	1991Q1-2014Q4	1991Q1-2014Q4/1995Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
Japan	1991Q1-2014Q4	1991Q1-2014Q4		OECD
Latvia	1991Q1-2014Q4	1991Q1-2014Q4/1995Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
Luxembourg	1991Q1-2014Q4	1991Q1-2014Q4/2000Q1-2014Q4	2000Q1-2014Q4	OECD/Eurostat
Malta	1996Q1-2014Q4	2000Q1-2014Q4	2000Q1-2014Q4	Eurostat
Mexico	1991Q1-2014Q4	1991Q1-2014Q4		OECD
Netherlands	1991Q1-2014Q4	1991Q1-2014Q4/1996Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
New Zealand	1991Q1-2014Q4	1991Q1-2014Q4		OECD
Poland	1991Q1-2014Q4	1995Q1-2014Q4		OECD
Portugal	1991Q1-2014Q4	1991Q1-2014Q4/1995Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
Republic of Korea	1991Q1-2014Q4	1991Q1-2014Q4		OECD
Slovakia	1991Q1-2014Q4	1991Q1-2014Q4/1995Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
Slovenia	1991Q1-2014Q4	1991Q1-2014Q4/1995Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
Spain	1991Q1-2014Q4	1991Q1-2014Q4/1995Q1-2014Q4	1995Q1-2014Q4	OECD/Eurostat
Sweden	1991Q1-2014Q4	1991Q1-2014Q4		OECD
Switzerland	1991Q1-2014Q4	1991Q1-2014Q4		OECD
Turkey	1991Q1-2014Q4	1991Q1-2014Q4		OECD
United Kingdom	1991Q1-2014Q4	1991Q1-2014Q4		OECD
USA	1991Q1-2014Q4	1991Q1-2014Q4		OECD

Note: The real GDP data is chained to the year 2010 for the data taken from the Eurostat and for the data taken from the OECD. The GDP data from Eurostat is denominated in Euros, whereas the GDP data from OECD is denominated in Dollars. For the calculations of the country weights until 2010 annual data on GDP from the Penn World Table Version 7.1. in international Dollars chained to 2005 was used (cf. Crespo-Cuaresma 2013). After 2010 country weights were calculated using the above data sources.

C. Calculations

C.1. Calculation of the A_0 matrix

From (3.11)

$$a_{11,0} = -\frac{c_{1,2}(L)}{c_{1,1}(L)} a_{21,0}$$

in (3.10)

$$-\frac{c_{1,2}(L)}{c_{1,1}(L)} a_{21,0}^2 + a_{12,0} a_{22,0} = \mathrm{Cov}(e_{1,t}, e_{2,t})$$

use (3.9)

$$-\frac{c_{1,2}(L)}{c_{1,1}(L)} a_{21,0}^2 \pm a_{12,0} \sqrt{\mathrm{Var}(e_{2,t}) - a_{21,0}^2} = \mathrm{Cov}(e_{1,t}, e_{2,t})$$

use (3.8)

$$-\frac{c_{1,2}(L)}{c_{1,1}(L)} a_{21,0}^2 \pm \sqrt{\mathrm{Var}(e_{1,t}) - a_{11,0}^2} \sqrt{\mathrm{Var}(e_{2,t}) - a_{21,0}^2} = \mathrm{Cov}(e_{1,t}, e_{2,t})$$

use (3.11)

$$-\frac{c_{1,2}(L)}{c_{1,1}(L)} a_{21,0}^2 \pm \sqrt{\mathrm{Var}(e_{1,t}) - a_{21,0}^2 \frac{c_{1,2}(L)}{c_{1,1}(L)}^2} \sqrt{\mathrm{Var}(e_{2,t}) - a_{21,0}^2} = \mathrm{Cov}(e_{1,t}, e_{2,t})$$

$\Leftrightarrow$

$$(\sqrt{\mathrm{Var}(e_{1,t}) - a_{21,0}^2 \frac{c_{1,2}(L)}{c_{1,1}(L)}^2} \sqrt{\mathrm{Var}(e_{2,t}) - a_{21,0}^2})^2 = (\mathrm{Cov}(e_{1,t}, e_{2,t}) + \frac{c_{1,2}(L)}{c_{1,1}(L)} a_{21,0}^2)^2$$

