THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

LSE 'Europe in Question' Discussion Paper Series

Brexit and the Euro

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LEQS Paper No. 154/2018

March 2020

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Brexit and the Euro

Nauro Campos* and Corrado Macchiarelli **

Abstract

The year 2019 marks the 20th anniversary of the euro as well as Brexit, the expected exit of the United Kingdom from the European Union. This paper examines the relationship between Brexit and the stability of the euro area. We look at stability from the perspective of the distance between core and periphery groups of countries which, we show, is mainly determined by the level of synchronization of economic activity among them. We provide new evidence that the UK economy, since 1990, has become significantly more integrated with the EU economy. The UK moved from being in the periphery before 1990 to being in the core afterwards. We also provide evidence that the level of business cycles synchronization of the UK economy with the EU has had the highest, among all countries, variability over time. We conclude with some policy implications from Brexit for the stability of the euro area.

Keywords: European Monetary Union, Eurozone, Core-periphery

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Acknowledgments

We would like to thank without implicating Tamim Bayoumi, Iain Begg, Paul De Grauwe, Barry Eichengreen, Jarko Fidrmuc, Christopher Hartwell, Andrew Martin, Andre Sapir, and seminar participants at Harvard University, CASE-Warsaw and European Parliament for valuable comments on previous versions.

Brexit and the Euro

1. Introduction

The year of 2019 marks the 20th anniversary of the European single currency (the euro) and the expected exit of the United Kingdom (UK), known as Brexit, from the European Union (EU). What will be the impact of Brexit on the stability of the euro area? Does Brexit undermine the euro because it undermines the EU as a political and economic project, or will it allow the rest of the EU to implement institutional changes that will help the euro work better? These are difficult and pressing questions that would benefit from a coherent framework. This paper tries to fill this gap by providing elements for an informed debate.

Regarding the stability of the euro area, a measure of how widely recognised are the current shortcomings of the Economic Monetary Union (EMU) is the Brussels' plan for a *Genuine* EMU (Begg 2015). Sapir and Wolff (2016) and Macchiarelli (2017) discuss how progress towards the GEMU may affect the UK. Agreement on the need for a solution co-exists with an apparently stark disagreement on the causes. One view is that "design flaws" (De Grauwe 2006) deepened imbalances while another is that "policy mistakes" (Sandbu 2015) hindered convergence. One of many proposed solutions is a flexible euro (Stiglitz, 2016): a two-tier model of a Northern and a Southern Euro where the latter is said to be "softer." One way to explain such proposals is that the Southern euro would not be part of the "core", or that it would

be "less core". All these views, however, rely upon "asymmetries": the less asymmetric, the more synchronised, the more stemtable will the euro area be.

As for Brexit, in June 2016 52% of British voters decided that being the first country ever to leave the EU was a price worth paying despite extensive advice from economists that Brexit would make the UK permanently poorer (Campos 2016). Moreover, Brexit is one among a constellation of crises inflicting upon the EU (refugees, debt, unemployment, etc). Although one among many, Brexit differs in that it can alone ignite other crises. Brexit raises existential questions about the integration project. It asks questions about the value of membership, the dynamics and distribution of its benefits and costs, and the type of integration that can at least sustain the net benefits we have seen since the 1950s.

One of the few benefits of the Brexit debate is that it has fostered a flurry of new research addressing questions that have not been sufficiently investigated previously. One of these questions regards cohesion among Euro area members, where the governance structure of the relationship between the countries that use the euro as their currency (i.e. the euro-ins) and those that do not is an important issue. The latter group includes both the countries that have negotiated the right to opt-out from participation under the Maastricht Treaty of 1992 (the euro-outs, i.e. UK, Denmark and Sweden) and those who are on the path to eventual adoption of the single currency (the pre-ins, i.e. Central Eastern EU).

The paper is organised as follows. Section 2 provides a conceptual framework. It discusses the theory of optimal currency areas, its recent developments and the centrality of the concept of synchronicity. Section 3 analyses the extent to which economic activity in the UK is synchronised with economic activity in the Euro area and how this has changed over time - especially after the introduction of the single currency. Consistent with the existing literature, we find synchronisation has increased after the introduction of the euro. Section 4 introduces new empirical measures of economic symmetry among European economies. Stability depends on

the degree of integration among member countries or, more specifically, on the relative distance between core and periphery countries. Using these new measures, we show that the gap between core and periphery pre-EMU has diminished after the introduction of the euro and that the UK contribution was key as that it moved from the periphery before 1990 to the core. On the other hand, the UK is also shown to be the one country in which this measure post-euro has varied the most (i.e., has been the least stable). The paper concludes with a discussion of policy implications to help increase the stability of the Euro Area.

2. Integration, symmetry and stability

Sharing a currency is an obvious way to deepen integration. The main research question driving the optimal currency areas (OCA) scholarship regards the costs and benefits of sharing a currency (Alesina and Barro, 2002). The main cost is the loss of monetary policy autonomy. Benefits are mostly in terms of reduction of transaction costs and exchange rate uncertainty, and of increasing price transparency, trade and competition. Glick and Rose (2016) summarise the econometric evidence on the trade effects of currency unions.

One insightful way of framing the OCA issue is proposed by De Grauwe and Mongelli (2005). They study the interactions between symmetry, flexibility and integration. The more changes in the levels of economic activity across countries happen in unison, that is, the more synchronised are their business cycles, the more integrated will countries be. Particularly, they show there exists a minimum combination of, e.g., flexibility and integration, that countries must observe for a monetary union to generate positive net benefits. De Grauwe and Mongelli (2005) place the Eurozone (EU) within (to the outside) of the OCA-line suggesting those countries are (not yet) sufficiently integrated to generate efficiency gains that can compensate for the macroeconomic costs of the union. They also note how the degree of economic integration and symmetry may change over time.

