Essays on Macroeconomic Dynamics: Trade, Integration and E(M)U Business Cycles.

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Abstract

Questions surrounding the macroeconomic dynamics in the cross-country context of the EU are investigated. Both fiscal and monetary policy issues are included in the analysis of this study. Chapter 1 revisits the debate surrounding the twin deficits hypothesis. The literature that tests for twin deficits is reviewed with focus on empirical applications to the EU. The impact that currency unions might have on twin deficits is investigated. A Panel VAR is used to test for the existence of twin deficits on EU data. The results support evidence for the existence of twin deficits within the EU but to a smaller degree than previous papers have suggested. Chapter 2 looks that the relationship between trade and business cycle synchronization. Attention is paid to the methodological issues surrounding the extraction of business cycles from the data. Next, a system of endogenous equations is estimated to test whether trade is significant in driving business cycle synchronization. The results show that trade is positive and significant in promoting cycle synchronization. Finally, Chapter 3 measures the degree of symmetry within the EU. A novel index is proposed which attempts to measure the speed of adjustment of demand to a supply-side shock. The index is then used in an empirical estimation to test whether the other components identified by the Optimal Currency Area (OCA) literature are significant in determining symmetry. The results show that openness and in particular, international trade, is positive and significant in promoting a faster demand-side response to a supply-side shock.

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Chapter 1

Testing the Twin Deficits Hypothesis: The Case of the EU.

Abstract

This paper revisits the literature surrounding the debate on the relationship between government deficits and international trade. The twin deficit hypothesis is revisited within the context of the EU and is empirically estimated using a panel VAR approach. A shock to government deficit is introduced to the Panel VAR and the responses of imports and exports are measured. The results show that in total, an increase in government deficits, of 2.5% causes a 0.4% deterioration in the trade balance in the first year. Although these results provide some confirmation of the existence of twin deficits, compared to previous estimates, the results in this study show quite a muted response of the trade balance. The dataset is then split in to Euro-adopters and countries with a national currency. The panel VAR is re-estimated on the two data-sets. The results show that Eurozone countries have a lower degree of a trade balance deterioration upon an increase in fiscal deficits than countries that still have a national currency.

1.1 Introduction

One of the strongest commitments to the pursuit of free capital mobility across border is the adoption of a common currency. For the EU, this was through the creation and expansion of a common currency for 19 of the member states. The benefits of a common currency include a more stabilized nominal exchange rate that is less vulnerable to speculative attacks. A second benefit includes, reduced cost of trade with other countries that share the currency, which is in some part due to the reduced exchange rate risk. Among the benefits, one could also list price transparency, lower transaction costs and institutional barriers (Alesina, Barro & Tenreyro 2002). Efforts to become more economically integrated has led to increased trade openness of countries with the real value of EU exports having increased by 33% during the years between 2008 and 2018[1]. Increased trade-openness brings about more competition, innovation and leads to increased macroeconomic growth (Eaton & Kortum 2002), however it also has the potential to reduce the effectiveness of individual macroeconomic stabilization policies. Increasing focus is being placed on domestic fiscal policy and the impact it has on neighbouring countries. The impact of domestic fiscal debt on the other members of the economic union, becomes of greater importance with deeper integration of either capital or goods and services markets. As countries become more open, the changes in domestic fiscal policy impact the terms of trade, which can lead to a deterioration of the trade balance. If international trade comprises a large proportion of GDP, then fiscal policy could have an significant impact on the domestic economy and the neighbouring economies that they trade with. The country's largest trading partners are likely to be affected by fiscal policy induced in that country. Issues of fiscal spill-overs are particularly pertinent when it comes to looking at trading blocs and economic unions where countries are economically integrated to a greater degree. One of the most direct ways in

[1]Eurostat- Intra-EU trade in goods - recent trends, percentage calculated as June 2017-July 2018 as a percentage of July 2008-June 2009

which a domestic economic movements can impact neighbouring countries is via trade. As a result, increased integration of the EU has lead to renewed focus on the question of 'twin deficits', particularly during the financial crisis, with ballooning debt particularly in the euro-area southern periphery. The twin deficit hypothesis refers to the phenomena that the increase in the government deficit must necessarily be met with an increase in the trade deficit, ceteris paribus (i.e. being the private sector in equilibrium such that S = I). In order to make a preliminary assessment on the role of trade on European integration, this study estimates the impact that a fiscal shock has on the trade balance whilst accounting for spill-overs within the EU by using a panel approach.