$\Leftrightarrow$

$$\mathrm{Var}(e_{1,t})\,\mathrm{Var}(e_{2,t}) - a_{21,0}^2\,\mathrm{Var}(e_{1,t}) - a_{21,0}^2\,\mathrm{Var}(e_{2,t}) \frac{c_{1,2}(L)}{c_{1,1}(L)}^2 + a_{21,0}^4 \frac{c_{1,2}(L)}{c_{1,1}(L)}^2 = \mathrm{Cov}(e_{1,t}, e_{2,t})^2 + 2\,\mathrm{Cov}(e_{1,t}, e_{2,t}) \frac{c_{1,2}(L)}{c_{1,1}(L)} a_{21,0}^2 + \frac{c_{1,2}(L)}{c_{1,1}(L)}^2 a_{21,0}^4$$

$\Leftrightarrow$

$$a_{2,1} = \pm \sqrt{\frac{\mathrm{Var}(e_{1,t})\,\mathrm{Var}(e_{2,t}) - \mathrm{Cov}(e_{1,t}, e_{2,t})^2}{\mathrm{Var}(e_{1,t}) + \mathrm{Var}(e_{2,t}) \frac{c_{1,2}(L)}{c_{1,1}(L)}^2 + 2\,\mathrm{Cov}(e_{1,t}, e_{2,t}) \frac{c_{1,2}(L)}{c_{1,1}(L)}}}$$

C.2. Calculation of the $C(L)$ matrices: Example with two lags

$$X_t = G_1 X_{t-1} + G_2 X_{t-2} + G_3 X_{t-3} + ... + G_n X_{t-n} + e_t = [I - G(L)]^{-1} e_t \tag{C.1}$$

$$X_t = [\Delta y_t, \Delta p_t]'$$

$$e_t = [e_{1,t}, e_{2,t}]'$$

Moving average representation:

$$e_t + C_1 e_{t-1} + C_2 e_{t-2} + ... = \sum_{i=0}^{\infty} C_i L^i e_t \tag{C.2}$$

$$X_t = G_1 X_{t-1} + G_2 X_{t-2} + e_t = [I - G_1 L - G_2 L^2]^{-1} e_t$$

$\Leftrightarrow$

$$[I - G_1 L - G_2 L^2]^{-1} = \sum_{i=0}^{\infty} C_i L^i$$

$\Leftrightarrow$

$$I = [I - G_1 L - G_2 L^2][I + C_1 L + C_2 L^2 + C_3 L^3 + ...]$$

$\Leftrightarrow$

$$\begin{aligned} I = (I - G_1 L - G_2 L^2) &+ (C_1 L - C_1 G_1 L^2 - C_1 G_2 L^3) \\ &+ (C_2 L^2 - C_2 G_1 L^3 - C_2 G_2 L^4) \\ &+ (C_3 L^3 - C_3 G_1 L^4 - C_3 G_2 L^5) \end{aligned}$$