Before the EMU, there was an intense debate about the extent to which a monetary union affects symmetry (Krugman, 1993). Focusing on the symmetry-openness dimension, one can see that increased integration may raise business cycles correlation. De Grauwe and Mongelli (2005) argue the EU would move in this way: they predict specialisation will bring about less symmetry.

There are at least two recent developments in OCA theory that should be noted. The original OCA formulation stressed labour mobility, product diversification and trade openness as key adjustment criteria and explored the possible endogeneity of currency unions (Frankel and Rose 1998). Recent work calls attention to the role of credibility shocks. If there are varying degrees of policy commitment (furthering time inconsistency problems), countries with dissimilar credibility shocks should find convenient to join a currency union (Chari *et al*. 2019). A second relevant recent strand highlights that, although OCA criteria are often thought of as independent, they should instead be considered jointly, e.g., by focusing on the interactions between openness and mobility (Farhi and Werning 2015).

The optimality of a currency area is a function of the distance between its members. If relative distances are large, it is common to speak of a core and periphery gap. It is expected that core countries would be those more closely meeting the OCA criteria. Given its importance for OCA, it is not surprising there have been various attempts of classifying countries into core and periphery sets. A basic way of distinguishing these methods is whether the authors pre-impose membership, or they allow the data to determine whether a country is a member of the core or of the periphery at a certain point in time. Artis and Zhang (2001), for instance, investigate actual and prospective membership of the EMU by applying clustering techniques to a set of variables suggested by OCA theory; the extent of synchronisation in business cycles (symmetry in output shocks), volatility in the real exchange rate, synchronisation in the real interest rate cycle, openness to trade, inflation convergence, and labour market flexibility. Their analysis reveals that the member countries may be divided into three groups: those belonging to the core (Germany, France, Austria, Belgium and the

Netherlands), those part of a Northern periphery (Denmark, Ireland, the UK, Switzerland, Sweden, Norway and Finland) and those belonging to a Southern periphery (Spain, Italy, Portugal and Greece).

Bayoumi and Eichengreen (1993) put forward a more theory-based approach focusing on business cycle synchronisation embedded in a standard Aggregate Demand and Aggregate Supply framework that classify Germany, France, Belgium, Netherlands and Denmark as core countries pre-EMU, and Greece, Ireland, Italy, Portugal, Spain, and the UK as the pre-EMU periphery. In related work, Bayoumi and Eichengreen (1997) offer an "optimum-currency-area index for European countries." They identify the determinants of nominal exchange rate variability which reflect OCA characteristics and support predictions of which countries pertain to which sets. Conceptually, they make the point that OCA focuses on criteria that ultimately make exchange rates more stable and monetary unification less costly. In their model, bilateral exchange rate variability is a function of GDP, trade, economic structure dissimilarity, and a measure of output synchronisation. Using 1973 to 1992 data, they find all these determinants carry expected signs and are of statistical significance, so they use these to forecast exchange rate variability in 1987, 1991 and 1995. Their econometric analysis allows three groups: in the first "rapidly converging" group are Germany (the numeraire), Austria, Belgium, the Netherlands, Ireland and Switzerland. The second group is characterised as one that has experienced little convergence and is composed by the United Kingdom, Denmark, Finland, Norway and France. The third group is a set of countries that are "gradually converging" to the EMU and includes Sweden, Italy, Greece, Portugal and Spain. They conclude that economic integration has thus increased countries' readiness for monetary integration" (Bayoumi and Eichengreen 1997, p. 769).

3. How integrated is the UK with the Euro Area?

During the negotiations for the 1992 Maastricht Treaty, Denmark and the UK secured the rights not to join the European Monetary Union (EMU). Every one of the other

current 26 European Union members is legally committed to adopt the euro as its currency, when ready (De Grauwe, 2016). In 1997, the new Labour government decided to reconsider the decision to stay out of the euro. The UK Treasury was charged with the policy analysis which focused on the so-called "five tests" involving synchronisation of business cycles, labour mobility, investment, competitiveness of the financial system, and growth and stability. Despite several studies showing convergence between the euro area and the UK (e.g., Canova et al. 2005; Giannone et al. 2010), the final verdict from the Treasury was that long-term convergence of UK and euro area business cycles had not reached satisfactory levels and that "despite the risks and costs from delaying the benefits of joining" a decision to join was not "in the national economic interest."

Since the introduction of the euro on January 1, 1999, the UK and Sweden have adopted a free float exchange rate regime while Denmark participates in the ERM2 with the krona pegged to the euro. The high levels of business cycle synchronization and a large share of exports to the euro area suggest the costs of adopting the euro remain small for Denmark (Holden, 2009). Pesaran *et al.* (2007) provide econometric evidence suggesting that both Sweden and the UK would have benefited significantly had they joined the euro in 1999. By the same token, Saia (2017) estimates trade flows between the UK and its main trading partners if the UK had joined the euro. He finds that that aggregate flows between the UK and Euro area members would have been as much as 13% higher and that similar results obtain for trade with non-euro area member states.

