Business Cycles Synchronisations in the Eurozone:
A Dynamic Factor Model Approach

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Abstract

Before the establishment of the Eurozone, it was criticised as a non-optimal single currency according to the Optimal Currency Area theory, such that the occurrence of 'one size fits all' monetary policy issue would be potentially problematic in the single currency area. However, there were also theories suggesting that the intra-trade and economic integration among members can improve the co-movements of cycles; therefore, different countries will be more likely be subject to common patterns of economic shocks. This would indicate that the appropriateness of the ECB's single monetary policy could be improved after the granting of eurozone membership. Consequently, this paper investigates the outcome of these competing forces through examining the synchronisation of business cycles in the Eurozone. By adopting the Dynamic Factor Model (DFM), we are able to investigate the synchronisation of individual business cycles against the EMU common trend by considering the data from members' nation level aggregates, whereby the common trend of the eurozone cycles is captured by the unobservable common factor for all observations. This method enable us to employ the time series data for consideration of each member's growth dynamic, but without falling into the problem of low degrees of freedom which is a common issue for the research of eurozone macroeconomics. The results suggest an imbalance of business cycle synchronisation between Eurozone members, particularly for those countries which were badly suffered during the current eurozone crisis (i.e. Greece, Ireland and Portugal). Hence, it this study tentatively suggests that it would appear optimal for a number of countries to exit the eurozone.

Key words: business cycles synchronisation, dynamic factor model, Eurozone,

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I. Introduction

The EMU is criticised as a non-optimal currency area. This is partially due to the heterogeneity of economic structures among member countries. This implies the different reactions at each domestic market to a common union policy, and different impacts on the domestic macroeconomic performance due to a common external shock. Therefore, the business cycles of the EMU members might also remain heterogeneous across the EMU. For instance, countries in an upward phase of the cycle may prefer a relative tight monetary measure; in contrast, countries in a downward phase of the cycle may need more expansionary monetary policy. Hence, if business cycles for currency union members remain or moving toward divergence, the union wide monetary policy is unlikely to be optimal to the large majority of the EMU members, even when the MTM is homogenous (Artis et al 2004, Grauwe 2005, Savva et al 2010).

However, the current development in the theory of OCA (mainly influenced by Frankel and Rose 1998) have suggested that the economic structures can be dramatically changed due to participation in the currency union -- known as *endogeneity of OCA hypothesis*. The argument is that cycles will tend to be more synchronised due to the increasing in the trade, if the intra-industry trade dominates the inter-industry trade. This argument favours the original OCA theory that is developed based on the classical and monetarists ideas, which is mainly contributed by Mundell and Fridman in 1950s and 1960s (Cesarano 2006). The modern view of OCA theory suggests that due to the economic integration members will tend to share the same, or, at least very similar business cycles. Therefore, different countries will more likely subject to common patterns of economic shocks. Moreover, due to the synchronisation of business cycles across the currency union, the fluctuations of prices also tend to be the similar among members. This indicates that the cross-country relative prices are constant, therefore, the exchange rate policy is not needed. Indeed, trade intensity is found to lead to more synchronization within the euro area.

Hence, if evidence of business cycles convergence existed in the euro area, we may say that the centralised monetary policy is likely to be optimal, and dependence of domestic fiscal instruments may become lower among the EMU members. Although, many previous studies have suggest that the business cycles in the euro area have become more similar (Fatás 1997, Artis and Zhang 1995 & 1999, Agresti and Mojon 2001, Belo 2001, Monfort et al. 2003, Altavilla 2004, Darvas and Szapary 2004, Enders et al. 2010, Siedschlag and Tondl 2011). However, other previous works argued that the business cycles of many euro countries are still substantially out of sync, and has no strong evidence support the argument of a European business cycle (Kose et al. 2003, Kaufman 2003, Artis et al. 2004, Darvas and Szpary 2004, Massmann and Micthell 2004, Camacho et al. 2008, Giannone et al. 2010, Lee 2012, Lehwald 2012). Because of the relative short history of the EMU, above results are mainly draw from the literature that are focused on the pre-EMU period. Therefore, the above conclusions, which mainly based on members experience before the adaptation of single currency, can be considered as a misleading representation of about what actually happed during the first decade of the currency union. Thus, the actual picture of cyclical convergence over the first decade needs to be studied.

II. Literature Review

The modern view of OCA theory has a quite influential status that emphasise on the view point of the positive relation between monetary integration and economic convergence in EMU. This 'optimistic view' is raised by the Frankel and Rose (1997) which argues that further economic and monetary integration can lead to less divergence among members of a currency union. In other words, the business cycles synchronisation will improve among member states after the creation of the union, therefore, the cost of not having their own national level monetary policy that could be used for adjust internal imbalance is minimised. In favour of pro-EMU supporters, this theory can be interpreted as that if a country enters a common currency area, even if it did not satisfy the criteria ex ante, eventually through economic integration it can satisfy it ex post. This argument implies that even if the EMU is established with non-optimal members, it will still shift towards to an optimal currency area through continued economic interaction, and the single monetary policy is more likely to be union wide appropriate.

This theory is known as endogeneity hypothesis of OCA. Frankel and Rose (1997) points out that as the creation of the currency union and remove of trading barriers (such as remove custom and border control, remove of exchange rate uncertainty and transaction cots etc.), the correlation among movements of key business cycle variables (e.g. GDP, consumption, industrial production etc.) will increase if intra-trades take the most part of trading pattern or common demand shocks prevail. Their theory implies that the international trade pattern and international business cycle correlation are endogenous and based on the forward looking model. The principle foundation of the endogeneity hypothesis build upon on the Lucas critique (Lucas 1976) which states that a prediction based on historical data, especially highly aggregated data, would be invalid if the relationship between relevant variables can be altered by conducting of economic policies. If the policy change alters the relationship between the variables, then the future relationship between the variables may not be fully represented by the historical relationship.

In summary, according to the pro-EMU theory (Frankel and Rose 1997, Frankel 1999, de Grauwe and Mongelli 2005), countries which have a close relationship of trading will have high inter-dependence of each one's national income. Thus, they may able to consider forming a currency union according to endogeneity hypothesis, and the correlation of business cycles should improve since it is closely related to the trade integration between members. This implies that the high level of intra-trade in the Europe would enforce the synchronisation of business cycles, which eventually can lead the Europe to become a common currency area.

Beine et al. (2003), who applied a time series VAR model with 23 years monthly IP data of a group of EMU countries (Austria, Belgium, France, Germany and the Netherlands), found that the common cyclical movements do not exist among these countries. That, in turn, implies these key members of EMU do not constitute an OCA area. The later work of Artis (2004) also reaches a conclusion that is not in favour of supports of the EMU. In addition to this, by using GDP as the indicator of synchronisation, the results of this paper contradicted with his previous work (Artis and Zhang 1997 & 1999). The author discovered that actually among European countries, many countries they do not move along a similar phase of cycles; therefore, the European business cycle is rather an elusive phenomenon. However, Kaufman (2003) has a contradictive result with Beine et al. (2003). He also used the IP and point out that the European countries are coherent group according the cyclical movements.