$\Leftrightarrow$

$$I = I + (C_1 L - G_1 L) + (C_2 L^2 - G_2 L^2 - C_1 G_1 L^2) + (C_3 L^3 - G_2 C_1 L^3 - C_2 G_1 L^3) + ...$$

$\Rightarrow$

$$C_1 - G_1 = 0 \Rightarrow C_1 = G_1 \tag{C.3}$$

$$C_2 - G_2 - C_1 G_1 = 0 \Rightarrow C_2 = G_2 + C_1 G_1 \tag{C.4}$$

$$C_3 - C_1 G_2 - C_2 G_1 = 0 \Rightarrow C_3 = C_1 G_2 + C_2 G_1 \tag{C.5}$$

$$C_4 - C_2 G_2 - C_3 G_1 = 0 \Rightarrow C_4 = C_2 G_2 + C_3 G_1 \tag{C.6}$$

D. Abstract

D.1. English Abstract

This study assesses the effects of the financial crisis on the synchronization of business cycles within the EMU. I use the dispersion of the weighted country specific demand shocks to evaluate the degree of synchronization. These shocks are retrieved from a bivariate SVAR of GDP and prices. Since this study uses most recent data, the late recovery phase of the EMU from the recent crisis can be examined properly. In a nutshell, I found that at first especially the biggest EMU countries were hit by the crisis to a similarly large extent, which led to a high synchronization of business cycles within the EMU. However, in an early recovery phase the imbalances of these member states led to a major divergence trend within the EMU. Since 2010 a convergence pattern prevails and the pre-crisis degree of convergence is again reached. In this late recovery phase small countries like Greece and Portugal are the main driving forces of divergence. Based on the dispersion measure, the formation of a currency union of the core, periphery or enlargement countries seems on the grounds of the OCA theory not advisable. This is because they exhibit a higher level of divergence than the EMU as a whole. In the light of the recent convergence pattern, the shrinking of the negative output gaps of member states to pre-crisis levels and a further synchronization of the individual output gaps among them, a break-up of the EMU is not advisable from an OCA theory perspective. In contrast to that, the OCA theory suggests that Greece should leave the EMU, since its exclusion from the EMU would have decreased dispersion of business cycles within the EMU by approximately 5% since 2010. Furthermore, as the signs of a recovery of Greece are not very pronounced, one cannot assume that its business cycle will synchronize with the rest of the EMU in the near future. However, the OCA theory is only a simple approach to this very complex issue and has its obvious limitations. The actual consequences of an exclusion of Greece from the EMU are manifold, severe and cannot be predicted.

D.2. German Abstract/Zusammenfassung

In dieser Studie wurde der Einfluss der Finanzkrise auf die Synchronisation der Konjunkturzyklen der Mitgliedsstaaten der Europäischen Wirtschafts- und Währungsunion (EWWU) untersucht. Der Grad der Synchronisation wurde anhand der Streuung der gewichteten Nachfrageschocks der einzelnen Mitgliedsländer ermittelt. Die Nachfrageschocks wurden hierbei aus einem bivariaten SVAR gewonnen. Ein Vorteil der vorliegenden Studie zu bisherigen Studien ist, dass aufgrund des längeren Untersuchungszeitraums die längerfristige Anpassung der EWWU-Mitgliedsländer an die Krise untersucht werden kann. Die vorliegende Studie zeigt, dass die größten EWWU-Länder im Jahr 2008 von der Finanzkrise in einem ähnlichen Ausmaß getroffen wurden und dies zu einer hohen Synchronisation der Konjunkturzyklen innerhalb der EWWU führte. Doch die strukturellen Unterschiede der einzelnen EWWU Länder traten in einer ersten Erholungsphase nach der Krise in den Vordergrund und hatten eine wachsende Divergenz unter den Konjunkturzyklen der EWWU Mitgliedsländer zur Folge. Seit 2010 passen sich die Konjunkturzyklen innerhalb der EWWU wieder aneinander an und der Synchronisationsgrad nähert sich jenem vor der Krise an. Divergenzen stiften in dieser späten Erholungsphase lediglich kleine Mitgliedsstaaten wie Griechenland und Spanien.
In dieser Studie wurde außerdem untersucht, ob andere Währungsunionen innerhalb der heutigen EWWU Grenzen sich als sinnvoll im Sinne der Theorie der optimalen Währungsräume (Mundell, 1961) erweisen. Dies konnte sowohl für die Gruppe der zentralen EWWU Staaten (Deutschland, Niederlande, Belgien, Luxemburg, Frankreich), wie auch für jene der sogenannten *Giips* Länder (Griechenland, Italien, Irland, Portugal und Spanien) und die Gruppe der erst kürzlich zur EWWU gestoßenen Erweiterungsländern (Litauen, Malta, Zypern, Slowakei, Slowenien, Estland) verneint werden, da die Konjunkturzyklen innerhalb dieser Gruppen eine höhere Streuung aufweisen als in der gesamten EWWU. Zieht man das erneute Angleichen der Konjunkturzyklen unter den EWWU-Mitgliedsländern sowie das Schrumpfen der Produktionslücken der Mitgliedsländer und die Bündelung der Konjunkturzyklen innerhalb der EWWU in Betracht, ist von einem Bruch der EWWU aus Sichtweise der Theorie der optimalen Währungsräume abzuraten. Dagegen, sollte - laut dieser Theorie - Griechenland den Euroraum verlassen, da die EWWU 5% an Synchronisation unter den Konjunkturzyklen der Mitgliedsländer gewonnen hätte, wäre Griechenland seit 2010 nicht mehr Teil des Euroraums. Zudem scheint ein Angleichen des griechischen Konjunkturzyklus an jene der restlichen Mitgliedsstaaten basierend auf den hier vorliegenden Daten erst in ferner Zukunft möglich

zu sein. An dieser Stelle muss allerdings festgehalten werden, dass die Theorie der optimalen Währungsräume lediglich einen sehr vereinfachten Lösungsansatz zu den momentan vorherrschenden Problemen im Euroraum darstellt und die Folgen eines tatsächlichen Austritts Griechenlands aus der EWWU schwer abschätzbar sind.