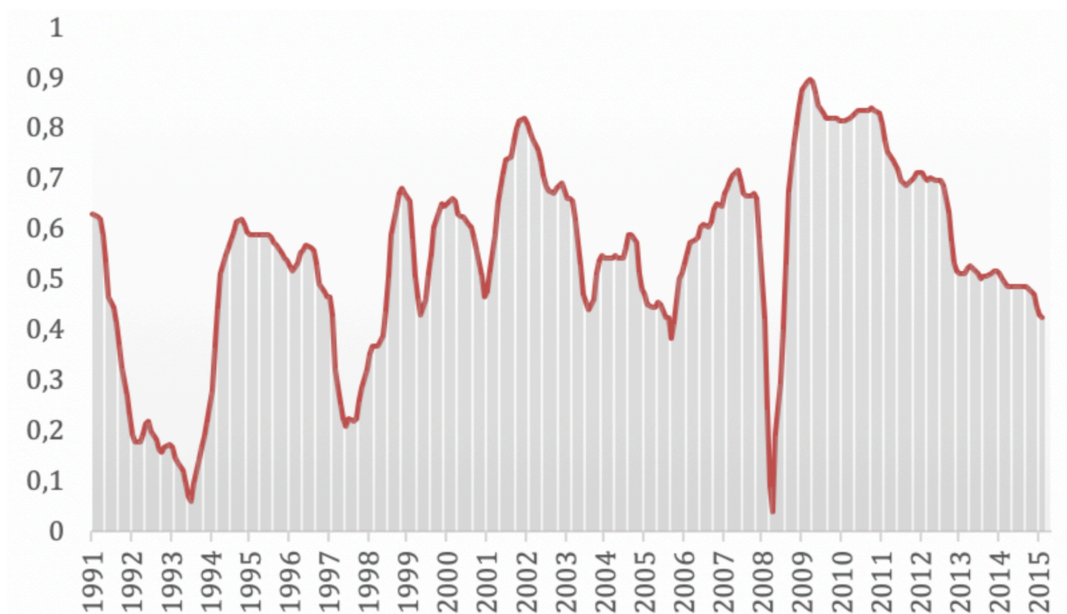
In order to understand the extent of synchronisation between the euro area and the UK, we carry out a correlation analysis of the cyclical components (i.e. gap) in industrial production. Figure 1 shows the co-movement between the UK and euro area business cycles (Engle, 2002, Harding and Pagan, 2006.) It shows for instance both the consequences of the 1992 exit of the British pound from the EMS and the 2007-09 run up to the crisis. In line with existing studies, we find that there has been an overall increase in synchronisation (De Haan et al. 2008.) Accordingly, the average correlation

coefficient between industrial production growth in the UK and euro for the full period (1991-2015) is 0.54 which is line with most of the evidence (Campos *et al.* 2019) but it started from 0.37 in 1991-1998, increased to 0.77 in 1999-2006, and again to 0.81 in 2007-2015 during the Great Recession (Figure 1).

Our estimates show that, after the introduction of the euro, the UK and Euro area business cycles became substantially more synchronised. This result has important, yet still poorly, understood implications in terms of a possible exit from the EU, i.e. Brexit. Here, three observations are in order. One is that the net benefits from the increases in synchronicity since 1999 are not irreversible. They can be reduced by policy inconsistencies and delays but irreversibility should not be taken for granted.

Figure 1

Conditional correlation: UK and euro area cycles (1990-2015)



Note: In the figure we generate a measure of this correlation that is conditional on cyclical features. We use the exponential smoother from Engle (2002) and obtain cycles using a Kalman filter (Harvey, 1989). Given possible structural breaks, the specification for the trend-cycle decomposition is augmented with standard interventions. To detect influential residuals, we use the Harvey and Koopman (1992) two steps auxiliary regression procedure. In the first step, focus is on outliers and break detection. The second step involves estimating the model with those interventions which were found significant in the first step. Source: Authors' calculations. Data on industrial production from datastream.

The second regards the consequences of this upsurge in synchronisation. Our results suggest a euro-out such as the UK became somehow more integrated even if not using the euro as its currency. All else equal, an upsurge in synchronisation leads to an increase in the net benefits of currency union membership and raises the costs of leaving the EU.

The third remark is this standard analysis has two main limitations. One is that it only allows relative comparisons of symmetry based on individual estimates when interdependence or country groupings is the main issue of interest. Secondly, synchronisation is an important (measurable) part of the explanation of symmetry adjustment within an OCA but surely not the only one.

4. The Stability of the Euro Area and Brexit

The seminal Bayoumi and Eichengreen (1993) paper establishes the existence of a core-periphery pattern in the run-up to the EMU. Using pre-EMU data to estimate the degree of business cycles synchronization, Bayoumi and Eichengreen convincingly argue that there is a core (Germany, France, Belgium, Netherlands and Denmark) where supply shocks are highly correlated and a periphery (Greece, Ireland, Italy, Portugal, Spain, and the UK) where synchronisation is significantly lower. This is mostly based on the degree of supply shocks synchronisation as they note that demand shocks correlations are much lower, even for those countries in the "core." Yet, they reason, correctly, that this pattern would undermine the EMU project if persistent.

Their methodology (1993) extends the Blanchard and Quah's (1989) procedure for decomposing permanent and temporary shocks. Based on the standard Aggregate Demand-Aggregate Supply (AD-AS) model, supply shocks have permanent while demand shocks have temporary effects on output. Both have permanent (but opposite) effects on prices. In order to quantify how countries have become entrenched since the euro, we first revisit Bayoumi and Eichengreen (1993) using the same estimation

methodology, sample, and time window (25 years) to replicate their results for 1989-2015.

