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Abstract

We analyse the dynamics of the standard deviation of demand shocks and of the demand component of GDP across countries in the European Monetary Union (EMU). This analysis allows us to evaluate the patterns of cyclical comovement in EMU and put them in contrast to the cyclical performance of the new members of the EU and other OECD countries. We use the methodology put forward in Crespo-Cuaresma and Fernández-Amador (2010), which makes use of sigma-convergence methods to identify synchronization patterns in business cycles. The Eurozone has converged to a stable lower level of dispersion across business cycles during the end of the 80s and the beginning of the 90s. The new EU members have also experienced a strong pattern of convergence from 1998 to 2005, when a strong divergence trend appears. An enlargement of the EMU to 22 members would not decrease its optimality as a currency area. There is evidence for some European idiosyncrasy as opposed to a world-wide comovement.

Keywords: Business cycle synchronization, structural VAR, demand shocks, European Monetary Union.

JEL classification: E32, E63, F02.

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1 Introduction

The conduct of monetary policy in a currency area such as the European Monetary Union (EMU) constitutes a difficult task. Different national governments with a certain degree of stabilization power confront the problem of having lost their monetary and exchange rate policy, whereas the central bank develops a common monetary policy upon the basis of the aggregates of the currency area. Thus, common monetary policy will not fit the interests of at least part of the member countries and, moreover, it can be a potential source of asymmetries when the response to a common monetary shock is different among the members of the currency area.[1]

Optimum currency area (OCA) theory put forward by Mundell (1961) predicts that this institutional architecture must rely on strong integration in different economic aspects - OCA criteria such as mobility of labour force, economic openness, financial integration, flexibility of prices and wages, similarity of inflation rates, diversification in production and consumption, fiscal integration and political integration (see Tavlas, 1993, or Mongelli, 2002, or Dellas and Tavlas, 2009, for surveys). When asymmetric shocks hit the national economies forming a currency union, moving away from equilibrium, these OCA prerequisites become the channel for adjustment towards the equilibrium. The higher the level of integration or flexibility in those criteria, the quicker and more complete the adjustment, and the more optimal the currency union. Those OCA criteria are typically summarized by means of the synchronization of business cycles of the members forming the currency area. Furthermore, the empirical literature evaluating the optimality of currency areas has focused on synchronization of shocks and/or business cycles with the aim of analyzing the optimality of EMU or the net benefit of joining the EMU for potential members. In so far as shocks are less asymmetric or cyclical developments are more synchronized, common monetary policy will fit the interests of the members of the currency union. The more synchronized the business cycles of the members of the currency area, the lower the probability of asymmetric shocks, and the less dramatic the loss of monetary and exchange rate policy for the member country (see Afonso and Furceri, 2008, for a theoretical model). Notwithstanding, since the work of Frankel and Rose (1998) the literature has remarked the potential for endogeneities of OCA criteria, a set of interactions that are likely to improve the OCA-rating of a currency area (see De Grauwe and Mongelli, 2005, for an assessment of endogeneities of OCA-criteria). In particular, two kinds of endogeneities have been highlighted, between business cycle synchronization and trade integration and between business cycle synchronization and financial integration, upon the basis that the removal of borders from monetary integration implies a change in the structure of relationships among the members of the integration area. As a result, a country that *ex ante* does not satify the requirements for being an optimal member of a monetary union could accomplish those prerequisites *ex post* (Frankel and Rose, 1998).

The analysis of business cycle synchronization in EMU has focused basically on four issues. First of all, the assessment of synchronization in EMU-12, detecting a period of conver-

[1] Huchet (2003) and Caporale and Soliman (2009) document different reactions to monetary shocks for countries in the Eurozone. Recently, Jarociński (2010) has concluded that responses to monetary shocks between a group of EMU-12 countries before euro adoption and a group of new EU members are qualitatively similar.

gence from the 90s (Angeloni and Dedola, 1999, Massmann and Mitchell, 2003, Darvas and Szápari, 2005, Afonso and Furceri, 2008) and some evidence of increasing heterogeneity during the recession of 2000-2002 (Fidrmuc and Korhonen, 2004). Secondly, whether there is a core-periphery difference, reaching some agreement on the existence of a core group of countries that shows higher synchronization. Thirdly, concerning the enlargement of the EMU, some new EU countries of the recent enlargements of 2004 and 2007 present similar rates of comovement to those displayed by some of the periphery EMU-12 members (Artis *et al.*, 2004, Fidrmuc and Korhonen, 2004 and 2006, Darvas and Szápari, 2005, Afonso and Furceri, 2008). Finally, regarding the idiosyncrasy of the European synchronization against a world-wide business cycle, there exists some evidence for the disappearance of the European differential during the 90s, diluting the European business cycle within a global cycle (Artis, 2003, Pérez *et al.*, 2007). Recently, Crespo-Cuaresma and Fernández-Amador (2010) have developed a comprehensive methodology based on sigma-convergence analysis that offers answer to all these issues within the same framework. All their results are in line with those of the literature here summarized.

We analyze the dynamics of cyclical dispersion in Europe for the period 1960-2008, extracting the demand shocks and the demand components of Gross Domestic Product (GDP) from quarterly real GDP and Consumer Price Index (CPI) series for all members of EMU-12 using the methodology for the estimation of demand and supply shocks developed by Blanchard and Quah (1989). As a measure of coherence, the time series of the cross-country standard deviation of both demand shocks and demand components of GDP (demand-GDP, identified as a proxy of cyclical developments) are studied. Our methodology is based on that developed by Crespo-Cuaresma and Fernández-Amador (2010), where the dynamics of the dispersion of cyclical components is analyzed as an indicator of business cycle coherence. Significant changes in this measure are assessed using Carree and Klomp's (1997) sigma-convergence test and Bai and Perron (1998 and 2003) procedure for detection of structural breaks in order to determine periods of convergence/divergence amongst the EMU-12 members. The analysis is also carried out over a core group of EMU countries, the European Union (EU) members and a control OECD group with the aim of determining the idiosyncrasy of the Eurozone and implications of a potential EMU enlargement for the optimality of the currency area. Therefore, this research can be seen both as a generalization and as a test for robustness of the results obtained by Crespo-Cuaresma and Fernández-Amador (2010). Moreover, the analysis of dispersion of demand shocks and demand fluctuations of GDP, jointly with the analysis of responses of demand-GDP to a demand shock allow us to determine to what extent the dynamics of cyclical comovements is due to coherence in shocks and what the effect of the propagation mechanism is. In this sense, our analysis offers some findings on whether the cyclical synchronization within EMU is the result of *good luck* or "good policy" decisions - that is, whether there exists synchronization of shocks, or whether the propagation mechanisms of the European countries help in smoothing potential asymmetries in shocks and thus produce some synchronization effect.

Our results show that the Eurozone has converged to a stable lower level of dispersion from the end of the 80s in terms of coherence of demand shocks, and from the beginning of the 90s in demand-GDP, supported by strong similarities among transmission mechanisms probably influenced by progressive integration following the implementation of the Maastricht convergence criteria, but also influenced by other factors, specially concerning trade. This convergence pattern has diluted the differential of the core group. Only from 2005 onwards, this differential appears again. New EU members have also experienced a strong pattern of convergence from 1998 to 2005, when a strong divergence trend appears. However, due to the size of these economies, an enlargement of the currency union to 22 members would not decrease the OCA-rating of the EMU. New EU members imply similar distorsions in synchronization for an enlarged EMU to those of the majority of the members of the EMU-12. Finally, the Eurozone has been more synchronized relative to the OECD control group since the mid-90s, and has presented some form of idiosyncrasy as opposed to a world-wide comovement.

The paper is structured as follows. In section 2 we present the estimation of demand shocks and the demand component of GDP. Section 3 provides a revision of the methodology employed for the analysis of cyclical synchronization developed by Crespo-Cuaresma and Fernández-Amador (2010). Section 4 shows the results for the analysis of both demand shocks and demand-GDP synchronization, and summarizes the results of impulse response functions. A comparative analysis of the EMU-12 with some relevant groups is also carried out in this section. In section 5, the cost of inclusion in the monetary union is put forward and computed for EMU-12 members, and for the members of an enlarged EMU. Section 6 concludes.

2 Extraction of demand shocks, supply shocks and business cycles

The first step of our analysis deals with the extraction of structural (demand and supply) shocks from macroeconomic data. The estimation of supply and demand shocks is carried out by using a bivariate structural vector autoregressive (SVAR) model based on the methodology developed by Blanchard and Quah (1989). This method has become a standard tool in empirical macroeconomics to extract structural shocks, and can be easily implemented, since it is based on imposing simple long-run restrictions in the variance-covariance matrix of structural shocks in the framework of VARs. We perform our analysis using data on GDP and CPI, in the spirit of the work by Fidrmuc and Korhonen (2003). Our model specification is based on New-Keynesian assumptions (see, for example, McKinnon, 2000). It is assumed that the dynamics of the observed variables depend on unobserved supply and demand shocks. Supply shocks have a permanent effect on output and inflation, whereas demand shocks have permanent effects on inflation, but only transitory effects on output. *A priori*, positive supply shocks have a positive impact on output, and a negative one on inflation. A positive demand shock will produce an increase on inflation.

The dynamics of the bivariate vector of observed variables of a country is postulated to depend on an infinite moving average representation of supply and demand shocks,

$$y_t = B_0 \upsilon_t + B_1 \upsilon_{t-1} + B_2 \upsilon_{t-2} + ... = \sum_{j=0}^{\infty} B_j L^j \upsilon_t \quad (1)$$

where y_t is the vector of the observed variables (GDP growth and inflation), υ_t is the vector of demand and supply shocks $\begin{pmatrix}\upsilon_t^d & \upsilon_t^s\end{pmatrix}'$ and B_j are 2×2 matrices (with a characteristic element b_j^{kl} where k and l refer to the observed variable and the structural shock, respectively). These B_j matrices summarize the transmission effects from the unobserved structural innovations (the supply and demand shocks) lagged j times to the observed variables, and L is the lag operator. B_0 is the contemporaneous effect of the structural shocks on the observed variables. Structural innovations are assumed to be uncorrelated and with variances normalized to unity, so that the variance-covariance matrix of shocks is assumed $\Sigma_\upsilon = I$. In the long-run, demand innovations are suppossed to have no effect on the dynamics of output growth. That is, $\sum_{j=0}^{\infty} b_j^{11} = 0$. Given the property of stationarity, a VAR representation of the bivariate process of equation (1),

$$y_t = \varepsilon_t + C_1\varepsilon_{t-1} + C_2\varepsilon_{t-2} + ... = \sum_{j=0}^{\infty} C_j L^j \varepsilon_t \tag{2}$$

can be estimated from a SVAR model of the form

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... = \sum_{j=0}^{\infty} A_j L^j y_t \quad . \tag{3}$$

Model (3) given the stationarity property, can be inverted in order to retrieve the Wold moving-average representation (2) and thus, the structural innovations. The variance-covariance matrix of the residuals ε_t is $\Sigma_\varepsilon = \Omega$. All the B_j coefficients can then be recovered from the relationship between the residuals and the structural innovations $\varepsilon_t = B_0\upsilon_t$, since all the elements of B_0 are defined, given $B_j = C_j B_0$ for all j. Therefore, the conditions for identifying B_0 must be given. Firstly, the elements of the main diagonal of B_0, the variances of the structural innovations are normalized to unity. Secondly, the structural shocks are orthogonal, which imposes that $B_0 B_0' = \Omega$. Finally, the long-run effects of the structural unobserved shocks on the observed variables are determined by the matrix $\sum_{j=0}^{\infty} B_j = \sum_{j=0}^{\infty} C_j B_0$. Thus, the third condition for identification of B_0 is the long-run restriction imposed by the fact that demand shocks have no long-run effect on output $\sum_{j=0}^{\infty} b_j^{11} = \sum_{j=0}^{\infty} c_j^{11} b_0^{11} = 0$. Furthermore, the B_0 matrix can be determined in a unique way.