Monfort et al. (2003) adopt the DFM with selection of quarterly GDP for G7 countries over 22 years period between 1970 and 2002. He points out that among these countries (France, Germany and Italy) form a coherent area distinct from the others. This result is in line with the paper of Lumsdaine and Prasad (2003), which use a large monthly IP data from 1963 to 1994, states that for EMU countries the correlation with European component is much stronger than the world component. Mansour (2003) estiamtes the annual GDP growth for 113 countries by using DFM, and show that European factor is generally weaker the world factor. However, he also made positive conclusion about the EMU that is the EU is the most integrated region than others. In contrast, Kose et al. (2003), which uses variable of output and its key components (consumption and investment) with a similar time period as Lumsdaine and Prasad (2003), made a different conclusion. The author shows that the common European factors only have minor impact on the fluctuations of European aggregates. This implies that here has no evidence of a European cycle.

Siedschlag and Tondl (2011) analyse the impact of trade integration and specialisation on the business cycles synchronisation in the EMU. The result of this paper supports the optimistic view of the euro area. These authors show that the deeper trade integration with the euro Area had a pronounced direct positive effect on the synchronisation of regional output growth within the euro area. Industrial specialisation, which is the result of monetary integration, was sources of cyclical divergence. However, it also had an indirect positive effect on regional output growth synchronisation via its positive effect on trade integration. Giannone et al. (2010) and Lehwald (2012) have reached similar conclusions that emphasise on the business cycles convergence has actually diverged between the core and periphery groups. The synchronisations of main macroeconomic variables have increased in core area of the EMU since the creation of the union. Whereas, inside the periphery group the co-movements of key variables were declined during the post-EMU period. Lee (2012) also had unfavourable results to the euro area. His finding is that output and inflation among EMU members was moving towards to synchronisation during the run-up period of the euro area. However, there is little evidence to show the EMU factor is still prevailed after the operation of single currency.

Overall, the evidences on the business cycle synchronization in the euro area are mixed and it partly depends on the periods distinguished and the benchmark that is used. However, most of the current evidence suggests that periods of greater and lesser synchronization tend to alternate. Still, there is quite some evidence that during the 1990s, business cycle synchronization in the euro area has increased.

III. Methodology – *Dynamic Factor Model*

For this particular research, we aim to investigate the synchronisation of the euro zone business cycles. Since, the euro zone only has relative short history and the data availability is rather unbalanced across different member countries. The problem of low level of observations of business cycles variables may not be avoidable. The Macroeconomic related researches usually face the problem of data availability, especially, in terms of numbers of observation. Since the post-war period, there are many series of variables has become available which across the different fields of macroeconomics. However, regardless the sizes of series, the number of observations of this macroeconomic series are relatively short. They are either in annual form e.g. 20 to 40 years, or in quarterly format that provides relatively large data set. This fundamental issue of macroeconomic research may only be eliminated through the passage of time. In the short term, it still remains crucial to our works; especially, when we need study the dynamics of macroeconomic phenomena and policies.

In terms of methods of research, despite the correlation approach is one of the most widely used method in this field ((Artis and Zhang 1995, Belo 2001, Fidrmuc and Korhonen 2003, Darvas and Szapáry 2005, Gayer 2007, Levasseur 2008, Kappler et al. 2008, Gouveia and Correia 2008, Gogas and Kothroulas 2009); however, it also suffers several drawbacks. First, correlation coefficient must be estimated at a sub-period of sample. This means different sub-periods could lead to very different estimates of the euro effect on business cycle synchronisation (Artis and Zhang 1997 & 1999, Inklaar and de Haan 2005). Second, it does not allow for a separation of idiosyncratic components and common co-movements. Third, it is basically a static analysis that fails to capture any dynamics in the co-movement. Furthermore, in addition to these important drawbacks of correlation approach, for this study which we try to discover the business cycles synchronisation for the euro zone as whole, rather than looking at a bivariate correlation of a pair of countries. In order to overcome the problem of relative short data set of the euro zone countries, and conduct an analysis for the entire EMU; we can adopt the Dynamic Factor Model (DFM) approach to conducting this analysis.

DFM has some advantages than other methods in various respects (Forni et al 2000, Lehwald 2012). First, factor models can cope with many variables without running into scarce degrees of freedom problems often faced in regression-based analyses. Exploiting a lot of information can lead to more precise forecasts and macroeconomic analyses. A second advantage of factor models is that idiosyncratic movements, which possibly include measurement error and local shocks, can be eliminated. This yields a more reliable signal for policy makers and prevents them from reacting to idiosyncratic movements. The final advantage is that factor model can remain agnostic about the structure of the economy. This means the analysis does not need to rely on tight assumptions, which is sometimes the case in structural models.

There are two main approaches of DFM: the linear space model and the generalised dynamic factor model. Those are usually also known as parametric (first generation) and nonparametric (second generation) models of DFM (Stock 2010). The former through linear state space model use the Kalman filter to compute the Gaussian likelihood, and the parameters are estimated by maximum likelihood, then the Kalman filter is used to obtain efficient estimates of the factors (Stock and Watson 1989, Sargent 1989, and Quah and Sargent 1993). This approach provides optimal estimates of the latent factors. However, the main drawback is that this model usually only capable to handle relative small number of parameters and series. The second generation (Forni and Reichlin 1998) of estimators entailed nonparametric estimation with large *N* using cross-sectional averaging methods, primarily through principal components methods. The key result in this approach is that the principal components estimator of the space spanned by the factors is consistent. Moreover, if *N* is sufficiently large, the factors are estimated precisely enough to be treated as data in subsequent regressions. The main disadvantage of this approach is that this model necessitates a very large number of cross sections of idiosyncratic components in order to be valid.

For empirical studies, there has no evidence of which approach is superior to another. The principle for selecting the appropriate approach should follow the feature of these two methods, which are the size of cross-sections. The nonparametric method of DFM is the common choice among the recent studies on the synchronisation of euro zone business cycles (Giannone et al. 2010, Siedschlag and Tondl 2011, Lehwald 2012, Lee 2012). However, those authors have not given any justifications for not selecting the first generation of DFM. Similar studies which focus on the G7 and East Asia area (Monfort et al. 2003 and Moneta and Rüffer 2009) adoptes the parametric method, and have shown the evidence of capability of parametric methods on the research which focus on dozens of countries. Thus, in this paper, we will follow the methods of Monfort et al. (2003) and Moneta and Rüffer (2009) employ the first generation approach of DFM for our analysis.

Since we are following the Monfort et al. (2003) and Moneta and Rüffer (2009) by adopting the liner state space model for DFM approach, therefore the model can be written as[1]:

$$\begin{aligned} Y_t &= AY_{t-1} + BF_t + \varepsilon_t \\ F_t &= CF_{t-1} + \eta_t \end{aligned} \qquad \textbf{Equation 1}$$

The variance-covariance matrix of the error term ε is assumed to be diagonal:

[1] Details of the model is available in appendix.

$$V[\varepsilon]=\begin{bmatrix}\sigma_1^2 & & & 0 \\ & \cdot & & \\ & & \cdot & \\ & & & \cdot \\ 0 & & & \sigma_n^2\end{bmatrix}$$

This model assumes that the cross-section of n stationary series Y_t is depends on the country specific autoregressive component of order one; there are *k* unobservable factor F_t which common to all series; the ε_t and η_t are independent Gaussian white noise term. The matrix *B* is fator loadings which measures the impact of common factors on each series of Y_i. Matrix *A* is assumed to be diagonal, therefore, it capturing the core notion of the DFM that the comovements of the multiple time series arise from *F*. For the second equation of the state space model, the C matrix is also set to be diagonal which ensure the dynamics of the unobservable factors *f* is univariate.