In order to empirically test the existence of twin deficits in the EU, a pooled-panel VAR approach is adopted. By using a pooled approach, we can account for the reaction of all the countries simultaneously to the fiscal shock. The empirical estimation allows for the responses of imports and exports to be estimated separately. This allows for the source of the trade balance movement to be identified as either import or export driven, thus allowing for more insight in to the transmission mechanism. The results show that a positive shock to government deficit leads to a slight deterioration of the trade balance, where by a 2.5% increase in government deficit leads to a 0.4% deterioration of the trade balance in the first year. This result shows a very modest deterioration of the trade balance in response to a fiscal shock. When decomposing the trade balance into imports and exports, respectively, the results show that both imports and exports rise in response to a positive government deficit shock, however imports rise to a slightly higher degree than imports, thus leading to a trade balance deterioration. Furthermore, the increase in fiscal deficit provides a boost to GDP upon impact and leads to an initial appreciation to the real exchange rate which then falls and remains below base from the second year.

The exchange rate regime that the country has will have an effect on the impact of the domestic policy on the external balance. Mundell (1961)

proposes a theoretical framework which defines the relationship between the exchange rate regimes and a country's external balance. In order to understand what impact the currency union might be having on the estimation, the panel dataset is split in two two groups of countries. One dataset consists of the 19 euro-area countries and the other dataset consists of the nine EU, non euro-area countries. The re-estimation on the split samples show that the non euro-area countries have a much higher sensitivity of trade openness to a fiscal debt shock than the euro-area countries. Furthermore, the non Euro-area countries experience a larger rise in the real exchange rate in response to the fiscal deficit increase compared to the countries who adopted the Euro.

Although focused on the EU, the results of this study cast a perspective on the increased economic integration of nation states through a Free Trade Area. Many countries currently participate in free trade area's (FTA's). Some of the prominent FTA's are NAFTA (US, Canada and Mexico), ASEAN (SouthEast Asian Economies) and SAFTA (South Asian Economies). As free trade areas are growing in terms of the number of countries that are choosing to participate in them, understanding the impact that participation in FTA's can have on domestic fiscal policy is important. Understanding how increased trade-openness and integration of goods markets effects domestic transmission mechanisms helps policy makers to better understand and anticipate the final impact of idiosyncratic fiscal policy on other domestic economies. Vice versa, knowing the impact of a foreign fiscal shock on the trade balance allows policy makers to better anticipate the total effect of fiscal spending changes on their domestic economy.

Fiscal policy is conducted on a national level and is de-centralized. Fiscal policy is conducted with the welfare of the domestic population in mind and not the entire EU. Other aspects of Economic policy including, product regulations and monetary policy are conducted on a EU wide basis(De Grauwe 2013, Buti & Van den Noord 2009). This mismatch in perspectives means that the spillovers of fiscal policy on neighbouring countries are a cause of concern

(Alloza, Burriel & Pérez 2019). The most direct impact on neighbouring countries of a fiscal shock is through changes in the movements of trade. This study hopes to update previous work by looking at how the current economic links within the EU affect the external balance response of fiscal shocks and in particular whether these closer ties have changed either the direction or scale of spillovers (Monacelli & Perotti 2008).