We perform our analysis upon GDP and CPI series for 36 countries of the EU (25 excluding Malta and Romania) and a control group of OECD countries. Data are from Eurostat and OECD (see *Appendix A* for details on samples and sources). Seasonal adjustment was necessary and carried out by using TRAMO-SEATS (Gómez and Maravall, 1996) for GDP series of Bulgary, Switzerland, Estonia, Greece, Latvia and Slovenia, and for CPI series of Bulgary, Cyprus, Estonia, Latvia, Lithuania, Poland and Slovenia. GDP growth and inflation are calculated as the first difference of quarterly (log) GDP and (log) CPI series, respectively. For every pair of series of each of the 36 countries we estimate the full-set SVAR using country-specific lag-lengths chosen using the Schwarz (1978) information criterion with a maximum lag-length of 18 quarters and requiring stationarity in the equation (3). The lag-length obtained ranges from 3 to 5 lags, with most of the countries requiring 5 lags. Demand and supply shocks series are then retrieved, as well as the demand and supply components of GDP. Output fluctuations can be retrieved by means of the long-run restrictions estimated. In order to recover the output due to supply shocks, the level is obtained adding a constant drift and the intercept term to the series of output fluctuations. The GDP due to demand is then defined as the difference between the output series and the supply-side component. Figures 1 to 3 present the demand shocks for countries pertaining to the EMU-12, the new EU countries, and the OECD control group including the three opting-out EU countries (Denmark, Sweden, and United Kingdom). Figures 4 to 6 display, respectively, the demand components of output estimated for those three groups. In our analysis, the latter are considered a proxy of the business cycle or the mid-term developments in economic activity, though as noted by Blanchard and Quah (1989) those are indeed different concepts.[2]

As a measure of synchronization among the members of a currency area we will use the cross-standard deviation series of demand shocks and the demand components of GDP. This will allow us to identify to what extent the propagation mechanism induces synchronization in the cyclical developments of countries considered in each group. We also make use of responses of demand-GDP to a demand shock in order to determine similarities among the transmission mechanism of the countries considered. In the following section we revise the methodology developed in Crespo-Cuaresma and Fernández-Amador (2010) for analyzing business cycle comovements in a defined group.

3 The assessment of synchronization: Methodology

As an indicator of dispersion we use the (weighted) cross-country standard deviation time series:

$$\hat{S}_t = \sqrt{\sum_{j=1}^{N} \omega_{jt}(\hat{\phi}_{jt} - \sum_{k=1}^{N} \omega_{kt}\hat{\phi}_{kt})^2/(1 - \sum_{j=1}^{N} \omega_{jt}^2)}, \tag{4}$$

of a group of N countries, where $\hat{\phi}_{jt}$ is alternatively the demand shock or the demand-GDP of country j in period t, and where the weight ω_{jt} for each country may be based on the size of the country or assumed equal across economies.[3] Therefore, time series techniques from sigma-convergence literature of economic growth can be applied in order to determine the patterns or regimes of synchronization.

The first step in order to analyze the synchronization of a selected group consists in assessing whether the dynamics of the standard deviation series leads to significant changes in the level of dispersion. Defining convergence as a reduction of the standard deviation of the variable of interest across economic units that form the group considered (Lichtenberg, 1994, and Carree and Klomp, 1997), the Carree and Klomp's T_2 test statistic is computed in order to test for significant changes in the dispersion series. This statistic is given by

$$T_{2,t,\tau} = (N - 2.5)\log[1 + 0.25(\hat{S}_t^2 - \hat{S}_{t+\tau}^2)^2/(\hat{S}_t^2\hat{S}_{t+\tau}^2 - \hat{S}_{t,t+\tau}^2)], \tag{5}$$

[2]Detailed results of the estimated models can be obtained from the authors upon request.
[3]See *Appendix A* for a description on the weighting schemes used.

where $\hat{S}_t$ is alternatively the cross-country standard deviation of the demand shocks $\hat{\upsilon}_t^d$ or the demand-GDP, and $\hat{S}_{t,t+\tau}$ is the covariance between $\hat{\upsilon}_t^d$ and $\hat{\upsilon}_{t+\tau}^d$ or demand-GDP in periods t and $t+\tau$, respectively. Under the null hypothesis of no change in the standard deviation between period t and period $t+\tau$, T_2 is $\chi^2(1)$ distributed and can thus be used to test for significant changes in dispersion. $T_{2,t,\tau}$ was calculated using different potential convergence/divergence horizons ranging from two years ($\tau = 8$) to eight years ($\tau = 32$).

In a second step, the time series properties of the dispersion measure are studied in order to identify systematic periods with different degrees of synchronization. The dispersion series is represented by an autoregressive process potentially subject to breaks in the intercept and/or the autoregressive parameter that determine potential different regimes of synchronization. The specification considered is the following,

$$\hat{S}_t = \sum_{j=1}^{R} (\alpha_{0,j} + \alpha_{1,j}\hat{S}_{t-1} + \ldots + \alpha_{r,j}\hat{S}_{t-r}) I(T_{j-1} \leq t < T_j) + \varepsilon_t, \tag{6}$$

where r is the number of lags considered in the specification, ε_t is a white noise disturbance, R is the number of regimes considered (and $R-1$ the number of breaks in the parameters of the process), T_0 is the time index of the first observation and T_R is the time index of the last observation. We consider three specifications. A partial structural model with the structural change defined only in the intercept ($\alpha_{i,j} = \alpha_i$, $\forall i = 1, \ldots, r$ and $\forall j = 1, \ldots, R$), a partial structural model with only the autoregressive parameters subject to structural change ($\alpha_{0,j} = \alpha_0$, $\forall j = 1, \ldots, R$), and a pure structural change model where all the parameters are allowed to change across regimes. The breaks are estimated in each case by choosing the values in the vector $\tau = (T_1, ..., T_{R-1})$ that globally minimize the sum of squared residuals, that is,

$$\{\hat{T}_1, \ldots, \hat{T}_{R-1}\} = \arg\min \sum_{t=1}^{T_R} \hat{\varepsilon}(\tau)_t^2,$$

where the search for the breaks is done after imposing a minimum of 15% of the full sample to be contained in each regime, in order to avoid spurious results caused by small subsample sizes. The breaks were estimated in each case allowing for a maximum of 4 regimes ($R = 4$, 3 breaks). The significance levels of the sup-F tests used for assessing the existence of breaks are obtained in each case by simulating the asymptotic critical values using the method proposed by Bai and Perron (1998 and 2003).

In the following section we analyze the synchronization of demand shocks and demand components of GDP in the Eurozone and some related groups with the aim of answering the following four questions: Whether there is a specific pattern of convergence in the euro area during the 90s, to what extent a core of countries performs better than the EMU-12, whether the integration of the new EU members implies a reduction in the optimality of the Eurozone, and whether the possible appearance of a European comovement has been narrowed within a world-wide synchronization trend. In addition to this, we study if synchronization derives from synchronization of shocks (good luck or a good job of economic policy), or is the result of something else than this and the propagation mechanism helps in demand-GDP convergence.

4 Comovements in shocks and cyclical synchronization

4.1 EMU synchronization

The dynamics of the weighted and unweighted standard deviation series of demand shocks and demand components of GDP are displayed in Figure 7, together with the trends of such series obtained by using the Hodrick and Prescott (1997) filter. From the comparison of unweighted and weighted measures, we can conclude that small countries seem to induce heterogeneity in comovements of shocks in the beginning of the sample until the late 70s and from the mid 90s onwards. When looking at the demand-GDP developments, small countries tend to bring about divergence in the Eurozone during the whole sample period. We focus on weighted measures, hereafter. Concerning dispersion of shocks, a pattern of convergence is detected in the beginning of the sample till 1972, when a short period of divergence starts until the mid-70s. A new pattern of convergence in demand shocks appears during the late 70s until the late 80s. From the last years of the 80s onwards, the level of synchronization of demand shocks remains relatively stable around a lower level, and only two sharp peaks of divergence emerge during the recession of 2000-2002 and the recessionary period in the end of the sample.

With regard to the dispersion of demand-GDP, the sample starts with a strong convergence period in the beginning of the 60s. This turns into a very short period of divergence in the end of the 60s, before experiencing a new reversal that culminates in the mid 70s. After a period of higher cyclical dispersion from the middle of the 70s to the beginning of the 80s, a persistent convergence trend takes place, especially in the second half of the 80s, which is reversed in the beginning of the 90s, during the recessionary period of the first years of that decade. From 1993 on, a very stable period of more synchronization starts which is only reversed in the last year of the sample, since 2008/2.

In order to test for the significance of changes in the standard deviation of shocks and demand-GDP in EMU-12, we compute the Carree and Klomp's (1997) test described in the previous section. Figure 8 displays the changes in the standard deviation of demand shocks and demand-GDP in EMU-12 that appear significant at the 5% significance level for the horizons corresponding to two, four, six and eight years. The variable which is plotted in Figure 8 is defined as

$$c_t = (\hat{S}_t - \hat{S}_{t+\tau})I[T_{2,t,\tau} > \chi^2_{0.95}(1)], \tag{7}$$

where τ is alternatively equal to 8, 16, 24 and 32 quarters, $\chi^2_{0.95}(1)$ is the 95th percentile of the $\chi^2(1)$ distribution and $I[\cdot]$ is the indicator function, taking value one if the argument is true and zero otherwise.[4]

Figure 8 indicates that the medium-run dynamics shown in Figure 7 actually lead to significant changes in the dispersion of both demand shocks and demand-GDP in EMU-12 for the period under study. With respect to the dispersion in demand shocks, the most important fact is the period of strong convergence coming from the late 70s to the end of the 80s.