The specification for this model is that the matrix A in **Equation 1** is set to be diagonal, and there is one common factor which can be used to capture the co-movements of Euro12 members business cycles. This setting of the model restricts each country's real GDP growth at time t only depends on its own previous lag. The co-movement of real GDP growth fluctuations among Euro12 members, which may be the result of common shocks or a spill-over effects between members, are captured by the common factor F. Hence, although the model does not directly measure the inter-linkage among members' economic activities; however, we do assume the spill-over effects exist in the union.

In terms of the data, the most widely used variables for measuring synchronisation of business cycles are data on GDP and industrial production. The GDP is usually collected in quarterly bases and it is common to include the components GDP in data such as consumption, investment, or exports. For measuring the synchronisation of cycles, here has no consensus view on which particular variable is absolute superior to others. For this research, we aim to investigate the synchronisation of business cycles for the Eurozone members after the establishment of the EMU. Since those new members of Eurozone are all joined the EMU recently; therefore, we will only concentrate on the original 12 members of the Eurozone (Euro12), which are Austria, Belgium, France, Finland, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. Overall economic activity for Euro12 countries is measured in quarterly real GDP growth rate which is provide by the Main Economic Indicators from OECD. Data period for real GDP growth is from 1985:Q1 to 2012:Q2.

IV. Empirical Results

In this section, we will present the results from Dynamic factor Model (DFM) analysis to evaluate to what extent the individual aggregate economic activities of each member can be explains by the common factor of the whole union; hence, to investigate the degree of synchronisation of the Eurozone original 12 members' (Euro12) business cycles. The initial step of the analysis in this paper is to estimate the common factor for Euro12's real GDP growth by using the DFM which specified in previous section.

By using the DFM method, we have obtained the initial estimates of the parameters for the **Equation 1** by using real GDP growth for all Euro12 members between the period 1985:Q1 to 1998:Q4. The estimation of this time period is to help us establish a comparison benchmark, which later can be used to compare with the results for EMU stage3 period, to see whether there has any evidence of improvements of business synchronisation inside the Eurozone.

In Table 1, we present results for the parameters estimation of DFM. The coefficients for idiosyncratic autoregressive α_i is significant for most of the series expect France, Portugal and Spain. Furthermore, the factor loading β_i for the Euro12 common factor are statistically significant for most members beside the Luxembourg. This indicates that the dynamic of economic growth among most euro12 members are depends on both of their own autoregressive elements and the Euro12 common factor.

Table 1

Parameter estimation for DFM – Euro12 members' real GDP growth (1985:Q1 to 1998:Q4)

	α	β
Austria	0.814 (0.000)	0.399 (0.000)
Belgium	0.648 (0.000)	0.508 (0.000)
Finland	0.895 (0.000)	0.511 (0.004)
France	0.820 (0.695)	0.468 (0.000)
Germany	0.804 (0.000)	0.471 (0.000)
Greece	0.290 (0.025)	0.375 (0.000)
Ireland	0.933 (0.000)	0.469 (0.070)
Italy	0.653 (0.000)	0.399 (0.000)
Luxembourg	0.918 (0.000)	0.205 (0.635)
Netherlands	0.755 (0.000)	0.562 (0.000)
Portugal	0.009 (0.973)	0.795 (0.000)
Spain	0.079 (0.686)	0.643 (0.000)
	c	
common factor *F*	0.980 (0.000)	

$Y_{i,t} = \alpha_i Y_{t-1} + \beta_i F_t + \varepsilon_{it}$

$F_t = cF_{t-1} + \eta_t$

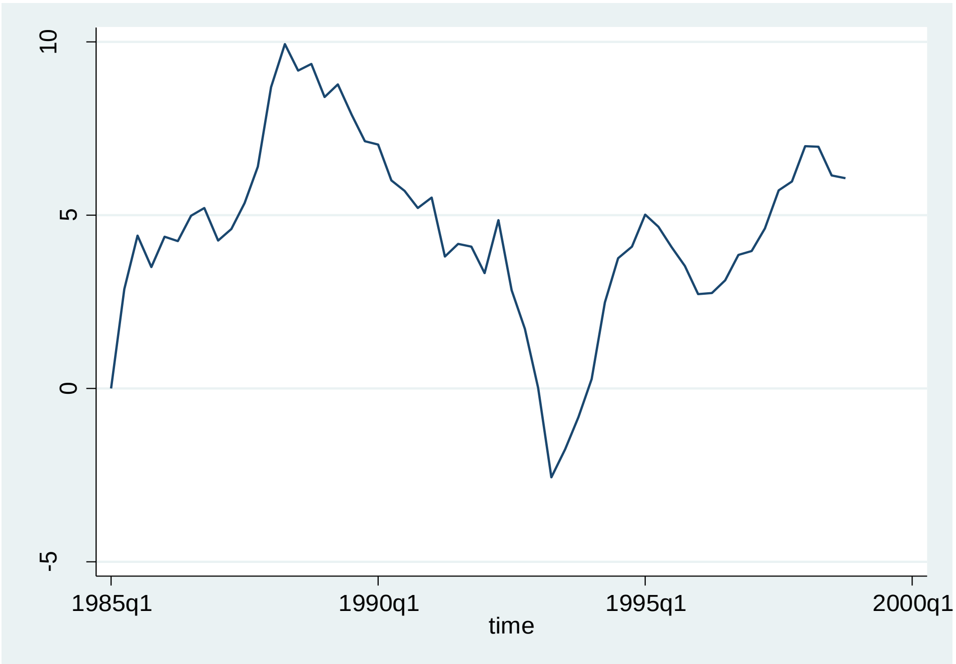
Note: numbers in the bracket is the *p*-value

The common factor for Euro12, which can capture the co-movements of all series in this dataset, can be used to identify the dynamic of economic growth for the

Euro12 as a whole by plotting it against the time variable. In Figure 1 we can identify a clear economic downturn during the early of 1990s. This common recession was triggered by the rising oil price which is caused by the first Gulf war, and rising real interest rates in Europe due to the re-unification of Germany as the Bundesbank responded to the expansionary fiscal policy in Germany by increasing its interest rate. Furthermore, during the autumn 1992 and summer 1993 the recession culminated in Europe as the result of the ERM crisis (Jonung and Hagberg 2005).