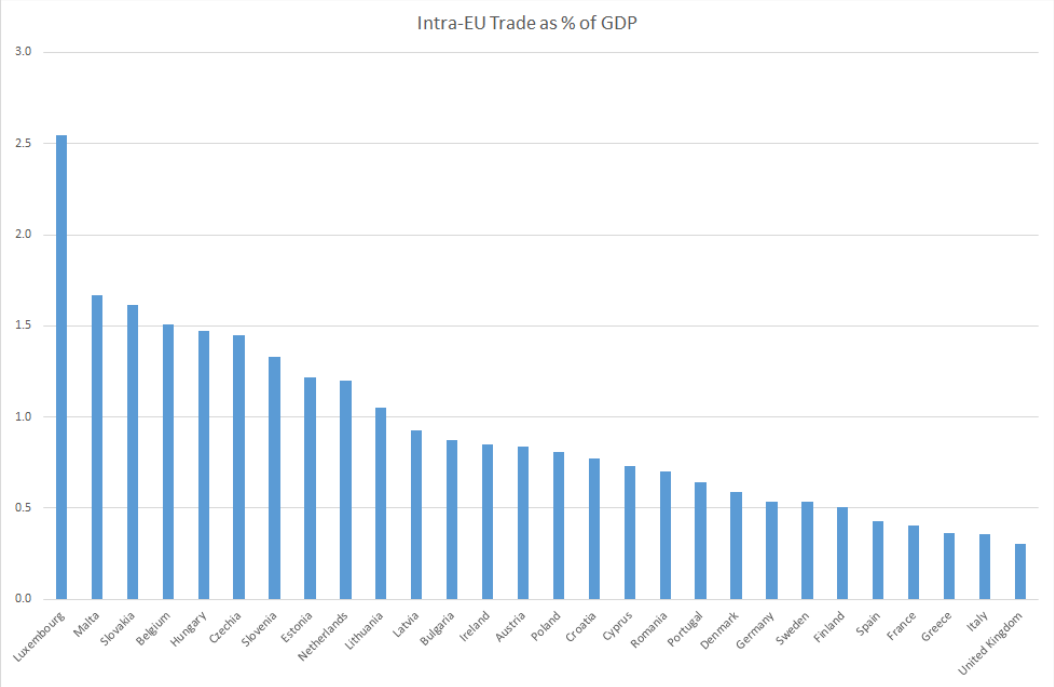


Figure 1.1: Intra-EU imports and exports as percentage of GDP. Source:Eurostat

Figure 1.1 shows the percentage of GDP that the value of intra-EU trade in goods and services is equal to. The data includes both goods and services[2].

The EU has extended to include 13 new member states. 10 countries acceded on 1st May 2004, 2 more on January 1st, 2007 and Croatia on July 1st,

[2]Services data from IMF Balance of Payments statistics and goods data is sourced from the EUCOMEXT dataset.

2013. This increases the pool of countries with which restriction-less trade can occur[3]. This study is unique in that it includes all 28 member states of the EU until 2018 in its estimation. Therefore there is a large enough dataset in which to split the dataset in to euro-area and non euro-area countries respectively as well as including a larger amount of information from when the euro was adopted. Furthermore, the time-series runs from 1995-2018 which allows for measurement of the dynamics during the financial crisis and recovery periods.

Understanding the EU wide impact of domestic fiscal policy can help both domestic and international policy makers be better prepared to anticipate and react to the final impact of policy shocks. The results of this study can contribute to existing debates about the need for fiscal coordination within the EU. If spillovers are large then, the argument that individual governments should hand over fiscal responsibilities to a EU wide body may be strengthened. This is because the final impact of one domestically shock is felt significantly by other countries but the other countries have no say in the matter.