[4]Results are robust if a 1% significance level is used. Computations are available from the authors upon request.

From 1995 on, the very stable dynamics of synchronization depicts few significant patterns, all of them of small magnitude. The signs of divergence coinciding with the recession of the 2000-2002 and the recession of the end of the sample are remarkable. Concerning the dispersion of demand-GDP, we should note the same convergence pattern starting in the beginning of the 80s until the beginning of the 90s. Since then (1994-1995), a very stable period appears also with hardly significant patterns of change, with only some small traces of divergence in the recessionary periods of 2000-2002 and in the end of the sample.

We also implement Bai-Perron's (1998 and 2003) test for the analysis of structural change (SC) in order to identify different regimes in the dynamics of dispersion of shocks and demand components of GDP. Table 2 presents the Augmented Dickey-Fuller (ADF, Dickey and Fuller, 1979) and KPSS (Kwiatkowsky *et al.*, 1992) tests for the EMU-12 group, a OECD group considering all the countries that are not part of the European integration process and the three opt-out clause members (Denmark, United Kingdom and Sweden), and a group including both groups (Global1). Unit root tests offer contradicting results. ADF tests (Dickey and Fuller, 1979) reject the null of a unit root for dipersion series of demand shocks and demand-GDP in EMU, whereas the KPSS (Kwiatkowsky *et al.*, 1992) test tends to reject stationarity.

Tables 3 and 4 summarize the results for demand shocks and demand-GDP dispersion series for EMU-12, OECD and Global1, respectively. Figure 9 displays the weighted standard deviation series and the unconditional expectations for each regime. Regarding the EMU-12 group, the dispersion series of demand shocks is represented by means of an autoregressive process of order 2 -AR(2), and the standard deviation of demand-GDP by an AR(1) specification. This seems to be sufficient to remove autocorrelation in the residuals. Therefore, we consider the data generating process represented in equation (6) potentially subject to breaks in the intercept, in the autoregressive parameters (partial-SC models), or in the intercept and autoregressive coefficients (pure-SC model).[5]

Models with one break are sufficient to capture the dynamics of the dispersion series. In those cases where a two-breaks model can be estimated, wide confidence intervals in the second break make more sensible to use models with one break. Regarding the synchronization of demand shocks (see Table 3), the model with one structural change in the intercept estimated in 1986/1 is the prefered one in terms of Schwarz (1978) information criterion (not shown in Table 3). This model determines a decrease in the unconditional expectation of the dispersion series and in its volatility. With respect to the dispersion series in the demand fluctuations of GDP (see Table 4), the model with a structural break in the intercept in 1993/2 seems to be the prefered one, too, because the pure-SC model shows wide confidence intervals. The model also determines a decrease in the unconditional expectation of dispersion and in the volatility of the dispersion series.

Besides the analysis of dipersion of shocks and demand-GDP, it is useful to consider the responses of GDP-growth to a positive demand shock of 1% given the estimated parameters

[5] We report the selected models. Information about all the models considered is available from the authors upon request.

of the SVAR model (not shown because of space limitations).[6] We summarize such information. In general, we can extract some common features. All the countries show somehow a positive response to the demand shocks that tends to dissappear, becoming close to zero after 8-10 quarters. Only Austria, Netherlands and Belgium show negative responses in some periods in the beginning of the response-horizon. Together with the results offered above, synchronization of demand shocks, strengthened during the late 80s, have been supported by the transmission mechanism. The role of the latter may have been reinforced during the process of integration, supporting convergence in demand GDP fluctuations.

Therefore, the Eurozone has converged to a stable lower level of dispersion from the end of the 80s in terms of demand shocks, and from the beginning of the 90s in demand-GDP (as can be inferred by Figure 9), supported by strong similarities among propagation mechanisms probably influenced by progressive integration following the implementation of the Maastricht convergence criteria during the Stage Two of EMU, but also influenced by other factors related to trade. This result is in line with previous research of Angeloni and Dedola (1999), Massmann and Mitchell (2003), Darvas and Szápari (2005), Afonso and Furceri (2008), or Crespo-Cuaresma and Fernández-Amador (2010), for example. Moreover, according to Mayes and Virén (2009), the Maastricht Treaty and the transition period of the Stage Two seem to be linked to a structural change in the mid-term fluctuations in the EMU that increased the optimality of the Eurozone, though such convergence may start earlier with the convergence in demand shocks initiating in the mid 80s.

4.2 Comparative analysis

The literature on business cycle synchronization in Europe has pointed out some other questions with the aim of analyzing the singularity of the EMU comovement, and determining the optimality of the currency area. In this regard, three main issues have been highlighted. The first one concerns the debate between core and periphery countries and the potential differential of a core group of EMU countries (Belgium, France, Germany, Luxembourg and Netherlands) showing higher cyclical synchronization than EMU-12. The second issue is connected with the coherence of cyclical developments of the new EU members with respect to EMU-12 and the impact of a hypothetical enlargement of the monetary union including all the members from the recent enlargements of 2004 and 2007. The third issue is about the idiosyncrasy of the European synchronization relative to a world-wide comovent.

Figures 10 and 11 present the dispersion series of demand shocks and demand-GDP together with their Hodrick-Prescott (1997) trends for some relevant groups such as the core group, the group formed by the new EU members of the enlargements of 2004 and 2007, an enlarged EMU (EMU-22) and the EU-25 (see Figure 10), and the OECD control group, a group including the OECD and EMU-12 groups (Global1) and a group including all the 36 countries considered (Global2, see Figure 11). With regard to the core group (see Figure 10), the level and dynamics of dispersion in demand shocks are very close to the EMU-12. From 1965 to 1980, the core group has clearly shown more synchronization in shocks. This is somehow reversed from the first years of the 90s on, however, when the core group presents slighty higher dispersion than EMU-12. Concerning the dispersion of demand-GDP, the core

[6] Computed impulse response functions are available from the authors upon request.

group is more synchronized than EMU-12 from the beginning of the sample until the late 80s -probably, due to higher integration in the economic structures and more similar economic policies in the core during this period. Afterwards, this differential in comovement seems to dissappear (specially from the late 80s until 1997). Only in the end of the sample (from 2005 on) the core group clearly becomes more synchronized once again. With respect to the group of new members from recent enlargements, for both demand shocks and demand-GDP dispersion series a strong trend of convergence is detected from 1998 to 2005, when it is reversed and a period of increasing divergence starts. The level of dispersion is higher than the one corresponding to the EMU-12 either for demand shocks or demand-GDP dispersion series. This convergence trend is consistent with evidence of real and nominal convergence of macroeconomic fundamentals provided by Kocĕnda (2001), and Kutan and Yigit (2004) for the late 90s. However, we find how a strong divergence trend appears in this group from 2005 on.

Considering a hypothetical enlarged EMU (EMU-22), differences in dispersion are not relevant -given the small weight of the new members relative to the EMU-12 countries. The dispersion of shocks shows similar dynamics and levels in both groups. Turning to demand-GDP dispersion, only in 2002-2003 and 2006-2008 significant gaps can be observed between the EMU-22 and EMU-12, when the EMU-12 experiences more synchronization. This finding reflects the convergence trend of the new EU countries towards the EMU-12 documented here and by Artis *et al.* (2004), Fidrmuc and Korhonen (2004 and 2006), Darvas and Szápari (2005), Kutan and Yigit (2005), Afonso and Furceri (2008), or Crespo-Cuaresma and Fernández-Amador (2010), for example. The appraisal of the EU-25 points out similar conclusions as that of the EMU-22, with attenuated differences, however. Moreover, the EU-25 reveals a slightly more synchronized behavior during the period 2004-2006.

Turning to Figure 11 where the results for the OECD are presented, this group has shown more synchronization in demand shocks than EMU-12 until the mid 80s, when the EMU-12 becomes more synchronized. With respect to the demand-GDP dispersion series, the EMU-12 has been more synchronized from the late 70s, and only approaches the OECD levels during the period spanning the late 80s until the end of the recession of 1991-1993, during the 1999-2000 period and in 2008/4. Consequently, considering the group formed by the EMU-12 and OECD (Global1), the demand shocks dispersion series reveals also the change from more to less synchronization relative to EMU-12. The demand-GDP dispersion series reveals that the EMU-12 has achieved more synchronization, but for the periods 1988-1994, 1999-2000 and in 2008/4. The global group including all the 36 countries (Global2) leads to similar conclusions.

Structural change analysis was also applied upon the OECD and Global1 dispersion series (see Tables 3 and 4 and Figure 9). As in the case of EMU-12, ADF tests (Dickey and Fuller, 1979) reject the null of a unit root for series of dipersion of demand shocks and demand-GDP in EMU, whereas the KPSS test (Kwiatkowsky et al., 1992) tends to reject stationarity (see Table 2). We can summarize the dynamics of the dispersion series of shocks and demand-GDP by means of AR(1) processes for both OECD and Global1 groups. With respect to OECD shocks dispersion (see Table 3), the prefered model is that with a structural break in the autoregressive coefficient. The OECD experiences a structural change around 1983/1 towards a lower average. The dynamics of dispersion is less volatile in the second regime, too. However, this change seems to be less dramatic than in the case of Eurozone. Moreover, in the first regime the OECD seems to be more synchronized than EMU-12, though in the second regime the latter shows more synchronization than the former. Finally, the break experienced in shocks dispersion series has not lead to a change in the demand-GDP standard deviation (see Table 4).

Concerning the Global1 group, the specification with a break in the intercept estimated in 1983/1 seems to perform slightly better in the case of the synchronization of demand shocks (see Table 3). Every specification implies a decrease in the expectation and volatility of the dispersion series after the break. In the case of the dispersion series of demand-GDP, the specification with a break in the intercept estimated in 1984/2 performs better and reflects the decrease in both expectation and volatility of the data generating process (see Table 4). Nevertheless, the comparison between the figures of the EMU-12 and the Global1 group reflect the more synchronized behavior of the Eurozone from the mid-90s.

In addition to this, impulse response functions (not shown) show less similarity in the transmission of demand shocks among the new EU members and among the OECD group.

Overall, the EMU-12 seems to have converged to a stable lower level of dispersion from the end of the 80s in demand shocks, and from the beginning of the 90s in demand-GDP, supported by strong similitudes among transmission mechanisms probably influenced by progressive integration, following the implementation of the Maastricht convergence criteria, but also influenced by other factors, specially trade integration. This convergence pattern has diluted the differential of the core group. Only from 2005 onwards, this differential returns. The new EU members have also experienced a strong pattern of convergence from 1998 to 2005, when a strong divergence trend appears. However, due to the size of these economies, an enlargement of the currency union to 22 members would not decrease the OCA-rating of the EMU. Finally, the Eurozone presents higher levels of synchronization relative the OECD control group since the mid-90s, and has presented some European idiosyncrasy as opposed to a world-wide comovement.