Figure 1

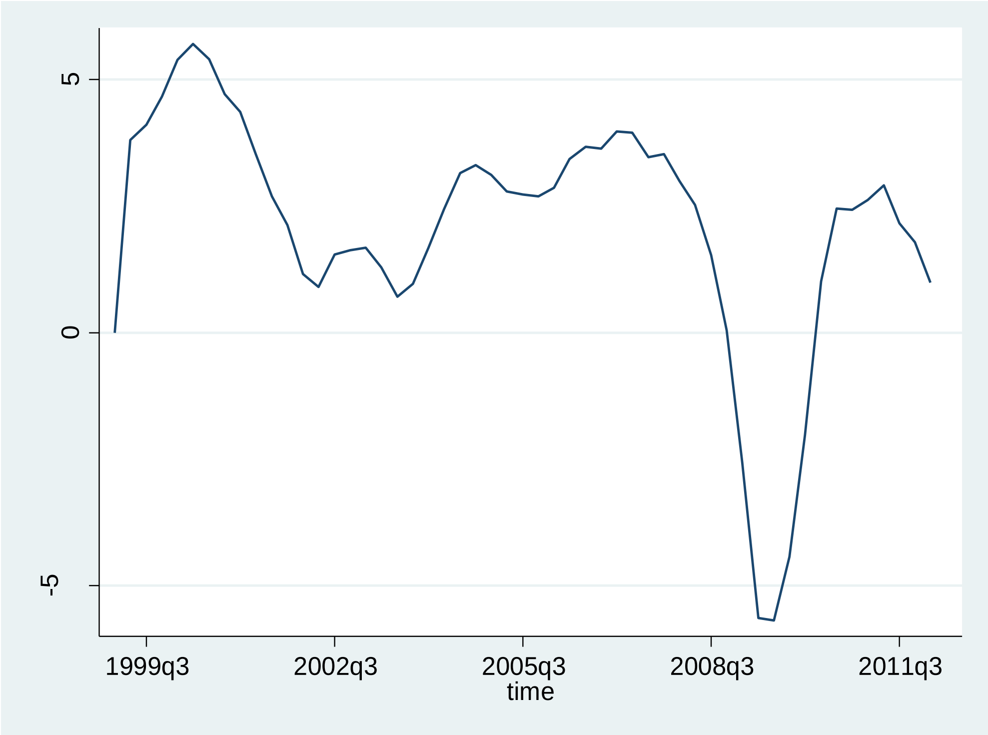
Common factor for Euro12 real GDP growth (1985:Q1 to 1998Q4)



In order to carry out the comparison of the results of both pre and post-EMU, we keep same setting of DFM and run the estimation again for period 1999:Q1 to 2012:Q2. Again, by plotting the common factors for post-EMU period (see Figure **2**), we can clearly identify a significant drop in the dynamic of growth since the 2007, which reflecting the recent late 2000s global financial crisis. And, here is another minor decline in the level of economic growth for the Euro12 during the begging of stage 3 of EMU, which may reflect of burst of IT bubble in early 2000s.

Figure 2

Common factor for Euro12 real GDP growth (1999:Q1 to 2012:Q2)



In Table 2 we present the estimation of parameters for the model by looking into the period of post-EMU. Expect France, the dynamic of growth for all members of Euro12 can be explained by their own autoregressive element. The coefficients for each country's factor loading are significant, but not the case for Greece. The interesting part of Table 2 is that besides Portugal and Spain the values of factor loading β_i are general much higher than the values in Table 1. Although, for Portugal and Spain, the factor loading dropped; however, the degree of falling in value is small. Moreover, the coefficient of factor loading for Greece is statistically insignificant. This result may provide initial evidence, which suggest that for the Euro12 the synchronisation of cycles may be improved during the stage 3 of EMU. However, before making any conclusion, we need to do few more tests by using the results which are obtained through DFM analysis.

Table 2

Parameter estimation for DFM – Euro12 members' real GDP growth (1999:Q1 to 2012:Q2)

	α	β
Austria	0.773	0.805
	(0.000)	(0.000)
Belgium	0.757	0.780
	(0.000)	(0.000)
Finland	0.526	1.248
	(0.000)	(0.000)
France	0.286	0.685
	(0.127)	(0.000)
Germany	0.961	1.161
	(0.000)	(0.000)
Greece	0.890	0.321
	(0.000)	(0.214)
Ireland	0.543	1.450
	(0.000)	(0.000)
Italy	0.961	0.960
	(0.000)	(0.000)
Luxembourg	0.302	1.457
	(0.036)	(0.000)
Netherlands	0.844	0.817
	(0.000)	(0.000)
Portugal	0.778	0.599
	(0.000)	(0.000)
Spain	0.972	0.553
	(0.000)	(0.000)
	c	
common factor *F*	0.950	
	(0.000)	

$Y_{i,t} = \alpha_i Y_{t-1} + \beta_i F_t + \varepsilon_{it}$

$F_t = cF_{t-1} + \eta_t$

Note: numbers in the bracket is the *p*-value

Table 3

Cross-countries correlation (1985:Q1 to 1998:Q4)

	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	*F*
Austria	1.000												
Belgium	0.585	1.000											
Finland	0.068	0.451	1.000										
France	0.663	0.796	0.552	1.000									
Germany	0.722	0.515	-0.190	0.444	1.000								
Greece	0.303	0.424	0.159	0.380	0.177	1.000							
Ireland	0.233	0.329	0.484	0.285	0.041	0.134	1.000						
Italy	0.450	0.695	0.501	0.781	0.430	0.210	0.095	1.000					
Luxembourg	0.411	0.299	0.026	0.416	0.402	0.274	-0.341	0.313	1.000				
Netherlands	0.561	0.631	0.412	0.579	0.460	0.405	0.471	0.368	0.275	1.000			
Portugal	0.490	0.688	0.463	0.785	0.453	0.276	0.255	0.616	0.363	0.503	1.000		
Spain	0.537	0.707	0.417	0.731	0.458	0.371	0.199	0.536	0.432	0.530	0.883	1.000	
F	0.672	0.694	0.372	0.897	0.563	0.345	0.272	0.702	0.470	0.514	0.818	0.744	1.000

Table 4

Cross-countries correlation (1999:Q1 to 2012:Q2)

	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	*F*
Austria	1.000												
Belgium	0.933	1.000											
Finland	0.904	0.860	1.000										
France	0.917	0.925	0.910	1.000									
Germany	0.877	0.817	0.837	0.821	1.000								
Greece	0.266	0.306	0.337	0.379	0.056	1.000							
Ireland	0.697	0.709	0.684	0.814	0.477	0.551	1.000						
Italy	0.884	0.880	0.906	0.946	0.858	0.360	0.750	1.000					
Luxembourg	0.835	0.825	0.840	0.870	0.652	0.474	0.786	0.809	1.000				
Netherlands	0.895	0.874	0.853	0.894	0.804	0.428	0.729	0.838	0.830	1.000			
Portugal	0.669	0.705	0.689	0.767	0.568	0.507	0.696	0.746	0.823	0.810	1.000		
Spain	0.759	0.733	0.797	0.846	0.551	0.736	0.880	0.808	0.840	0.826	0.745	1.000	
F	0.856	0.808	0.867	0.865	0.765	0.398	0.751	0.863	0.779	0.875	0.642	0.851	1.000

First, we may run a simple cross-countries correlation test to generate a brief view on the co-movement among real GDP growth for each member of Euro12, and the correlation among common factor of Euro12 and individual countries economic activities. From Table 3 and Table 4, we can see that the cross-countries correlations about real GDP growth and common factors are generally increased across Euro12 members since the establishment of EMU. In Table 5, we can see the average value of cross-countries correlation of real GDP growth has improved significantly for each individual member. The lowest degree of improvement is Portugal, but it is increased by 34 present compare with post-EMU period. The average correlations for most Euro12 countries are between sixties and seventies. Nevertheless, for Greece, despite the improvement of average cross-countries correlations were improved by 41 present; however, the average correlation for post-EMU period is only 0.400. This is even lower than some countries' figures for pre-EMU period e.g. Austria, Belgium, France, Italy etc.