In order to assess whether the EMU has strengthened or weakened the core-periphery divide during 1990-2015, we introduce a test that produces a theory-consistent measure of the extent to which a country can be classified as periphery or core. Our indicator is based on the frequency in which the hypothesis of symmetry is rejected. The way we interpret the results is that the lower (higher) the percentage of rejections, the more a country is said to be part of the centre (periphery). Importantly, this measure of symmetry does not depend on the adoption of a specific country as the numeraire (such as Germany). Our results suggest that the introduction of the euro weakened the original core-periphery pattern and even countries not using the euro as their currency have become progressively more synchronous (Figure 2). These results broadly confirm the endogenous OCA hypothesis (Frankel and Rose 1998.)

It should be noted that the direct comparison of pre and post EMU in Figure 2 show that although the range on the demand side remains the same, it has increased in terms of the supply shocks (with minimum values of -0.7 after as opposed to -0.3 before.)

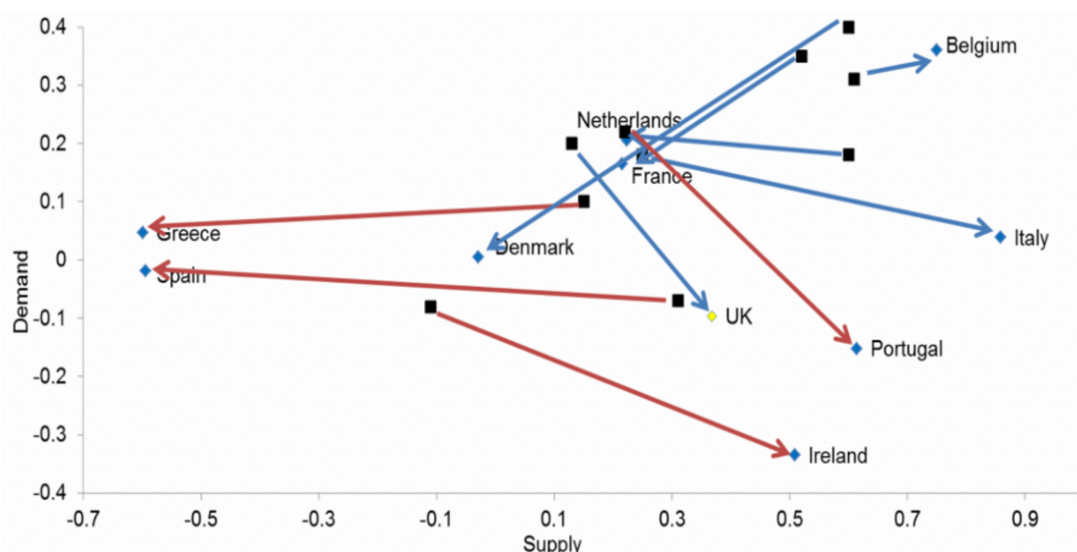
This measure helps us to track how the core and the periphery changed over time. The distance between the core and the periphery could well have increased post-EMU. Or it could have decreased. The periphery could have fully converged with the core or it could have moved towards the core or both could have moved towards each other. The asymmetry could also have decreased by core and periphery converging by large changes in demand and small changes in supply correlations or the other way around. Actually we find that the periphery experienced a decrease in demand correlations and an increase in supply while the core experienced a decrease in both.

For the EU12, we find that the periphery is composed of Ireland, Greece, Portugal, and Spain, while the core contains the UK, Denmark, Germany, France, Netherlands, Belgium, and Italy. Our results are comparable with the results that Bayoumi and Eichengreen and others have produced for the pre-EMU period (Di Giorgio, 2016).

This snapshot covers the post-EMU period but says little about such dynamics evolved over time

Figure 2.

The dynamics of the correlation of supply and demand disturbances between pre- (1963-1988) and post-EMU (1991-2015)



note: The figure compares estimates from pre-Maastricht based on Bayoumi and Eichengreen (1993), covering the period 1963-1988, with Campos and Macchiarelli (2016) equivalent estimates for the period 1991-2015 (post-EMU). For each country, a bi-variate SVAR is estimated using (log) real GDP and the (log) deflator, both in first differences. The structural identification of the shocks also follows Bayoumi and Eichengreen (1993) and control for changes in regimes. Red arrows denote movements of the so-called "core" countries and blue arrows movements of the "periphery". Source: Authors' calculation. OECD Statistics data (http://www.oecd.stat).

By adopting the same methodology and conditioning the first sample to 1960-1985 we can generate a time-varying measure, estimated, each time, on a fixed 25-year window (see Annex and Campos and Macchiarelli 2018). In Figure 3, higher (lower) values of the index indicate a higher probability of a country being classified as periphery (core). The results suggest that while Germany has been safely below the threshold, the UK has been moving in and out of the core (using a 50% admittedly arbitrary cut-off for core or periphery). This is not surprising *ex post* and consistent with the (summary) of previous business cycle synchronisation analyses.

We identify three groups of countries (Figure 3). A core that becomes more homogenous over time. A periphery that changes little over time. And a mixed set of

countries with interesting trajectories: the index for Denmark is almost constant, Greece and Sweden becomes systematically less core over time, Spain becomes systematically more core over time, and the UK is in-and-out of the core set of countries.