5 The cost of inclusion of a member

We can complement the previous analysis by means of the computation of the net-benefit of being part of a currency union for its members in terms of cyclical synchronization. The cost of inclusion of a country j in the group Ω is defined as

$$\mathrm{coi}_{t,j}|\Omega = \frac{\hat{S}_t|\Omega_{-j} - \hat{S}_t|\Omega}{\hat{S}_t|\Omega}, \tag{8}$$

where $\hat{S}_t|\Omega_{-j}$ is the (weighted) cross-country standard deviation series of the group Ω excluding country j and $\hat{S}_t|\Omega$ is the (weighted) cross-country standard deviation of the group Ω including country j at time t. The cost of inclusion is therefore defined as a rate of change in dispersion, taking negative values when the standard deviation of the group increases as the country is included (that is, when the country induces divergence in the group), and positive values when the inclusion of the country induces a decrease in the dispersion (that is, when it induces convergence). The cost of inclusion of a country is a representation of the impact that each country has in the degree of synchronization of a currency union at a given period in time. Figures 12-17 show the cost of inclusion of each member for the EMU-12 and the hypothetical enlarged EMU considered in the section above regarding the demand shocks and demand-GDP.

Figures 12 and 13 present the cost of inclusion of each country belonging to EMU-12 for demand shocks and demand-GDP, respectively. Regarding those computed in terms of demand shocks, it should be noted the role of Austria, Germany, France, Finland and Luxembourg as clear sources of convergence during almost the whole sample, as well as of Spain, Greece, Italy and Netherlands, since 1995. With respect to the cost of inclusion computed for demand-GDP measures, the same group of countries (Austria, Germany, France, Finland, Luxembourg) inducing convergence is detected. In contrast, Spain shows a more ambiguous behavior.[7] It should be noted that the (generally positive) ratios of Germany and France are of sizeable magnitude for both demand shocks and demand-GDP measures, what could be interpreted as Germany and France as the anchors of EMU. However, this is also clearly related to the substantial weight of both countries in the Eurozone and it is not appreciated when considering unweighted standard deviations (not shown).[8] Finally, we should highlight the costs resulting from Germany during the years following the reunification, specially regarding demand-GDP measures.

Figures 14-15 display the cost of inclusion of the members of an enlarged European currency union, for demand shocks and demand-GDP, respectively. The most important conclusion from these graphs is that new EU members do not imply significant costs as members of an enlarged Eurozone. Nevertheless, these results could be due to the small weight of these economies in the euro area. Therefore, we also include the results of the cost of inclusions computed with unweighted standard deviations (see Figures 16 and 17). Although the impact of the new EU members is somehow more ambiguous, with more periods of cost, their behavior is not different to the one observed in the majority of the members of the EMU-12.

6 Conclusions

We offer here five main findings with the aim of answering the most important issues raised in the empirical literature of cyclical synchronization in Europe. First of all, we show that the Eurozone has converged to a stable lower level of dispersion in demand shocks from the end of the 80s, and from the beginning of the 90s in demand-GDP, supported by strong similarities among propagation mechanisms probably influenced by progressive integration following the implementation of the Maastricht convergence criteria during Stage Two of EMU, but also influenced by other factors as trade integration. In line with Mayes and Virén (2009), the Maastricht Treaty and the transition period of the Stage Two seem to

[7]Some of the results in the end of the sample should be taken with caution. This is the case for example of Ireland where the model estimated does not capture the decrease associated with such recessionary period in the demand-GDP.

[8]Computations are available from the authors upon request.

be linked to a structural change in the mid-term fluctuations in the EMU that increased the optimality of the Eurozone, though such trend may start earlier, with the convergence in demand shocks coming from the mid 80s. Second, this convergence pattern has diluted the differential of the core group. Only from 2005 onwards, this differential returns. Third, the new EU members have also experienced a strong pattern of convergence from 1998 to 2005. Fourth, due to the size of these economies, an enlargement of the currency union to 22 members would not decrease the OCA-rating of the EMU in terms of cyclical synchronization, and does not imply costs for the Eurozone. In any case, the new EU members show similar costs of inclusion to those of the majority of the members of the EMU-12. Finally, the Eurozone appears more synchronized relative to the OECD control group in terms of demand shocks since the mid 80s and from the mid-90s in terms of demand-GDP, and has presented some European idiosyncrasy as opposed to a dilution in a world-wide comovement.

Our result concerning the lack of important effect of the enlargement of the EMU upon the OCA-rating is of special relevance, but some caveats could be highlighted regarding the estimations for the new EU economies and the use of only one OCA criterion for recomendations about euro adoption by these countries. Convergence of the new EU members towards EMU is well documented by the empirical literature. However, results concerning the new EU members undergo the problem of short sample size, and may reflect excepcional sample features coming from the transition from planned to market economies that these countries experienced during the decade of the 90s (see Campos and Coricelli, 2002, for a description of these features and Svejnar, 2002, and Foster and Stehrer, 2007, for a characterization of the transition periods) and where political factors were of remarkable importance (Roland, 2002). In addition to this, the preservation of the OCA-rating in output fluctuations after the enlargement reported here refers to the whole currency area. The net balance of joining a currency union is a wider concept. It depends on the character and symmetry of the shocks, but also on the transmission mechanisms of such shocks and the monetary policy in the countries forming the currency union. In this sense, in order to assess the convenience of euro adoption by the new EU members, other OCA prerequisites such as nominal convergence, trade and financial integration, fiscal coordination and labour market flexibility should be considered. Evidence reported by different authors using other criteria tends to support the enlargement of the EMU. In fact, there is some evidence of nominal convergence pointed out by Kutan and Yigit (2005) and Lein *et al.* (2008), for example. Lein *et al.* (2008) also highlight the effect of real convergence on price level catch-up through two main channels: Productivity growth in the new EU members, which has a positive impact in nominal convergence through Balassa-Samuelson effects, and trade intensification, with a negative impact through mark-ups reduction in the framework of competitiveness gains.

Economic integration, financial integration and fiscal coordination deserve careful consideration as potential factors affecting the optimality of the adoption of the euro by the new EU members, because of their endogenous relationship with synchronization of output fluctuations. Economic and financial integration are goals of the EU, and the monetary union should help reaching these goals. Rose (2000) opened a door for supporting the idea of a positive effect of EMU on trade, though his research is subject to some drawbacks (see Baldwin, 2006). Petroulas (2007) finds a positive impact of EMU on inward foreign direct investment (FDI) flows. Recently, Brouwer *et al.* (2008) make use of gravity models and present support concerning the existence of a complementary relationship between trade and FDI, a positive effect of the EU on trade and FDI, and a positive effect of EMU on FDI and a non-negative effect on trade. These results lead these authors to conclude that joining the Eurozone would increase the FDI stock countries receive as well as trade flows, being part of the trade increase a result from higher FDI stocks. Financial integration presents many facets. From an aggregate perspective, Blanchard and Giavazzi (2002) and Lane (2006b) suggest that monetary integration has increased financial integration, and Lane (2006a) finds evidence of a Eurozone bias in international bond portfolio movements, which implies that more cross-border asset trade tends to take place between members of the euro area than among other pairings. In particular, Spiegel (2009) shows that the monetary integration has an effect on bilateral bank lending through a *pairwise effect* coming from joint membership in a monetary union by two members what increases the quality of intermediation between borrowers and creditors when both are in the same currency union. Stock market comovements seem to be enhanced by monetary integration (Kim *et al.*, 2005, or Wälti, 2010, for example). Moreover, Abad *et al.* (2010) have shown that debt markets are mainly driven by domestic factors in EU and US, and that EMU debt markets, though only partially integrated with the Eurozone (represented by the German) government bonds market, are more influenced by euro risk factors than by global risk factors as opposed to those of non-EMU countries, which tend to be more influenced by world-wide risk factors. With respect to the new EU countries, Masten *et al.* (2008) find evidence that joining the EMU implies the development of domestic financial markets and financial integration for the new EU members, with a positive effect on economic growth.

One of the major concerns when joining a currency union is the loss of fiscal sovereignty. The theoretical literature has defined two main ways of policy coordination. Von Hagen and Mundschenk (2001) differentiate between narrow coordination, focused on monitoring national policies and practises challenging price stability, leaving relative freedom to policy goals and instruments, and broad coordination where explicit frameworks concerning common policy goals and strategies are developed in an agreement. Ferré (2008) shows in a game theoretical model that broad coordination in fiscal policy would be prefered to narrow coordination. In this broad coordination framework, the incentive to deviate from the agreement comes from the presence of supply shocks and different evolutions in competitiveness, whereas there is no incentive to deviate from the agreement under differential demand shocks, the most important from the point of view of stabilization policies. In addition, Afonso and Furceri (2008) found empirical evidence that the shock-smoothing role of fiscal policy is enhanced in an enlarged EMU. Finally, other major political issue of the enlargement of the EMU is labour market flexibility. Boeri and Garibaldi (2006) illustrate that the degree of labour flexibility of the new EU members is in many dimensions larger than in the Eurozone. They also show that jobless economic growth in these countries in the last years is related to productivity-enhancing job destruction after the prolonged labour hoarding during the transition periods until 1996. Thereby, taking into consideration our results and the main findings of the related literature, it is possible to be optimistic regarding the enlargement of the EMU from both the perspective of the performance of the common monetary policy and the new EMU members' side.