Table 5

Average cross-countries correlation for real GDP growth

	post-EMU	pre-EMU	improves
Austria	0.785	0.457	72%
Belgium	0.779	0.556	40%
Finland	0.783	0.304	158%
France	0.826	0.583	42%
Germany	0.665	0.356	87%
Greece	0.400	0.283	41%
Ireland	0.707	0.199	256%
Italy	0.798	0.454	76%
Luxembourg	0.780	0.261	199%
Netherlands	0.798	0.472	69%
Portugal	0.702	0.525	34%
Spain	0.781	0.545	43%

Note: average values are calculated from Table 3 and 4.

Moreover, since the co-movement of economic activities among Euro12 members are improved over last 12 years, this may indicate that the correlation between individual country's growths dynamic and common factor, which capture the co-movement of fluctuations of all Euro12 countries real GDP growth, should also being expect to increase. This is also can be seen from Table 3 and Table 4. The average value for correlation between Euro12 countries and common factor has increased from 0.589 to 0.777. And, not surprisingly, as the cross-countries correlations for real GDP growth are low in both pre and post-EMU periods for Greece; the correlation for Greek economic activities and Euro12 common factor only improved by 0.054 points.

The result of correlation analysis shows the co-movements of Euro12 countries economic activities has improved over the last twelve years. Moreover, the correlation between the common factor and individual member's growth dynamic are also increased between pre and post-EMU period. However, this only suggests that for most Euro12 members, their trends of economic growth are generally converging to the trend of Euro12. There could be the case of that the volatilities of common trend and individual trend are still insufficiently matching with each other. Therefore, even when EMU member is on similar trend as the Eurozone; but, because of the degree of fluctuations between individual and common trend remain different, we still cannot conclude that the synchronisation of business cycles has sufficiently improved for the Eurozone to conduct a union wide economic policy. This may be especially important to the policy makers. The policy designed for the union as a whole e.g. monetary policy, can be too radical for some country that may leads to increasing in the local price level. However, simultaneously it could insufficient for others, as the decline in their national output is far greater than union trend. Therefore, the correlation analysis may only provide some preliminary results for testing the degree of business cycles synchronisations in the Eurozone.

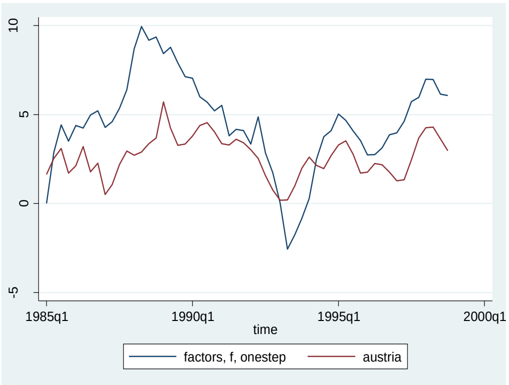
Since, it is necessary to go beyond than correlation analysis. In order to investigate the question of to what extent EMU members' national cycles are converged to the common trend for Eurozone. First, we can plot the common factor and national real GDP growth in a diagram; and this graphic analysis will be repeat twice for both pre and post-EMU period. Then, visually check the trends of each pair, to see besides sharing same direction of movements; whether the degree of their volatilities are also similar between euro12 common trend and national growth dynamics. This would allow us to quickly obtain some basic insights for synchronisation of business cycles.

Figure 3

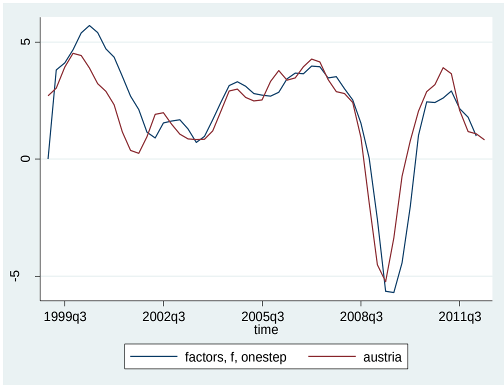
Euro 12 common factor VS individual members' real GDP growth – pre and post-EMU periods