E. Curriculum vitae

Name: Clara Nagele

Date of Birth: 12/14/1988

Place of Birth: Linz, Austria

Education

2013–now Master of Science in Economics at the University of Vienna

2009–2013 Bachelor of Science in Economics at the University of Vienna

1. Bachelor thesis title: E-learning as a chance to enhance education in developing countries. An evaluation of One Laptop per Child in Chile and China
Supervision: Kirsten Duchateau
2. Bachelor thesis title: The effect of deductibles on the health care policy („Die Wirkung von Selbstbeteiligungen im Gesundheitswesen“)
Supervision: Jörg Mahlich

2007–2012 Master of Arts in German Studies (Mag. Phil.) at the University of Vienna, with distinction
Thesis title: The Archaeology of the Catastrophe: Space perception and spatial constitution in selected texts of Wolfgang Koeppen („Die Archäologie der Katastrophe“ Raumwahrnehmung und Raumkonstituierung in ausgewählten Texten Wolfgang Koeppens“)
Supervision: Irmgard Egger

2007–2012 Master of Arts in History (Mag. Phil.) at the University of Vienna, with distinction
Thesis title: The meat consumption in Vienna 1830 – 1913 calculated on the basis

of the consumption tax („Der Fleischkonsum in Wien 1830 -1913 errechnet anhand der Daten der Verzehrungssteuer“)
Supervision: Peter Eigner

2004–2007 Akademisches Gymnasium (grammar school), Linz

1999–2004 Wirtschaftskundliches Bundesgymnasium Körnerschule (grammar school), Linz

Work Experience

08/2014 Internship at the Corporate Governance and Compliance Department of the Raiffeisenlandesbank Oberösterreich AG/Linz

07-08/2013 Internship at the Global Financial Markets Department of the Oberbank/Linz

10/2010-03/2011 Freelancer at the Hey-Hoffmann Verlag/Hamburg

06/2010-09/2010 Editorial internship at the Hey-Hoffmann Verlag/Hamburg

03/2010 Internship at the European Parliament, at the office of Othmar Karas, Vice-President of the European Parliament/Brussels

08-09/2010 Internship at the Public Relations Department of Faktenkontor/Hamburg

Scientific Publications and Conference Presentations

Working Paper “The Viennese Consumption Tax. An Evaluation on the basis of the tax items (1830-1913)“ (Die Wiener Verzehrungssteuer. Auswertung nach einzelnen Steuerposten (1830-1913)), with Friedrich Hauer, Sylvia Gierlinger, Jonas Albrecht, Till Uschmann and Maximilian Martsch, Social Ecology Working Paper, Number 134. Vienna 2012.

Article The Meat Consumption in Vienna 1830-1913 (Der Fleischkonsum in Wien 1830 -1913), with Till Uschmann (University of Vienna), Forschungen und Beiträge zur Wiener Stadtgeschichte. Vienna 2014.

Conference Presentation 66th Symposium of the Center of Environmental History, Vienna. Supplying Vienna 1829-1913. New research results on the urban meat and alcohol consumption. - January 2015

Scholarships

2013 Scholarship of the Department of Culture of the City of Vienna awarded for the research project "The Meat Consumption in Vienna 1830-1913"

Languages and other skills

Languages: German (native), English (fluent), French (intermediate), Italian (basic knowledge), Russian (basic knowledge)

IT skills: MS Office, STATA, Matlab, R, SPSS

Additional skills: driving license, first aid course

Hobbies

Interests: Literature, theater, various historical topics, traveling, hiking, winter sports

F. Abbreviations

AD-AS model – aggregate demand and aggregate supply model
AD curve – aggregate demand curve
ADF-test – augmented Dickey-Fuller test
CEE countries – Central and Eastern European countries
CEESEE countries – Central, Eastern and Southeastern European countries
CU – currency union
CUSUM-test – cumulative sum-test
EA – Euro Area
ECB – European Central Bank
EME – emerging market economies
EMU – European Monetary Union
EU – European Union
EWWU – Europäische Wirtschafts- und Währungsunion
FDI – foreign direct investment
HP-filter – Hodrick-Prescott filter
KPSS-test – Kwiatkowski–Phillips–Schmidt–Shin-test
OCA theory – optimal currency theory
OECD – Organization for Economic Co-operation and Development
LRAS – long run aggregated supply curve
SRAS curve – short run aggregated supply curve
SVAR – structural vector autoregression model
VAR model – vector autoregression model

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