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Appendix A. Data sources

Table 1: **Dataset: Samples and Sources**

Country	Sample period GDP	Sample period CPI	Source
Australia	1960q1-2008q4	1960q1-2008q4	OECD
Austria	1960q1-2008q4	1960q1-2008q4	OECD
Belgium	1960q1-2008q4	1960q1-2008q4	OECD
Bulgary	1960q1-2008q4	1997q1-2008q4[a]	Eurostat
Canada	1960q1-2008q4	1960q1-2008q4	OECD
Cyprus	1995q1-2008q4	1996q1-2008q4[a]	Eurostat
Czech Republic	1990q1-2008q4	1991q1-2008q4	OECD
Denmark	1966q1-2008q4	1960q1-2008q4	OECD
Estonia	1993q1-2008q4	1995q1-2008q4[a]	Eurostat
Finland	1960q1-2008q4	1960q1-2008q4	OECD
France	1960q1-2008q4	1960q1-2008q4	OECD
Germany	1960q1-2008q4	1960q1-2008q4	OECD
Greece	1960q1-2008q4	1960q1-2008q4	OECD
Hungary	1991q1-2008q4	1980q1-2008q4	OECD
Iceland	1960q1-2008q4	1960q1-2008q4	OECD
Ireland	1960q1-2008q4	1960q1-2008q4	OECD
Italy	1960q1-2008q4	1960q1-2008q4	OECD
Japan	1960q1-2008q4	1960q1-2008q4	OECD
Latvia	1990q1-2008q4	1996q1-2008q4[a]	Eurostat
Lithuania	1995q1-2008q4	1995q1-2008q4[a]	Eurostat
Luxembourg	1960q1-2008q4	1960q1-2008q4	OECD
Mexico	1960q1-2008q4	1969q1-2008q4	OECD
New Zealand	1960q1-2008q4	1960q1-2008q4	OECD
Netherlands	1960q1-2008q4	1960q2-2008q4	OECD
Norway	1960q1-2008q4	1960q1-2008q4	OECD
Poland	1990q1-2008q4	1989q1-2008q4	OECD
Portugal	1960q1-2008q4	1960q1-2008q4	OECD
Republic of Korea	1970q1-2008q4	1960q1-2008q4	OECD
Slovenia	1992q1-2008q4	1995q1-2008q4[a]	Eurostat
Slovak Republic	1993q1-2008q4	1993q1-2008q4	OECD
Spain	1960q1-2008q4	1960q1-2008q4	OECD
Sweden	1960q1-2008q4	1960q1-2008q4	OECD
Switzerland	1965q1-2008q4	1960q1-2008q4	OECD
Turkey	1960q1-2008q4	1960q1-2008q4	OECD
United Kingdom	1960q1-2008q4	1960q1-2008q4	OECD
USA	1960q1-2008q4	1960q1-2008q4	OECD

a: Original series in monthly frequency.

Weights for averaged indicators where computed by using annual data on real GDP (source: Penn World Table) in international dollars with reference in 1996 (Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.3, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, August 2009) for the period 1950-2007 updated up to 2008 using the GDP raw data described above and used for the extraction of business cycles. For each country, weights were calculated relative to the group considered. Two schemes of weights were used. The first one, a time-varying scheme in which for each year the weight was calculated and therefore a series of (annual) weights was used when computing the indicators. The second one is a scheme based on the mean weight for the whole sample period. This last weighting scheme was used when calculating the standard deviation series in the Carree and Klomp (1997) test. Our results are robust to the use of both weighting patterns.