Austria

Pre-EMU

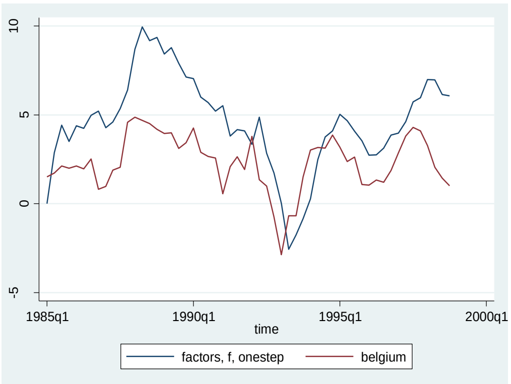


Post-EMU

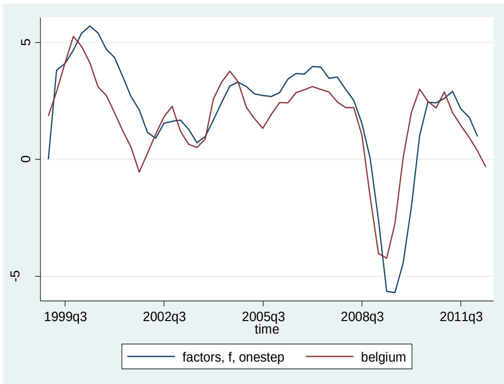


Belgium

Pre-EMU

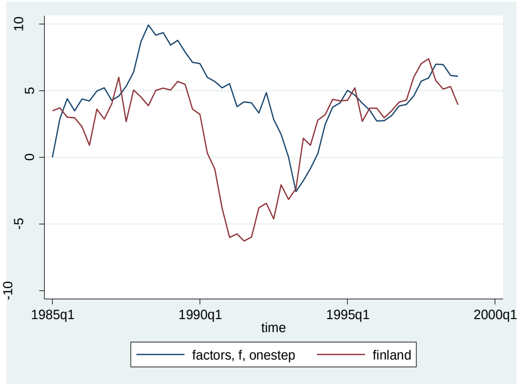


Post-EMU

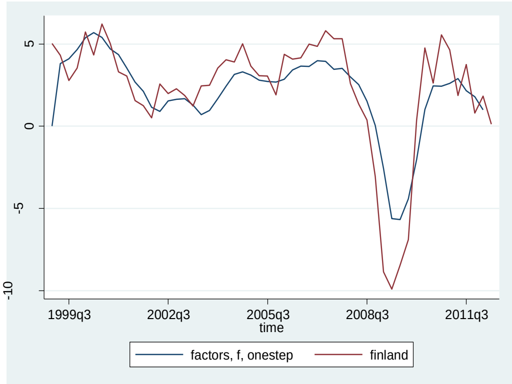


Finland

Pre-EMU

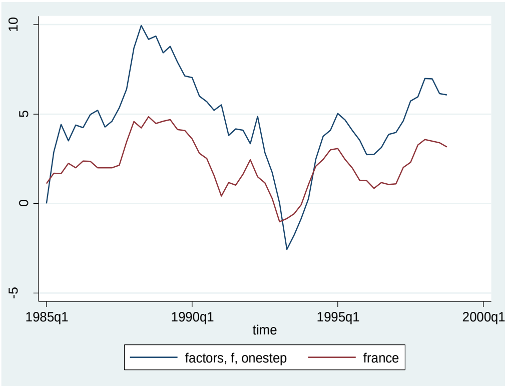


Post-EMU

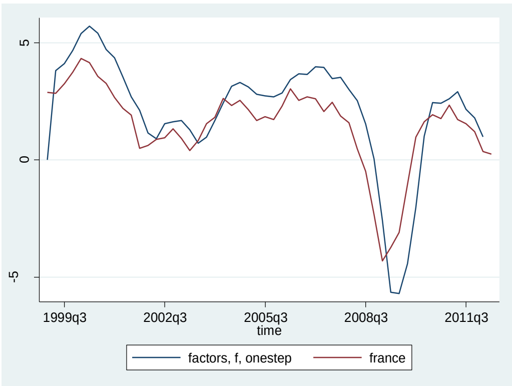


France

Pre-EMU

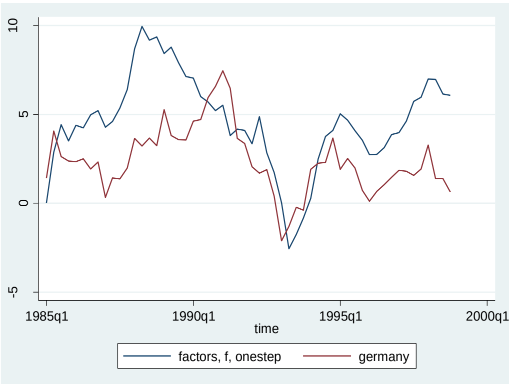


Post-EMU

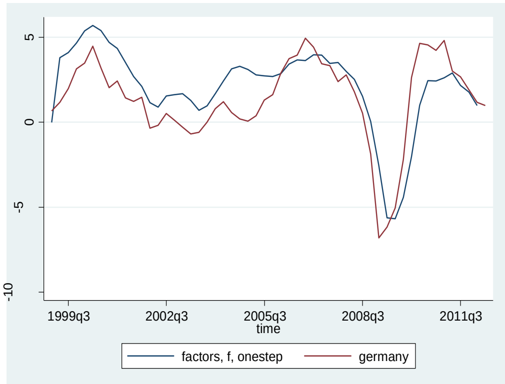


Germany

Pre-EMU

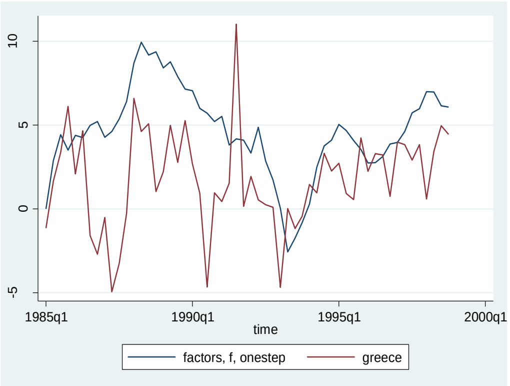


Post-EMU

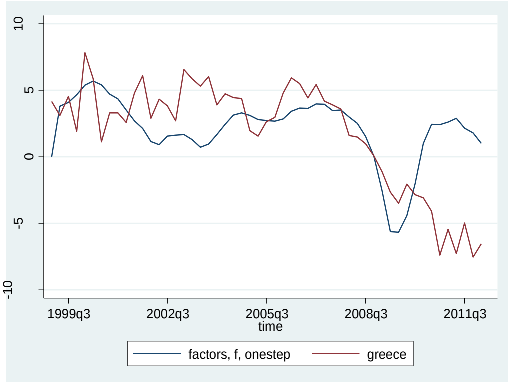


Greece

Pre-EMU

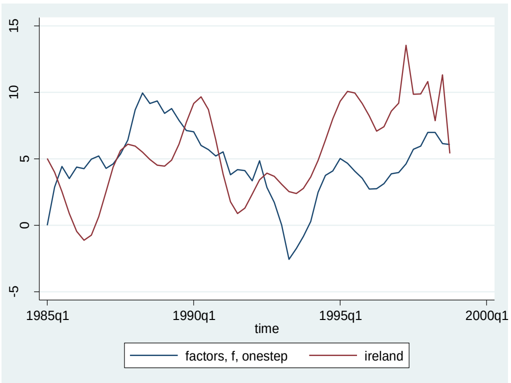


Post-EMU

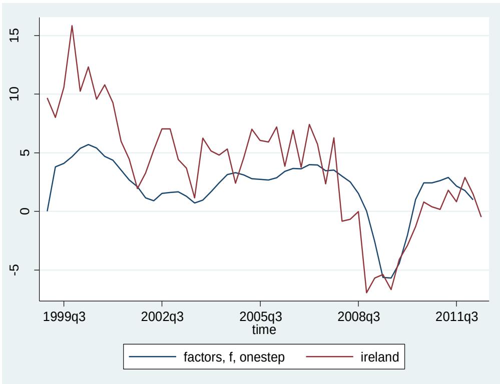


Ireland

Pre-EMU

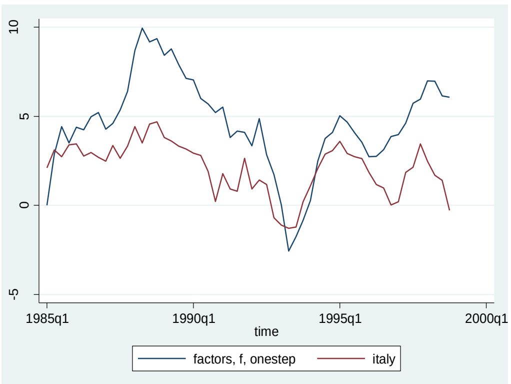


Post-EMU

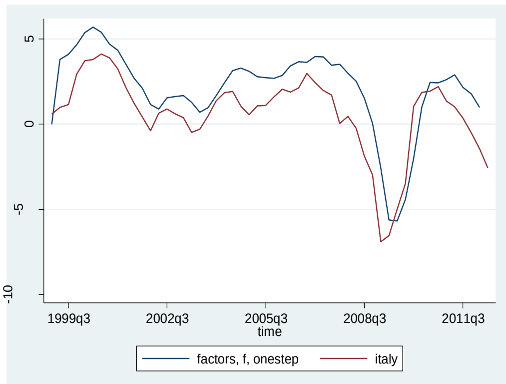


Italy

Pre-EMU

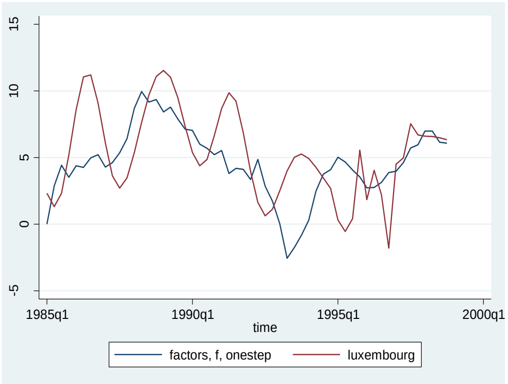


Post-EMU

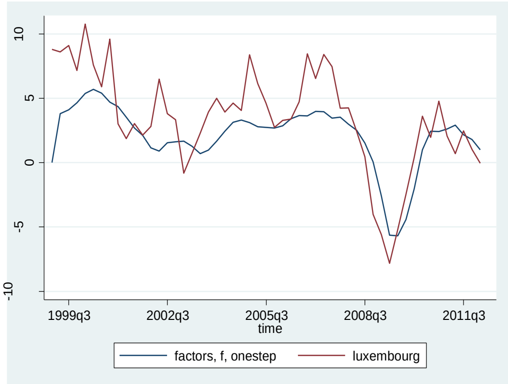


Luxembourg

Pre-EMU

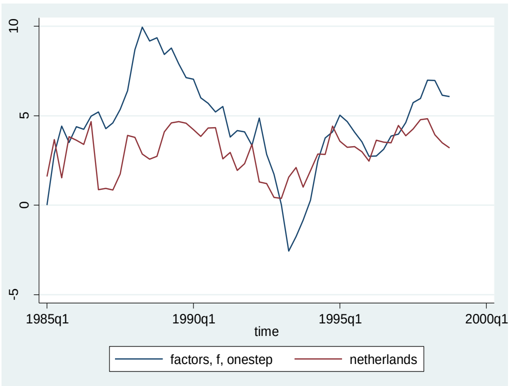


Post-EMU

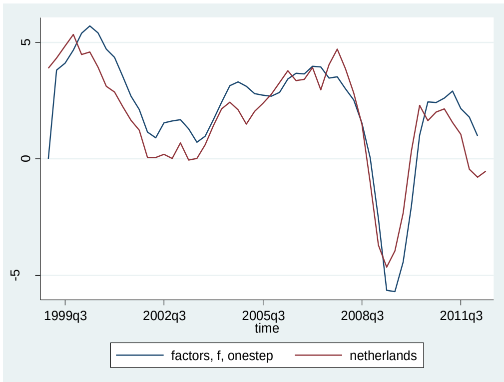


Netherlands

Pre-EMU

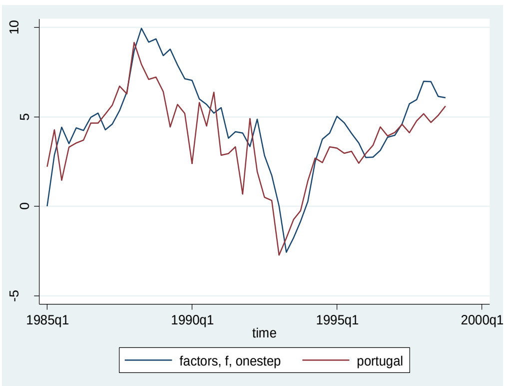


Post-EMU

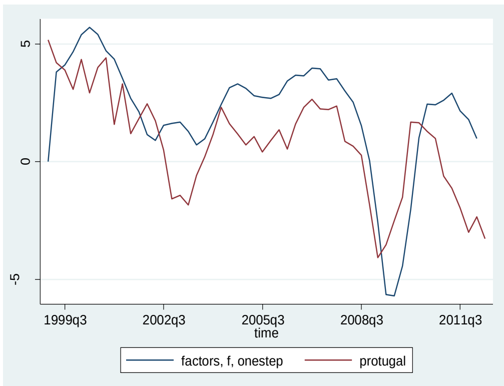


Portugal

Pre-EMU

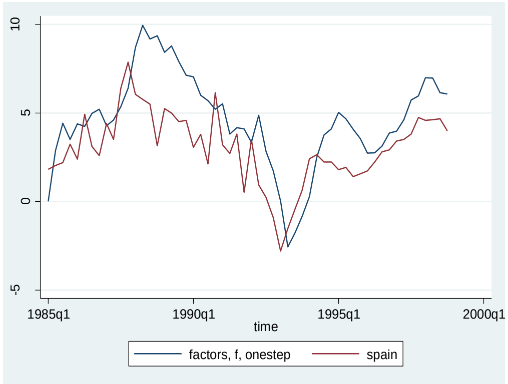


Post-EMU

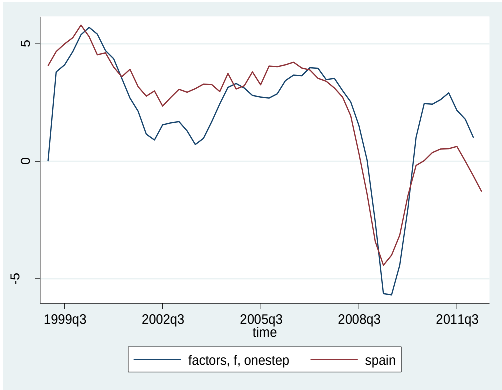


Spain

Pre-EMU



Post-EMU



Note: all diagrams are produced by the author

From Figure 3, it seems that the results are quit mixed. Generally, we could arrange Euro12 members into three groups. First group, since the creation of the Eurozone, the trend of movement of individual countries' real GDP growth and trend of common factor has become similar and the degree of fluctuations of these two lines are also in a close range. These countries are Austria, Belgium, France, Germany, Italy, Netherlands and Spain. The common feature of these countries is that the national trends and common trend were already sharing similar path. However, for each country, the volatilities of these two trends were quite different. Second group are made