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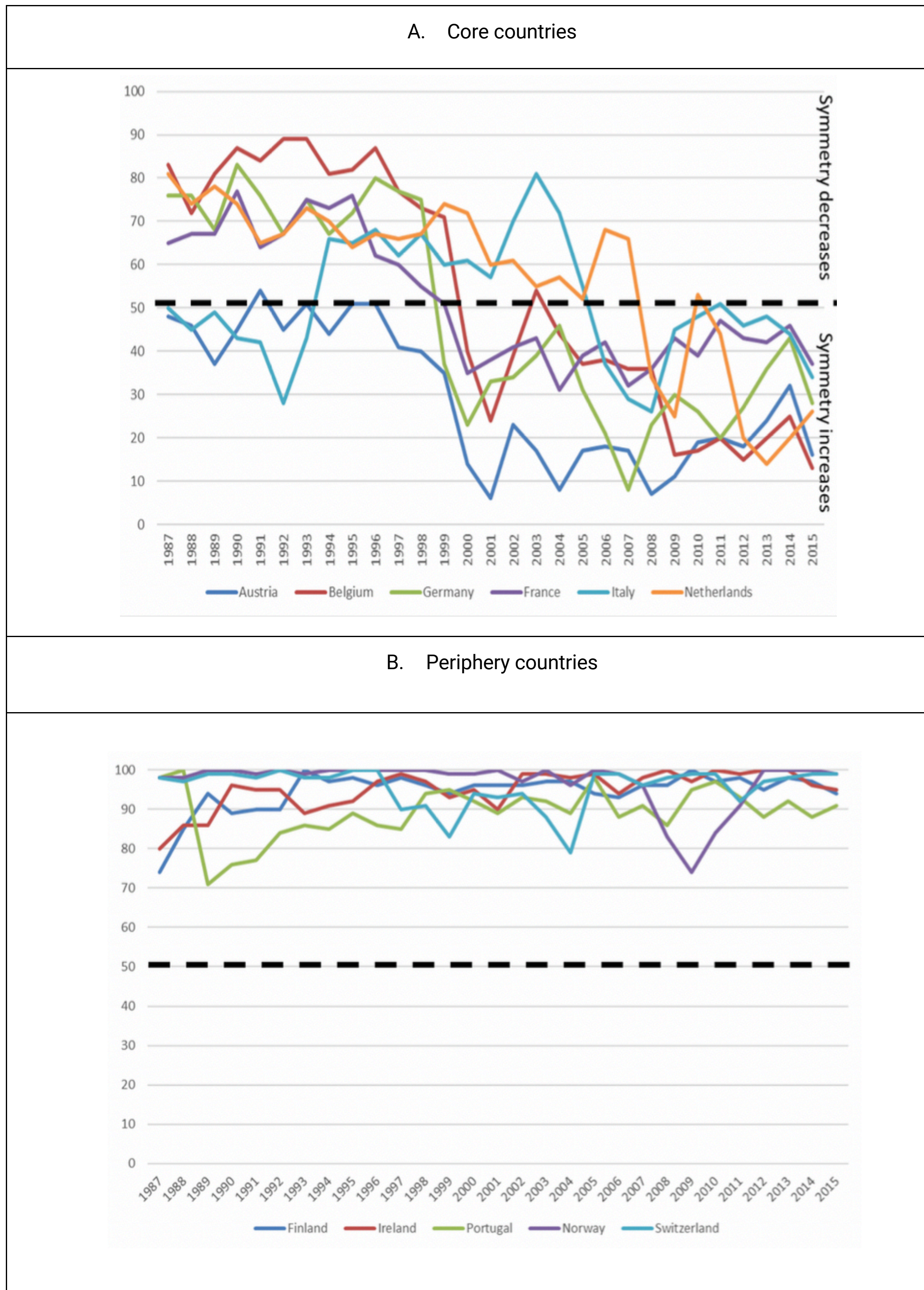
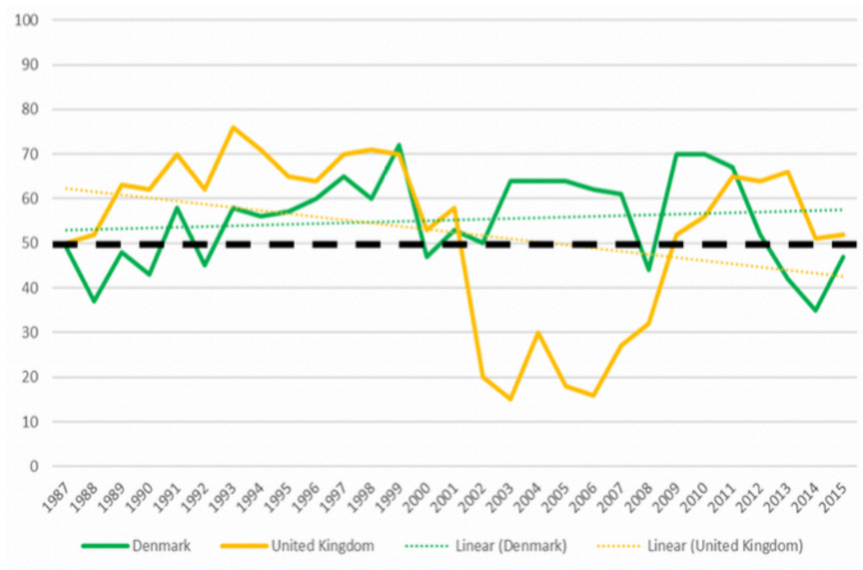
In order to understand the dynamics of this measure, we consider a set of variables suggested by OCA theory. We examine four main groups of possible explanatory variables: fiscal (debt to GDP ratio, cyclically adjusted budget balance), financial (corporate bond spread, 10-year government bond spread, 3-month interbank interest rate spread, interest on the average on consumer loan spread, return on equity differential, a set that is consistent with the European Central Bank's definition of financial integration, ECB, 2011), external (FDI, and real effective real exchange rate), structural reforms (employment protection legislation, EPL, and product market regulation, PMR) and a dummy variable on euro area membership.

Figure 3.