Section two introduces the theoretical underpinnings of the twin-deficits hypothesis. The impact that trade openness and currency unions may have on the mechanisms behind fiscal deficits are investigated. The literature that empirically tests for the existence of twin deficits is then reviewed. Section three introduces the structural panel VAR that is employed in this paper. A panel-var allows us to capture the inter-dependencies between the member states and allows us to measure how spillovers will affect the trade balance. These spill-overs are an important mechanism in understanding the final impact of a fiscal shock on the trade balance. Section four introduces the results of the main estimation. The results show that the current account imbalance slightly increases with a deterioration of 0.4% in the first year as a result of the increase in government deficits. However, the scale of movement of the trade balance is much weaker than in the results that Beetsma, Klassens

[3]2004: Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Malta, Poland, Slovenia, Slovakia 2007: Bulgaria, Romania, Source: Eurostat

Giuliodori (2008) estimate [4]. One reason behind this is because GDP is not as positively affected by the shock which means that the import-side of the trade balance does not pick up as much as in their study. The real exchange rate has a relatively muted response. The section then introduces the re-estimation on dataset that has been split in to the euro-area and non-euro area countries respectively. The results show that the non euro-area countries experience a greater incidence of twin deficits than the countries with the euro. Section five concludes.

1.2 The Twin Deficits Hypothesis

Twin deficits refers to an increase in current account deficits as a result of increased government increasing public deficits. The most well established explanation of twin deficits comes from national accounting and the relationship between private savings and public savings. To start with, the usual open macro-economy national accounting relation (Corsetti & Müller 2006): the relation below highlights how reduced public deficit could lead to lower net exports[5]. X-M refers to the trade balance which is defined as exports minus imports. Y refers to total output, C refers to consumption and $T-G$ refers to the fiscal balance which is Government revenues (taxes), minus Government Expenditure.

$$\text{Current Account} = (X - M) = (Y - T) - C - I + (T - G) \tag{1.1}$$

$$\text{Private Savings} = (Y - T) - C \tag{1.2}$$

$$\text{Public Savings} = (T - G) \tag{1.3}$$

[4]Beetsma, Klassens & Giuliodori (2008) was one of the earliest studies to apply the VAR approach to analyze the question of twin deficits in the case of the EU.

[5]See Corsetti and Müller (2006) for a full explanation

Rearranging the equations gives the following where, Budget deficit $= G - T$ and Current Account Deficit $= M - X$:

$$\text{Current Account Deficit} = \text{Investment} - \text{Private Savings} + \text{Budget Deficit} \tag{1.4}$$

Equation 1.1 states that the current account is net exports which is in turn equal to government savings (T-G), private savings and investment. Equation two shows that private savings are any proportion of output that has not taxed or consumed. The twin deficits hypothesis works under the assumption that Savings = Investment (S=I), which in turns means that M-X = G-T. Public savings are net exports plus governments surplus. Equation 1.4 shows that a rise in the budget deficit must necessarily be met with a fall in the current account. This very simple accounting identity relates fiscal deficits to current account deficits.

One issue that traditional theory does not deal with is the indirect effects of the initial trade shock on neighbouring countries. Integrated goods and financial markets all play a role in the fiscal transmission mechanism. The impact on neighbouring countries could in turn have effects on the initial country. In the situation like one of the EU, where countries have a high proportion of GDP that is part of the external balance, the effects of a fiscal expansion on neighbouring countries are important to capture.

Figure 1.2 shows the split between Intra-EU and extra EU trade that each country embarks on. It includes information for both goods and services and includes both imports and exports.

Some studies find evidence to support the rejection of a twin deficit hypothesis. This is because the negative impact on deficits is partially offset by ricardian equivalence. The reduction in total savings means that the return on investment has to increase and therefore the interest rate should go up (Kim & Roubini 2008). The marginal propensity to invest will play a role as if the private sector is very sensitive to the increase in return then private savings