up by Finland, Ireland, Luxembourg and Portugal. The similarity and volatility of trends for second group was poor during the pre-EMU period. Since the establishment of the Eurozone, the similarity of trends has improved, but volatility of national trends still remain relative high to trend of Euro12 common factor. Finally, Greece forms the third group for Euro12 members.

During the both pre and post-EMU periods, graphically here is no evidence to suggest co-movement between national growth dynamics and Euro12 common trend. This also reflected by the results in Table 3 and Table 4, which show that there is only a minor improves in the level of correlations for Greece for both cross-countries real GDP growth and correlation with common trend. Another interesting finding from above figure is Portugal. Both correlation and graphic analysis shows that inside of like the most of other Euro12 countries which had improved in the similarity and volatility between trends. However, the co-movements between Portugal business cycle and Euro12 common trend are actually declined after the entry of the Eurozone. For the case of Greece and Portugal, the results may indicate that for a sub-part of the Eurozone, the membership of a common currency area did not improve the synchronisation of members' business cycles. Inside, it may lead to decline of the degree of co-movements between national growth dynamic and union common trend.

V. Conclusion

In this paper, we have examined the business synchronisation of Euro12 members by using the Dynamic factor model (DFM). Different to previous empirical studies for EMU (Breitung and Eickmerir 2005, Lehwald 2012, Lee 2011) that employed the second generation DFM aaprozh, we have employed the first general generation approach. We have shown that for the case of Eurozone, this finite variable approach does capable to produce the statistically significant results for a research which focus on the level of region rather than the level of global.