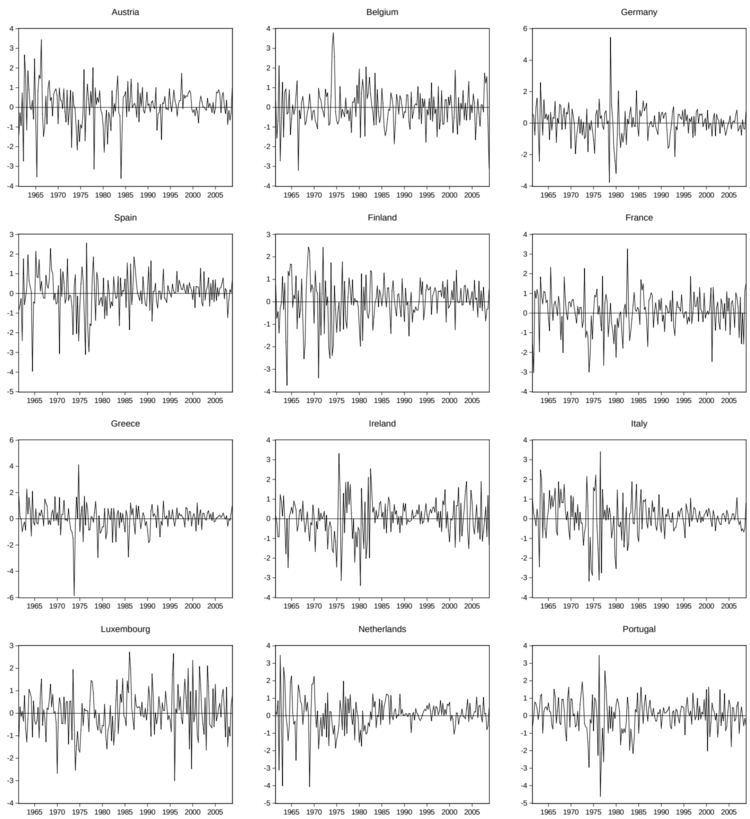


Figure 1: Demand shocks: EMU countries

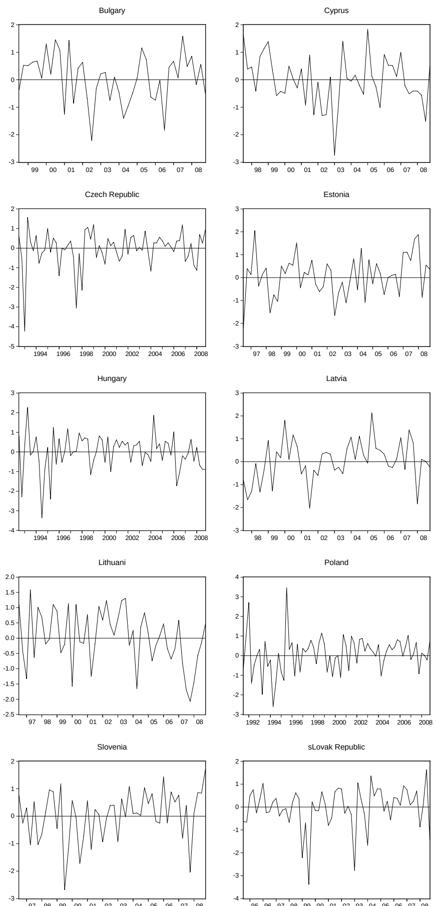


Figure 2: Demand shocks: Enlargement countries

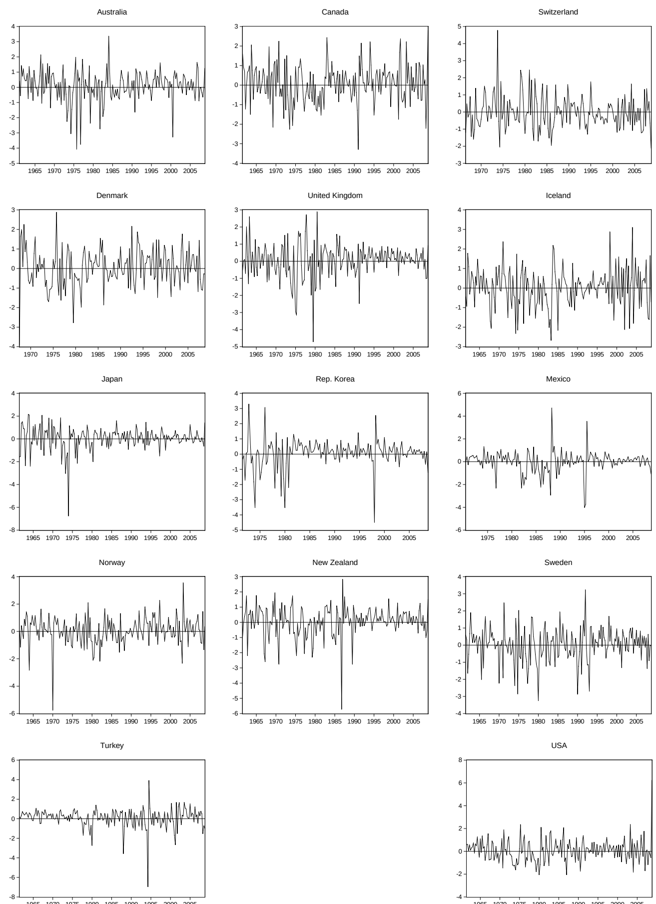


Figure 3: Demand shocks: OECD countries

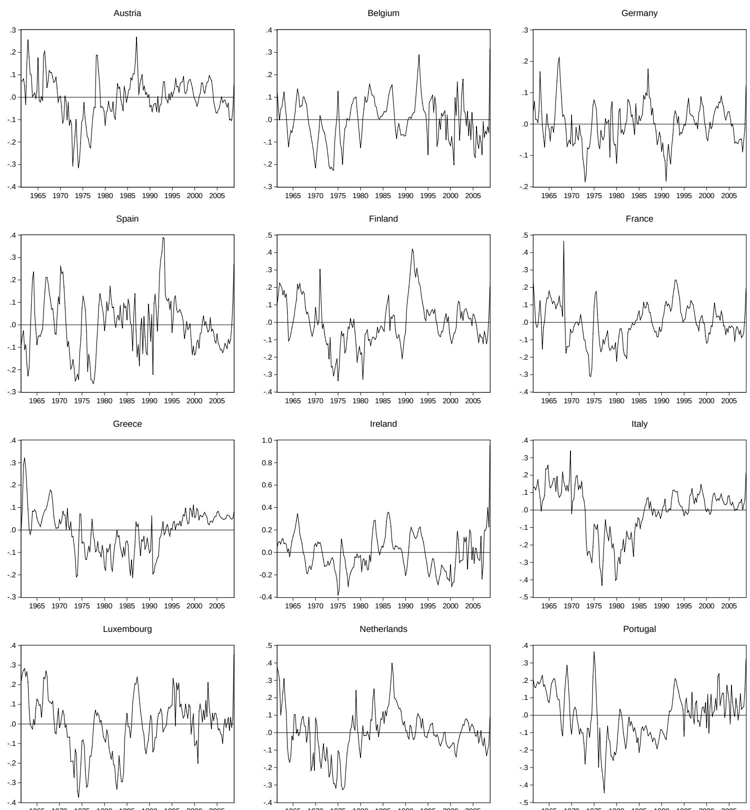


Figure 4: Demand component of (log) GDP: EMU countries

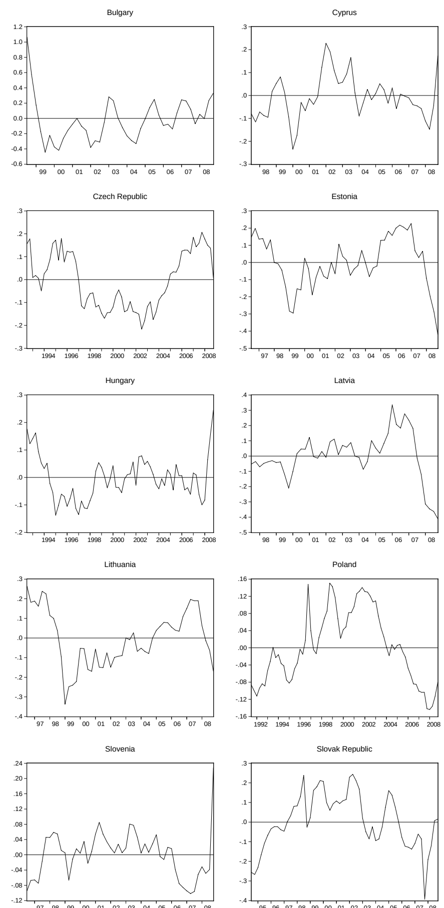


Figure 5: Demand component of (log) GDP: Enlargement countries

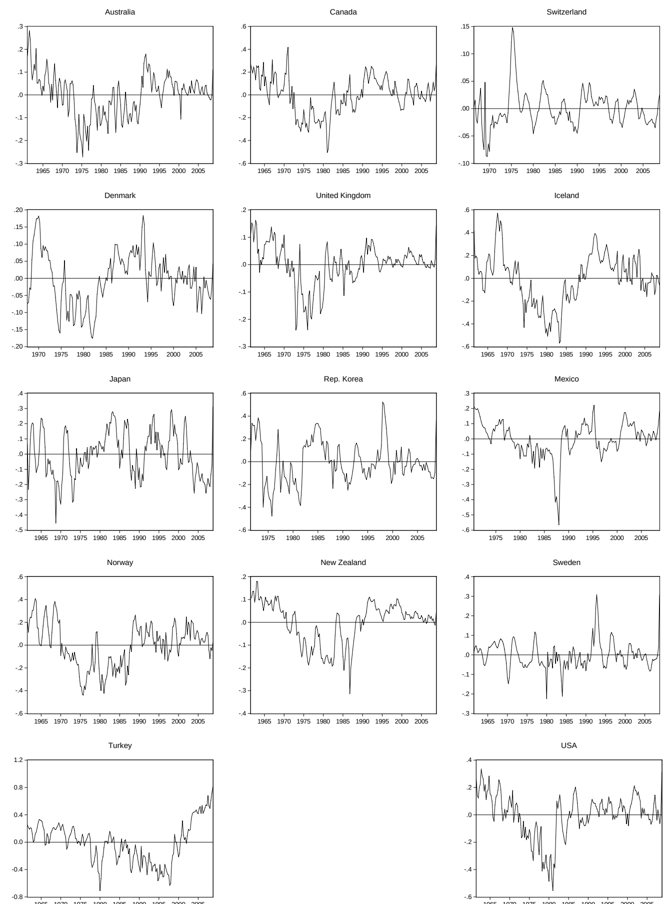


Figure 6: Demand component of (log) GDP: OECD countries

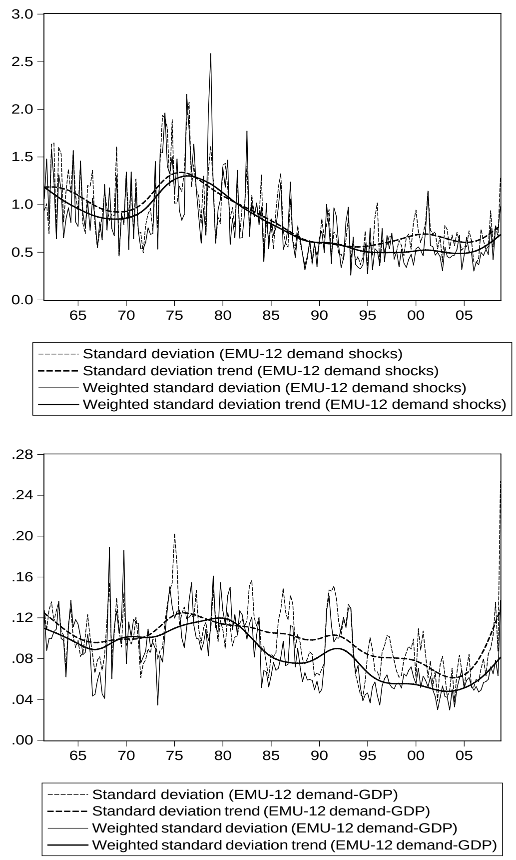
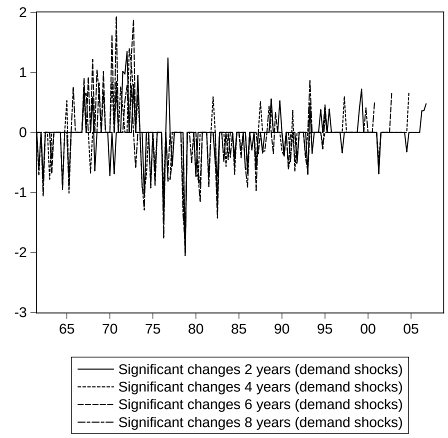


Figure 7: Dispersion in demand shocks and demand components of GDP: EMU countries

Table 2: **Unit root test results for weighted standard deviation series**

	Setting with intercept		Setting with intercept and linear trend	
	ADF test stat.	KPSS test stat.	ADF test stat.	KPSS test stat.
Demand shocks				
$emu-12$	-3.4709***	1.1963***	-6.7394***	0.1763**
$oecd$	-8.5315***	0.8429***	-9.2981***	0.1620**
$global1$	-6.4368***	0.9787***	-7.4474***	0.2191***
Demand-GDP				
$emu-12$	-3.1612**	1.0264***	-3.7994**	0.1375**
$oecd$	-4.6518***	0.3109	-4.7719***	0.1271*
$global1$	-4.2967***	0.4939**	-4.6158***	0.1286*

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



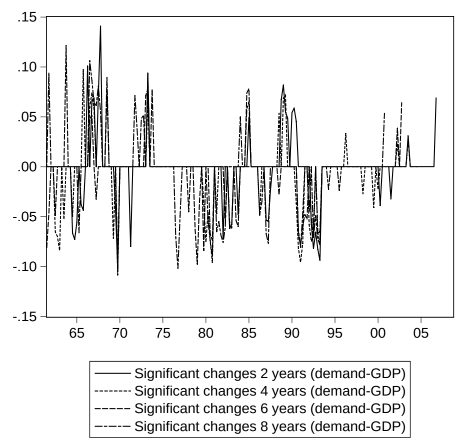


Figure 8: Significant changes in demand shocks and demand-GDP dispersion: EMU countries

Table 3: **AR models with structural changes (SC): Demand shocks**

	EMU-12 - Partial-SC (intercept)	*OECD - Partial-SC (autoregressive)*	*Global1 - Partial-SC (intercept)*
Breaks (SSR)			
R=2	(1986/1)	(1983/1)	(1983/1)
R=3	(1973/2,1980/3)	(1983/1,1995/3)	(1983/1,2003/1)
R=4	(1973/2,1980/3,1987/4)	(1983/1,1995/3,2001/1)	(1983/1,1995/2,2003/1)
Sup-F test (ℓ)			
Sup-F test (1)	24.7549***	14.3905***	23.4684***
Sup-F test (2)	14.1404***	7.8362**	14.4576***
Sup-F test (3)	13.1405***	7.7994***	11.3112***
UDmax	24.7549***	14.3905***	23.4684***
WDmax	24.7549***	14.3905***	23.4684***
Sup-F test (ℓ+1/ℓ)			
Sup-F test (2/1)	4.9460	2.2339	0.9954
Sup-F test (3/2)	15.1720***	1.4192	7.7244
No. breaks selected			
Sequential	1***	1***	1***
BIC	3	1	1
LWZ	1	0	1
	EMU-12 - Partial-SC (intercept)	*OECD - Partial-SC (autoregressive)*	*Global1 - Partial-SC (intercept)*
$\hat{\alpha}_{0,1}$	0.7051*** (0.0997)	0.7593*** (0.0848)	0.9133*** (0.1192)
$\hat{\alpha}_{1,1}$	0.1738** (0.0727)	0.2257** (0.0917)	0.1728* (0.0991)
$\hat{\alpha}_{2,1}$	0.1314* (0.0728)	-	-
break $\hat{\alpha}_{0,2}$	-0.3197*** (0.0635)	-	-0.3518*** (0.0746)
break $\hat{\alpha}_{1,2}$	-	-0.3059*** (0.0867)	-
break $\hat{\alpha}_{2,2}$	-	-	-
Break	(1986/1)	(1983/1)	(1983/1)
95% Conf. Interv.	(1985/2,1990/2)	(1975/1,1987/1)	(1980/4,1985/4)
90% Conf. Interv.	(1985/3,1989/1)	(1977/3,1985/4)	(1981/2,1985/1)
Uncond. expect. (R1)	1.0148	0.9806	1.1041
Uncond. expect. (R2)	0.5547	0.7029	0.6788
Variance (R1)	0.1668	0.1889	0.1309
Variance (R2)	0.0425	0.1663	0.1133
Q(1) test	0.0028	0.1276	0.1516
Q(4) test	2.1390	1.1567	0.2784
JB test	105.207***	1314.928***	2421.498***

Note: *, ** and *** stands for significance at the 10%, 5%, and 1% level. "Q(z) test" is the Ljung-Box test statistic (Ljung and Box, 1978) for autocorrelation up to zth order. "JB test" is the Jarque Bera test statistic (Jarque and Bera, 1987) for residual normality. LWZ is the modified Schwarz criterion of Liu *et al.*, 1997. The significance level of the sup-F tests were computed using the algorithm in Bai and Perron (1998 and 2003), using 1000 replications with Wiener processes of sample size 500.

Table 4: **AR models with structural changes (SC): Demand-GDP**

	EMU-12 - Partial-SC (intercept)	*OECD - No-SC*	*Global1 - Partial-SC (intercept)*
Breaks (SSR)			
R=2	(1993/2)	-	(1984/2)
R=3	(1983/4,1993/2)	-	(1978/1,1984/2)
R=4	(1973/4,1983/1,1993/2)	-	(1978/1,1984/2,2003/2)
Sup-F test (ℓ)			
Sup-F test (1)	25.4108***	-	7.5139*
Sup-F test (2)	15.4828***	-	7.2251**
Sup-F test (3)	13.6968***	-	6.0937**
UDmax	25.4108***	-	7.5139*
WDmax	25.4108***	-	8.2341*
Sup-F test (ℓ+1/ℓ)			
Sup-F test (2/1)	6.7236	-	7.6642
Sup-F test (3/2)	7.9787	-	5.4826
No. breaks selected			
Sequential	1***	-	1*
BIC	1	-	2
LWZ	0	-	0

	EMU-12 - Partial-SC (intercept)	*OECD - No-SC*	*Global1 - Partial-SC (intercept)*
$\hat{\alpha}_{0,1}$	0.0465*** (0.0065)	0.0309*** (0.0071)	0.0460*** (0.0089)
$\hat{\alpha}_{1,1}$	0.5284*** (0.0627)	0.7446*** (0.0549)	0.6784*** (0.0592)
break $\hat{\alpha}_{0,2}$	-0.0194*** (0.0043)	-	-0.0161*** (0.0051)
break $\hat{\alpha}_{1,2}$	-	-	-
Break	(1993/2)	-	(1984/2)
95% Conf. Interv.	(1992/2,1997/4)	-	(1981/3,1996/2)
90% Conf. Interv.	(1992/3,1996/3)	-	(1982/3,1993/1)
Uncond. expect. (R1)	0.0987	0.1208	0.1430
Uncond. expect. (R2)	0.0576	-	0.0930
Variance (R1)	0.0009	0.0025	0.0021
Variance (R2)	0.0003	-	0.0006
Q(1) test	0.8324	0.0004	0.0251
Q(4) test	10.316**	1.0772	1.6357
JB test	82.683***	52.341***	60.754***

Note: *, ** and *** stands for significance at the 10%, 5%, and 1% level. "Q(z) test" is the Ljung-Box test statistic (Ljung and Box, 1978) for autocorrelation up to zth order. "JB test" is the Jarque Bera test statistic (Jarque and Bera, 1987) for residual normality. LWZ is the modified Schwarz criterion of Liu *et al.*, 1997. The significance level of the sup-F tests were computed using the algorithm in Bai and Perron (1998 and 2003), using 1000 replications with Wiener processes of sample size 500.