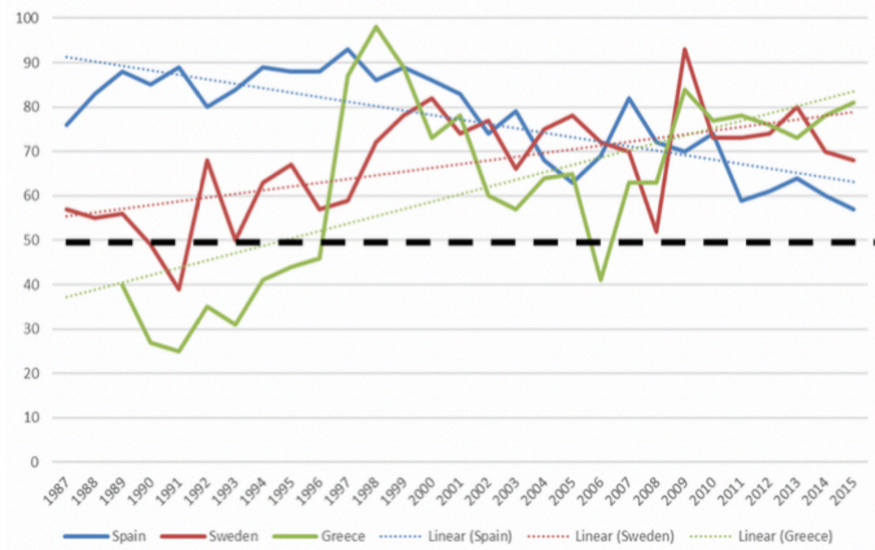
Measuring the extent of a country being classified as periphery over time: core, periphery and mixed countries



C. *Mixed set (I): Denmark trendline lower variance, UK high variance (OLS regression trendline added)*



D. Mixed set (II): Spain moving towards core, Greece and Sweden moving towards periphery (OLS regression trendline added)



Sources: Authors' own calculations

The estimation includes, besides the UK, Austria, Belgium, Germany, Denmark, Spain, Finland, France, Greece, Ireland, Italy, the Netherland, Portugal, as well as EU non-euro area countries such as Sweden, and non-EU countries such as Switzerland and Norway. We present the results for the period 1991-2015 but these are robust when we stop our estimation before the financial crisis in 2007.

The overall results (last column in Table 1) suggest that a strong role is played by the strictness of product market regulation whereby a high PMR increases the likelihood of country being in the periphery. This is in turn not surprising given that the index is based on supply side dynamics and the extent to which those prompt similar GDP reactions among member states. A second factor is the level of debt-to-GDP, again, in reducing the likelihood of a country being in the core, albeit the statistical evidence is not strong.

Membership to the currency union, for the countries in our sample, suggests an important role in making countries less "peripheral", impacting the probability of being classified as periphery by as much as 16 percentage points (Figure 4).

These findings are in line with the idea that one of the main concern for monetary union membership would be represented by the costs of adjustment in order to deal with asymmetries. In the absence of sufficient labor flexibility, and equally of fiscal transfers at the euro-area level, many countries would suffer from severe adjustment problems.

Table 1. Determinants of NORM-GMM estimates

	1991-2015									
	Fiscal		*Financial*		*External*		*Structural reforms*		*All*	
Debt (% GDP)	0.109	**							0.112	*
	(0.041)								(0.131)	
Adj. Budget Balance (% potential output)	0.812	*							0.681	
	(0.334)								(1.121)	
Corborate bond spread			0.390						0.616	
			(0.570)						(0.717)	
Gvt bond spread			0.905						-2.768	
			(0.733)						(1.841)	
3-month interbank			-4.497	**					-1.317	
			(1.321)						(2.128)	
Avg on cosumer loans spread			-0.114						0.478	
			(0.425)						(0.709)	
Return on equity diff.			0.642						-0.516	
			(0.409)						(0.387)	
FDI (%GDP)					-0.474	***			-0.491	
					(0.150)				(0.208)	
Reer (CPI adj.)					-0.249	**			-0.280	
					(0.117)				(0.291)	
EPL							-14.148	*	-25.358	
							(5.905)		(19.894)	
PMR							10.345	**	14.481	***
							(3.539)		(5.348)	
EZ membership	-19.070	***	-	***	-12.098	***	-11.662	***	-16.978	***
	(2.085)		(2.846)		(1.919)		(2.913)		(5.591)	
C	71.079	***	84.165	***	99.192	***	89.086	***	135.646	**
	(6.591)		(5.161)		(13.024)		(15.513)		(57.111)	
Effect	Random		Random		Random		Random		Fixed	
Adj-R2	0.183		-0.038		0.078		0.193		0.701	
Durbin-Watson	0.551		0.908		0.527		0.703		1.275	
J-Stat (p-value)	(0.000)		(0.000)		(0.000)		(0.000)		(0.000)	

Source: Authors' own calculations

5. Discussion

Even before the launch of the EMU, the concern about entrenched asymmetries spurred an alternative approach to European integration: the possibility of a two-tier or 'multi-speed Europe'. From an economic viewpoint, it is true that smaller groups of countries may be better candidates for forming an OCA given that they may be more homogenous (see also De Grauwe, 2016). Looking at the early evidence on the degree of synchronization of shocks across countries before the EMU (1963–88), compared to the same pattern 25 years after the EMU, however, suggest that a new, smaller, periphery has emerged (Spain, Portugal, Ireland and Greece). Thus, the EMU has weakened the core-periphery pattern, resulting into countries being more integrated over time.