First, we estimate the unobserved common factor which can capture the co-movement of Euro12 growth dynamics. Then, a conventional correlation test was used to investigate to what extent the movement of national growth trends are on a similar path as Euro12 common trend. The results show that the correlation between national real GDP growth and Euro12 common factor are generally improved after the creation of the Eurozone, expected Portugal. Hence, since the creation of euro, for majority members of the Euro12, the national growth dynamics are generally moving at the same direction as the co-movement of entire Euro12. This result may be important to policy makers since it suggests that for most major economies in the EMU, they all need a same type of union level monetary policy.

Nevertheless, the requirements of a same type of monetary policy may not necessary suggest that the 'one fits all' issue are not existing inside the EMU. Although, for most major members, who hold a majority share of Eurozone GDP, will need a same type of policy; however, the individual needs of policy may still remain divergent if the degree of fluctuations of growth dynamics are different across members. Therefore, a graphic analysis was carried out after we obtained the correlation coefficients for Euro12. The results suggested a mixed result. For Austria, Belgium, France, Germany, Italy, Netherlands and Spain, the synchronisation of cycles which in the aspect of the volatility of national and common trend are improved significantly. However, for the rest countries in the Euro12 area, there have no pronounced improvements. Especially, for the case of Portugal, the synchronisation of cycles was declined rather than improved.

Our findings have drawn different conclusion to a recent empirical study (Lee 2011), which suggests that the synchronisation of cycles only increased during the run-up period of EMU, but no evidence to show that the improvements has continued after the creation of EMU. The results here are in line with other recent empirical studies (Kaufman 2003, Montoya and Haan 2008, Giannone et al. 2010, Lehwald 2012). And, it has confirmed the argument that has been put forward by Sinn et al. (2011) who suggest that the introduction of EMU may encourage imbalance between member states rather than delivering enforcement of economic convergence, and also The after the establishment of the EMU, the single currency area has caused a divergence between core and periphery groups of Europ12.

The synchronisation of growth dynamics are improved in countries like Germany, France, Italy, Netherlands, and plus the other several relative small economies such as Austria and Belgium. In contrast to the core group countries, the improvements of synchronisation of business cycles in periphery group of the EMU are poor, there generally only has some improvements of the correlation between national growth dynamics and trend of Euro12 common growth factor; however, the volatilities between fluctuations of national GDP growth and co-movements of Euro12 cycles remain divergent. These undesirable results of business cycles synchronisation are especially severe to Greece and Portugal. For Greece, here only has an insignificant improves in the value of correlation coefficients, but no improvements in volatilities of its own cycle related to eurozone trend. While, the synchronisation of business cycles for Portugal was declined in aspects of both correlation and volatility of its own growth dynamic and common Euro12 growth factor.

Therefore, the endogeneity of OCA theory may only be the case for the core group of the EMU. The economic integration of economic activities does not guarantee a better co-movement of cycles for the entire Eurozone. Our results also raise a question to the membership of EMU again, probably same as many other academics, are those countries in periphery group should be included in the EMU at the first place. Furthermore, our estimation can be enhanced by implementing a variance decomposition analysis to numerically express the synchronisation of cycles in terms of volatility of national cycles and Eurozone co-movements. Moreover, based on the results which we obtained here, we also could evaluate which main GDP component is the main drive of the changes in the degree of business synchronisations within the EMU for each member. However, due to the length of this article those analyses will not be included here, but can be used to form a further research to enhance the understanding of this topic.

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Appendix

The basic idea of this approach is that the high dimensional vector of time series Y_t is driven by the latent dynamic unobserved factors f_t and vector of mean zero idiosyncratic disturbance e_t , which assumed to be uncorrelated with the factor innovations at all leads and lags (Breitung et al. 2005, Stock 2010). The simple DFM model can be written as:

$$Y_t = \lambda(L) f_t + e_t$$
$$f_t = \Psi(L) f_{t-1} + \eta t \qquad \textbf{EQ A1}$$

Where, Y_t and e_t represents a N series which are N×1 vector; there are M dynamic factors f_t and error terms η_t. L represents the lag operator, and the lag polynomial λ(L) and ψ(L) are vectors of N×M and M×M respectively. The term λ(L) f_t represents the common component of the Y_t , where each individual λ(L) is the dynamic factor loading $\lambda_i(L)$ for the i^{th} series $Y_{i,t}$.

In this paper, we will follow the methods of Monfort et al. (2003) and Moneta and Rüffer (2009) employ the first generation approach of DFM for our analysis. Let's start with the simple static factor model which can be written as:

$$Y_t = BF_t + \xi_t \qquad \textbf{EQ A2}$$

where the common movement in a cross-section of n stationary series Y_t can be captured by k common unobservable factors; B is a *n×k* matrix of loading coefficients; F_t is a *k×1* vector of factors; and ξ_t is an *n*-dimensional stationary process. This is also called strict factor model, where ξ_t is assumed to be uncorrelated. The main drawback of this model is that it does not allow the existence of dynamic relations between factors and other variables. Therefore, we may introduce the element of dynamics into EQ A2 to transfer the static model to DFM:

$$Y_t = B(L)F_t + \xi_t \qquad \textbf{EQ A3}$$

where $B(L)F_t = \sum_{i=1}^{\infty} B_i F_{t-i}$

Since we are following the Monfort et al. (2003) and Moneta and Rüffer (2009) by adopting the liner state space model for DFM approach, therefore the model can be written as:

$$\begin{aligned} Y_t &= AY_{t-1} + BF_t + \varepsilon_t \\ F_t &= CF_{t-1} + \eta_t \end{aligned} \qquad \textbf{EQ A4}$$

The variance-covariance matrix of the error term ε is assumed to be diagonal:

$$V[\varepsilon] = \begin{bmatrix} \sigma_1^2 & & & 0 \\ & \cdot & & \\ & & \cdot & \\ & & & \cdot \\ 0 & & & \sigma_n^2 \end{bmatrix}$$

This model assumes that the cross-section of n stationary series Y_t is depends on the country specific autoregressive component of order one; there are *k* unobservable factor F_t which common to all series; the ε_t and η_t are independent Gaussian white noise term. The matrix *B* is fator loadings which measures the impact of common factors on each series of Y_i. Matrix *A* is assumed to be diagonal, therefore, it capturing the core notion of the DFM that the comovements of the multiple time series arise from *F*. For the second equation of the state space model, the C matrix is also set to be diagonal which ensure the dynamics of the unobservable factors *f* is univariate.

In linear state space model, the each matrix and error terms are functions of an finite dimensional unknown vector of parameters and the past value of vector of parameters and the past value of *Yt* ; thus the model is parametric and can be estimated by the Kalman filter (Harvey 2008). The Kalman filter provides at each step *k* the likelihood function for *k*+1 conditional on information given at *k*. Therefore, the log-likelihood function for the entire sample can be constructed as a by-product of the Kalman filtering (Monfort et al. 2003). Furthermore, as the numbers of time series and observations are relative small compare with microeconomic and large scale macroeconomic researches, the maximum likelihood approach which used in parametric type of DFM does not run into computational problems.

One advantage of this model is that the parametric state space formulation can handle data irregularities (Harvey 1989). For example, if some series are observed weekly and some are observed monthly, the latent process for the factors in EQ A4 can be formulated as evolving on a weekly time scale. But, the dimension of the measurement equation (first equation in EQ A4 depends on which series are actually observed. That is, the row dimension of matrix *B* would change depending on the variables actually observed at the given date.