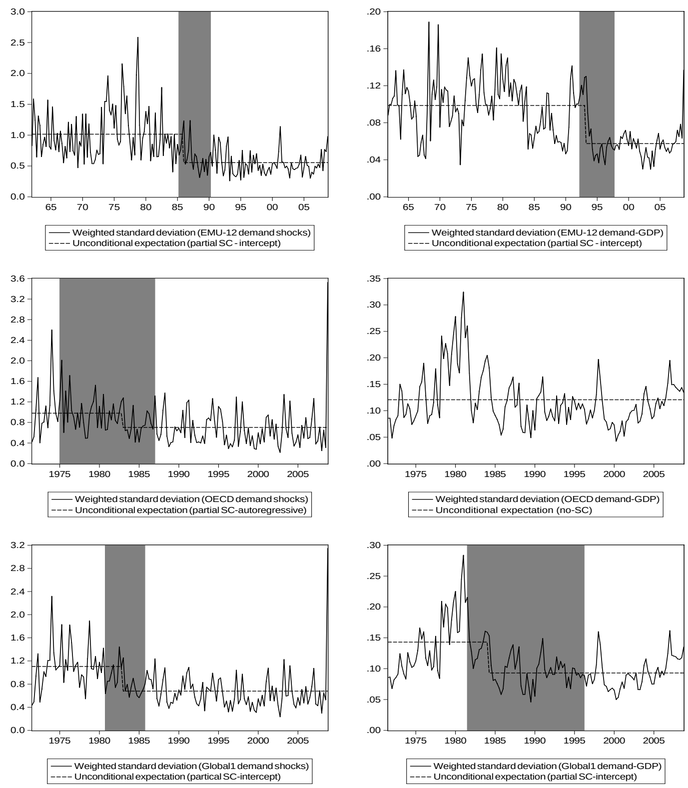


Figure 9: Dispersion regimes in EMU, OECD and Global1 $\mathbf{E}[S_t|\hat{T}_1, R_j, j = 1, 2]$ and 95% conf. interval

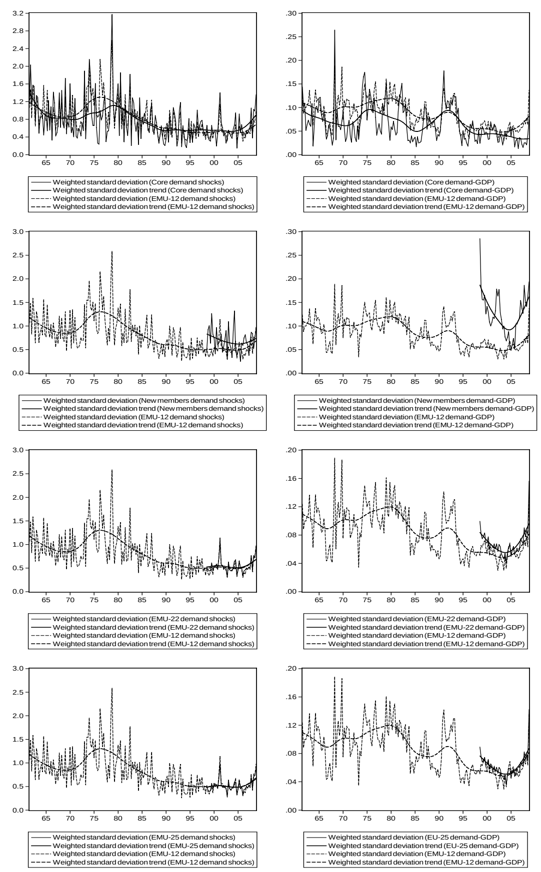


Figure 10: Dispersion in demand shocks and demand-GDP: Core, Enlargement group, EMU-22, EU-25

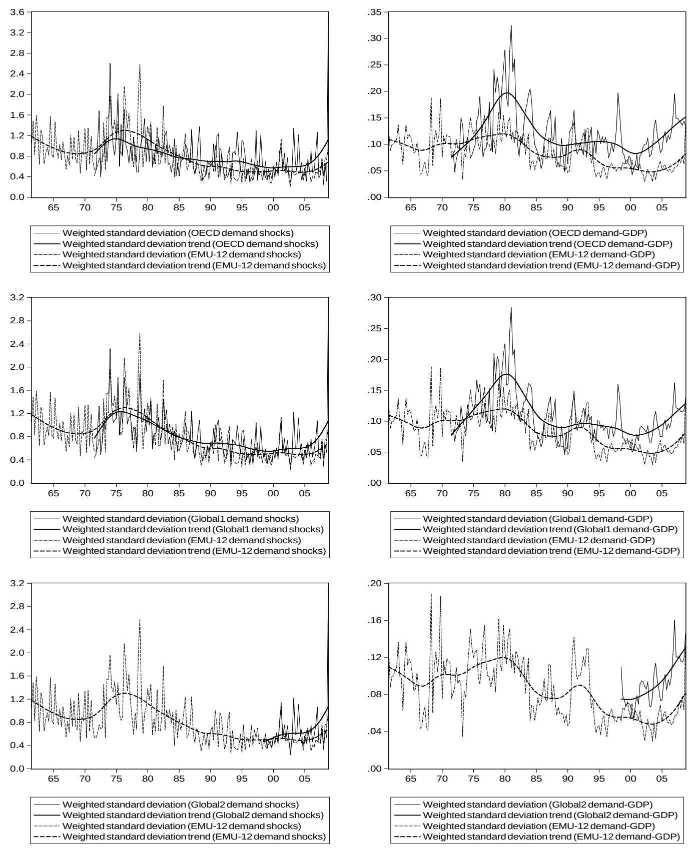


Figure 11: Dispersion in demand shocks and demand-GDP: OECD, Global1, Global2

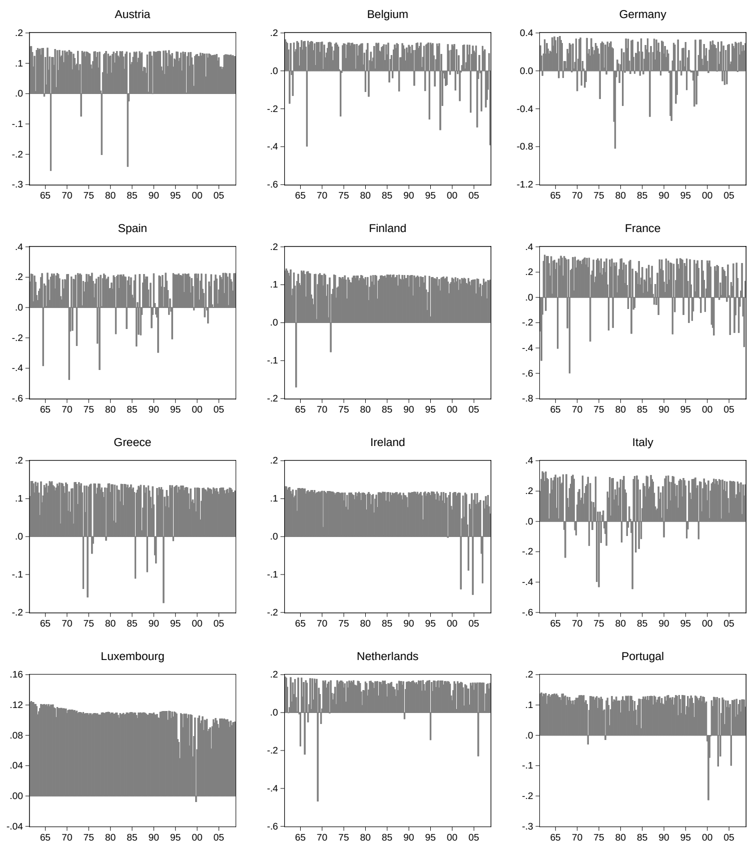


Figure 12: Cost of inclusion of a country: EMU (weighted, demand shocks)

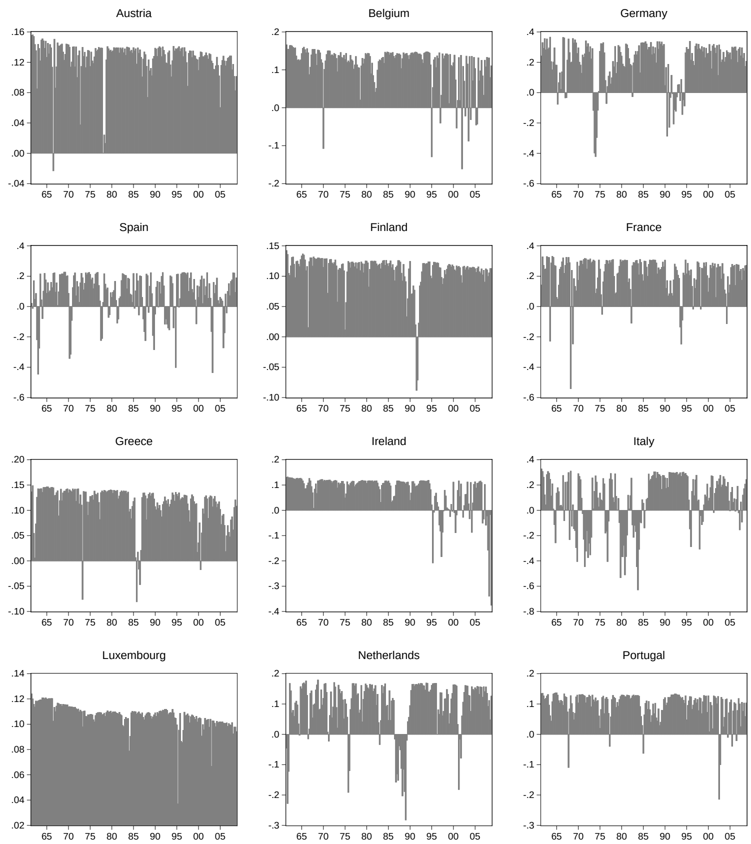


Figure 13: Cost of inclusion of a country: EMU (weighted, demand-GDP)