The UK, with its mixed experience shown above, represents a much lesser threat to euro area stability than the absence of concerted and forceful action from euro area members states themselves. This is particularly true if Brexit occurs in an orderly and gradual manner. In this respect, we argue that while the hypothesis of a 'multi-tier' Europe cannot be dismissed on the basis of the available evidence , our results support the view that a viable alternative to a 'multi-speed' scenario is a serious process of coordinated reform. This is indeed the spirit of the Five Presidents Report (Junker *et al.*, 2015).

As mentioned above, there has been considerable thinking and planning on how to make the EMU more effective, that is, how to ensure the stability and integrity of the EMU. The first clear attempt at addressing this matter was the so-called Four Presidents' Report (those of the European Council, European Commission, European Central Bank and Eurogroup) that in 2012 put forward as an explicit goal the need to move towards a Genuine Economic and Monetary Union (Macchiarelli 2016). The choice of words (i.e., Genuine) is indicative of the extent of the consensus about the need for EMU reform. In 2015 another report was issued by the four presidents, plus the President of the European Parliament, which provides a roadmap for further

deepening of the EMU in order to ensure the stability and smooth functioning of the EMU. The Five Presidents' Report stipulates a detailed range of actions and a clear timetable (in three phases) to bring progress in four main areas, namely, economic, financial, fiscal, and political union.

Our analysis documents that the introduction of the single currency preceded a substantial increase in symmetry among member states, thus improving an important dimension in most considerations about the stability of the Euro area. The main policy implications we derive hence complement those put forward by the Five Presidents' Report. This Report indicates what is to be done and when, while our analysis suggests countries that should receive special attention in order for these policy actions to be more effective.

Our results suggest Sweden is a crucial country in order to fulfil the goal of increasing the stability of the Euro Area. After the UK, the trajectory of Sweden's index since 1990 is worrisome. It indicates that this is one of the few countries that continue to leave (or it continues to increase its distance from) the core and has done so in a systematic and sustained way. No other country exhibits such a trajectory. Moreover, Sweden is an important trade partner to the Baltics which also show surprisingly (despite their euro membership and relative low levels of product market regulation) to have large distances from the core. Third and finally, without the UK (post Brexit), Sweden will become the country closer to the border with the periphery. For all these reasons, the EU should focus on Sweden to foster the stability of the Euro (and a successful implementation of the Five Presidents' Report.)

The Swedish Statistical Office monitors public opinion towards the single currency and the levels of rejection have been above 70% in recent years. Yet, there is a clear economic explanation for this. Campos *et al.* (2016) argue that Sweden benefitted relatively little from EU membership after it joined in 1995 (in large part because it was already a high-income country with highly developed institutions) and benefited substantially from avoiding joining the euro (partly because its largest trading

partners are not euro zone members.) Indeed, the evidence suggests that while around year 2000 the benefits from not joining were relatively difficult to estimate (or close to zero), a decade later these have become substantial and significant (Gyoerk 2017.)

In terms of the actual UK withdrawal from the EU, Brexit will certainly challenge both internal and external equilibria, with some EU non-euro area member states such as Poland, Denmark, and indeed Sweden, but also the 'pre-ins', feeling they will lose grip in shaping euro zone policies (Oliver, 2016), especially against an enhanced role of Germany and the other euro area member states. This may trigger further scepticism, should the EMU fail to provide an attractive alternative model for integration. We argue that deeper integration should carry on to the point of making euro-outs be eager to join, something which is indeed anticipated in phase 3 of the Five Presidents' Report. Any lesser solutions may turn out to be costly not only for the future of the EMU but for the future of Europe.

6. Conclusions

What is the impact of Brexit on the stability of the Euro Area? This paper argues that if one is concerned about stability and cohesion, asymmetry and imbalances, one way of thinking about these issues is offered by the notion of the probability of a country of being classified as periphery in a core and periphery framework.

Before Maastricht, the seminal contribution of Bayoumi and Eichengreen (1993) generated a clear picture. Looking at correlations between demand and supply shocks one could see two distinct groups of countries: a core and a periphery. It is a seminal paper because, *inter alia*, it is one of the first to point out the risks of an entrenched core-periphery to the then nascent EMU. Their influential diagnostics was based on data covering 25 years from 1963 to 1988. Using the same methodology, sample, and time window, we replicate their results for 1989-2015. We ask whether the EMU strengthened or weakened the core-periphery pattern. Our results suggest the EMU

has weakened the original pattern, that is, the number of countries in the periphery (core) decreased (increased.)

How did these groups (core and periphery) change over time? We find the UK belongs to a mixed set of countries. While Denmark's index is basically flat, i.e. it changes little over time, Greece and Sweden become systematically less integrated over time, while Spain shows the opposite pattern. Unsurprisingly perhaps, the UK goes in and out of the core.

Finally, we ask the question of what drives symmetry (and thus stability). Our estimates show that euro membership and Product Market Regulation are key. We find the probability of a country of being classified as core is driven chiefly by euro membership and product market regulation. Euro adoption makes countries more core, more regulation makes countries less core. This finding provides renewed and direct support for the endogenous OCA hypothesis and its interpretation in a broader sense.

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Appendix

In what follows we summarize the methodology used to construct our measure of summery. The underlying methodology is that of Bayoumi and Eichengreen (1993), which is an extension of the Blanchard and Quah (1989) procedure for decomposing permanent and temporary shocks.