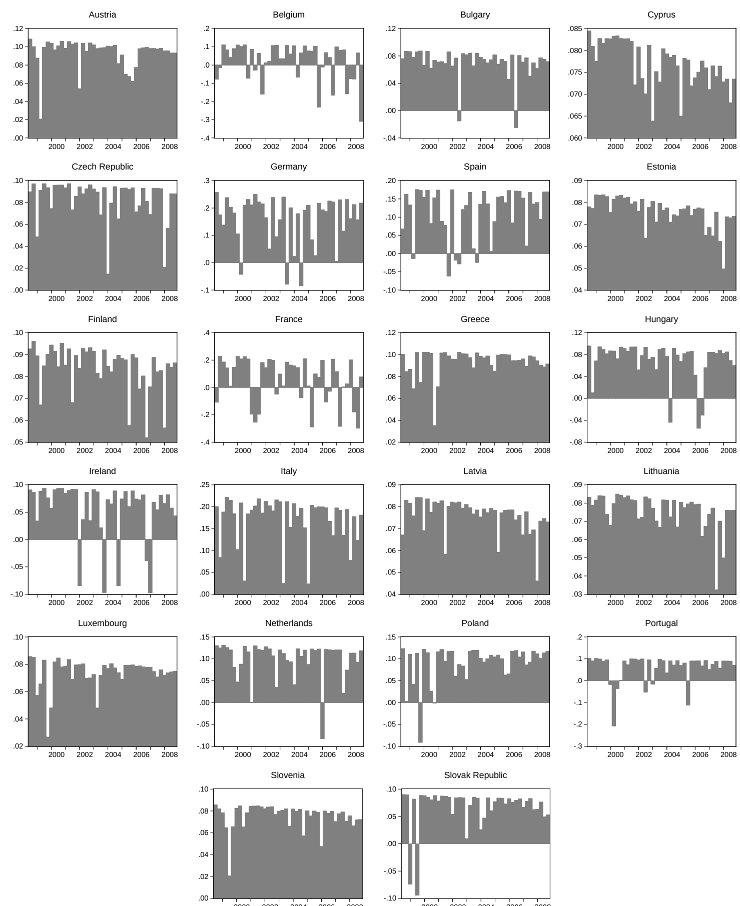


Figure 14: Cost of inclusion of a country: EMU-22 (weighted, demand shocks)

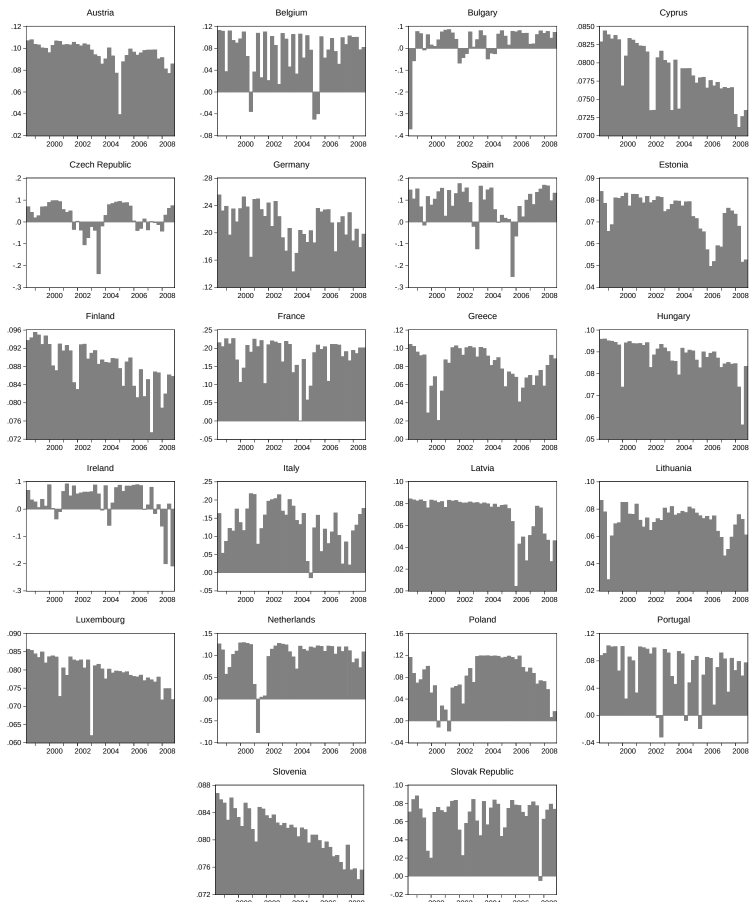


Figure 15: Cost of inclusion of a country: EMU-22 (weighted, demand-GDP)

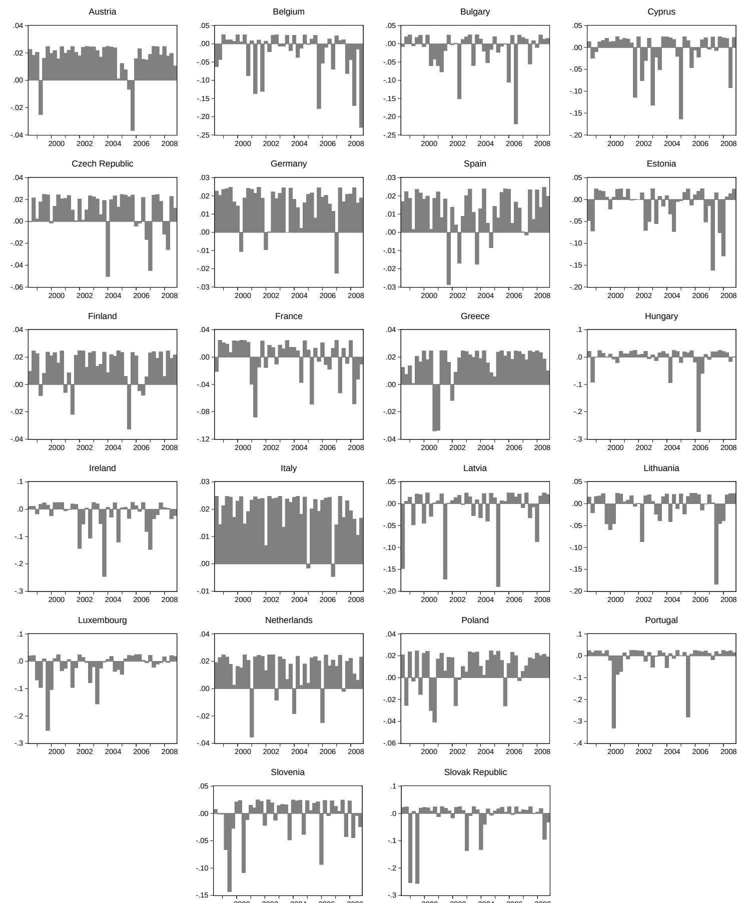


Figure 16: Cost of inclusion of a country: EMU-22 (unweighted, demand shocks)

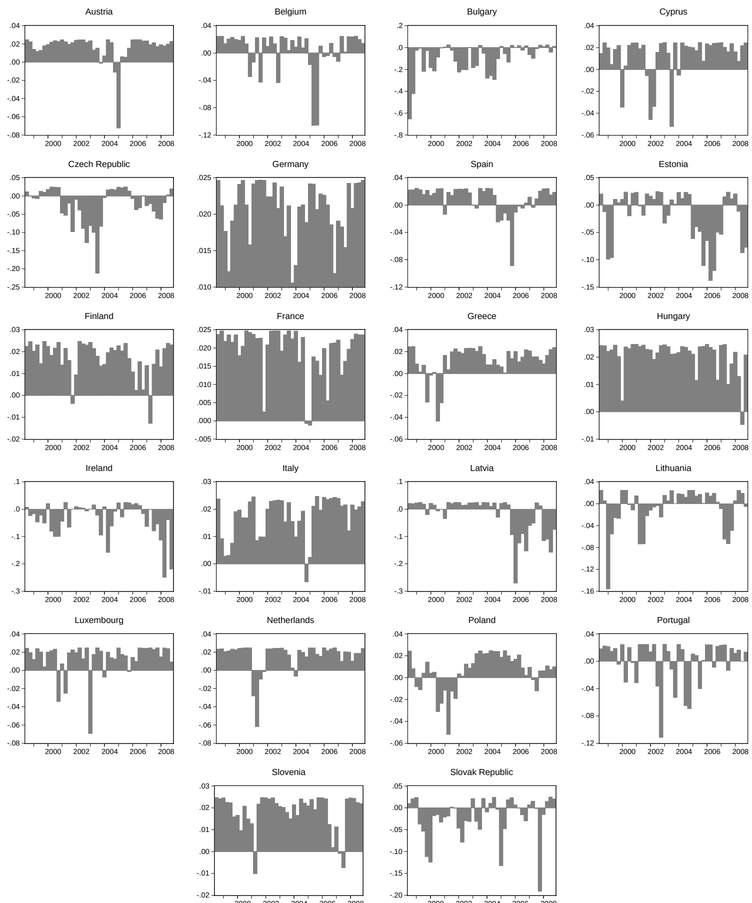


Figure 17: Cost of inclusion of a country: EMU-22 (unweighted, demand-GDP)

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Jesús Crespo-Cuaresma and Octavio Fernández-Amador

Business cycle convergence in EMU: A second look at the second moment

Abstract

We analyse the dynamics of the standard deviation of demand shocks and of the demand component of GDP across countries in the European Monetary Union (EMU). This analysis allows us to evaluate the patterns of cyclical comovement in EMU and put them in contrast to the cyclical performance of the new members of the EU and other OECD countries. We use the methodology put forward in Crespo-Cuaresma and Fernández-Amador (2010), which makes use of sigma-convergence methods to identify synchronization patterns in business cycles. The Eurozone has converged to a stable lower level of dispersion across business cycles during the end of the 80s and the beginning of the 90s. The new EU members have also experienced a strong pattern of convergence from 1998 to 2005, when a strong divergence trend appears. An enlargement of the EMU to 22 members would not decrease its optimality as a currency area. There is evidence for some European idiosyncrasy as opposed to a world-wide comovement.

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