Let us consider a system where the true model is represented by an infinite moving average of a (vector) of variables, X_t, and shocks, ϵ_t. Using the lag operator L, a bi-variate VAR featuring real GDP and its deflator can be written as an infinite moving average representation of demand and supply disturbances:

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

where $X_t = [\Delta y_t, \Delta p_t]$ and the matrices A represent the impulse response functions of the shocks to the elements of X. It follows that

$$\begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix} = \sum_{i=0}^{\infty} L^i \begin{bmatrix} a_{11i} & a_{12i} \\ a_{21i} & a_{22i} \end{bmatrix} \begin{bmatrix} \epsilon_{dt} \\ \epsilon_{st} \end{bmatrix}$$

where y_t and p_t represent the logarithm of output and prices and ϵ_t are $i.i.d.$ disturbances, which identify supply and demand shocks (Ramey, forthcoming). For the i-th country, a_{11i} represents element a_{11}, in matrix A_i and so on.

This framework implies that supply shocks have permanent effects on output, while demand shocks have temporary effects. Both have permanent (opposite) effects on prices. The cumulative effect of demand shocks on the change in output must be zero:

$$\sum_{i=0}^{\infty} a_{11i} = 0$$

The system can be estimated using a VAR. Each element can be regressed on lagged values of all the elements of X. Using B to represent these estimated coefficients:

$$X_t = B_1 X_{t-1} + B_2 X_{t-2} + \cdots + B_n X_{t-n} + e_t$$

$$= \left(I - B(L)\right)^{-1} e_t$$

$$= (I + B(L) + B(L)^2 + \cdots) e_t$$

$$= e_t + D_1 e_{t-1} + D_2 e_{t-2} + D_3 e_{t-3}$$

where e_t represents the residuals from the VAR equations. Using the standard relation between the VAR's residuals (e_t) and structural disturbances – i.e. demand and supply shocks – i.e. $e_t = C\epsilon_t$, it is clear that, for each country, exact identification of the C matrix requires four restrictions. Two are normalizations, which define the variance of the shocks ϵ_{dt} and ϵ_{st}. The third restriction is from assuming that demand and supply shocks are orthogonal to each other. The fourth that demand shocks have only temporary effects on output (equation 1.3).

The standard AD-AS model implies that demand shocks should raise prices in both the short and long run, while supply shocks should lower prices and increase demand permanently. In order to achieve that, it suffices to impose the additional over-identifying restriction in the VAR that supply shocks have permanent effects on output. We need to impose this restriction in our sample for the demand and supply shocks to be theory-consistent. This differs from Bayoumi and Eichengreen (1993) because they do not impose this last restriction, which leaves the model exactly identified. One reason we adopt the proposed over-identifying restriction is that inflation differentials are often considered a 'normal feature of currency unions. Therefore, we pay particular attention to modelling the effect of shocks on demand. The role of co-movements in output's cyclical fluctuations is further in line with the business-cycle literature. Since the proposed over-identifying restriction is sufficient to get structural disturbances in line with AD-AS dynamics, any additional long-run restriction may be redundant in this setting.

We test for the above over-identifying restriction, by imposing $\sum_{i=0}^{\infty} a_{12i} = \gamma$, where $\gamma > 0$. Under the latter assumption, demand across each country is restricted to

respond qualitative (sign) and quantitative (size) in the same way to supply shocks. In terms of the structural VAR analysis, this implies:

$$\sum_{i=1}^{\infty}\begin{bmatrix} d_{11i} & d_{12i} \\ d_{21i} & d_{22i} \end{bmatrix}\begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} = \begin{bmatrix} 0 & \gamma \\ . & . \end{bmatrix}$$

We do not restrict γ *a priori*; instead, we vary γ in the interval [0.1, 2]. The value we chose to report, consistent with Campos and Macchiarelli (2016a), is $\gamma = 1$.

In order to construct a test for the over-identifying restriction described above, we estimate the SVAR model consistent with Bayoumi and Eichengreen (1993). Differently from the latter, we bootstrap the original VAR residuals in a *i.i.d.* fashion and generate K = 10.000 data sets. For each of the k-*th* samples we proceed with a structural analysis and test for the over-identifying restriction based on a LR-test. We record the number of rejections of the over-identifying restriction test at each bootstrap replication, and calculate

$$NoR_i = 100 \times \frac{\sum_{k=1}^{K}\left\{NoR = 1 \middle| -2(L_r - L_u) > \chi^2_{q-\left(\frac{n^2-n}{2}\right)}\right\}_{i,k}}{K}$$

where $\boldsymbol{L_u}$ and $\boldsymbol{L_r}$ are the maximized values of the (gaussian) log likelihood function of the unrestricted and restricted regressions, respectively. under $\boldsymbol{H_0}$, the lr statistic has an asymptotic distribution with degrees of freedom equal to the number of long-run restrictions $(\boldsymbol{q})$ minus $(\boldsymbol{n}^2 - \boldsymbol{n})/2$, where $\boldsymbol{n}$ is the var-dimension (in this case $\boldsymbol{n} = 2$).

The dynamic version of the index is obtained by letting T be larger than before where τ denote the width of a sub-sample or window and define the rolling sample ‘metrics’. Here, we define

$$NOR_{t_i}(\tau) = \frac{1}{\tau - 1}\sum_{j=0}^{\tau-1} NOR_{(t-j)_i}(\tau)$$

The windows are rolled through the sample one observation at a time, so there the procedure returns $T - \tau + 1$ rolling estimates of the NORD (Campos and Macchiarelli, 2016b).

The basic intuition for our NORD measure is that it reflects the percentage of times we observe the rejection of the key restrictions needed to estimate the Aggregate Demand-Aggregate Supply model. The higher the percentage of rejections (or the more often they happen), the higher is the value of NORD. As such, NORD values range between 0 (perfect the probability of a country of being classified as periphery content) and 100 (i.e., the probability of a country of being classified as periphery content implying a perfect periphery).

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