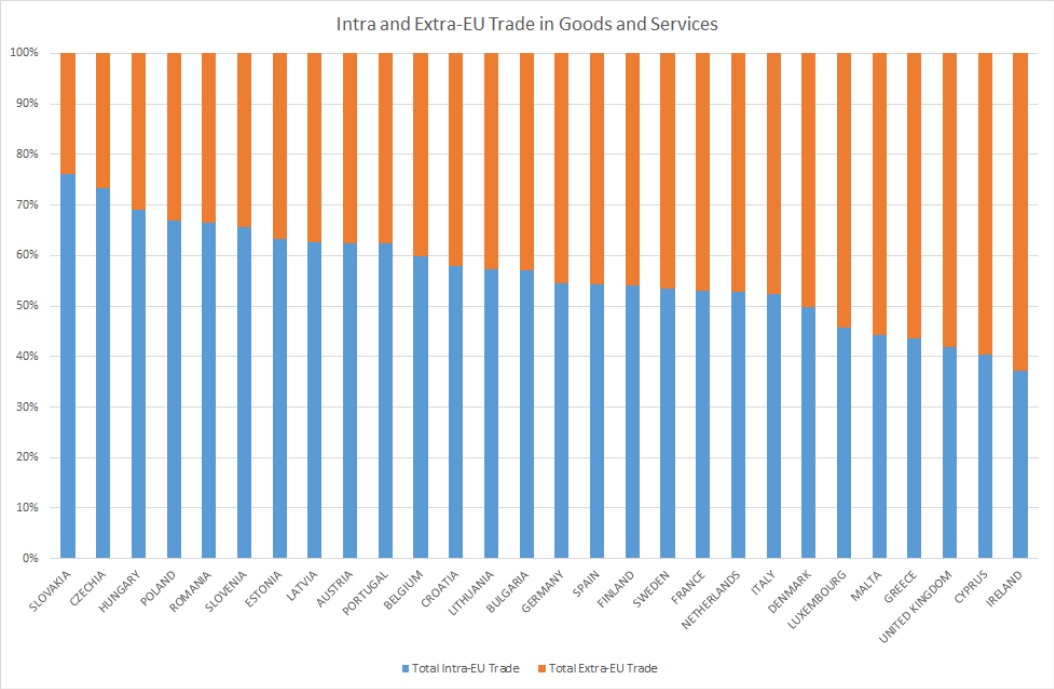


Figure 1.2: Intra , Extra EU split of Imports and Exports in Goods and Services, 2017. Source:Eurostat

will be crowded in which reduces the amount that needs to be 'borrowed' from abroad. Some studies find that government expenditure does not crowd out private investment but instead boosts it (Kim & Roubini 2008).

One explanation for the existence of twin deficits in the data could be down to the pro-cyclicality of government deficits. Public deficits are usually higher in times when the economy is less productive. When the economy is less productive, this can also coincide with or directly contribute to a terms of trade appreciation, thus increasing the relative prices of domestic goods (Beetsma, Giuliodori & Klaassen 2006, **?**). Therefore this can mean that twin deficits are misconstrued as there is a correlation between current account deficits and public deficits as they both move with the real business cycle (Kim & Roubini 2008).

For most of countries, trade within the EU counts for over half of value of their total international trade. Figure 1.1 shows the total amount of imports and exports that a member state conducts with the rest of the EU as a percentage of domestic GDP. For the majority of the member states, trade with the EU is either equal to or above their domestic GDP. This figure shows, how much exposure the member states have to each other and furthermore the extent to which they are 'trade-open' to the rest of the EU. Figure 1.2 further quantifies this reliance by showing the proportion of total trade for a country that intra-EU.

This increased openness could potentially alter the usual transmission mechanism of government expenditure. Corsetti and Müller (2006) investigate the effect that trade-openness might have on the transmission of fiscal shocks on to the trade-balance. Their findings are that countries that are more open are more likely to face larger twin deficits. They define trade-openness as the import content of domestic consumption. Their findings are that countries that are more open are more likely to face larger twin deficits. They believe that their is a macroeconomic trade-off between the following three things i) borrowing from abroad (fiscal deficits) ii) domestic or international consumption (trade-openness) iii) increased capital accumulation. (Corsetti & Müller 2006). In a closed economy, a fiscal expansion will have a higher impact on the domestic saving rate relative to the the foreign saving rate. This will encourage saving and reduce consumption and will cause a fall in imports and therefore limiting the negative impact on the trade balance. However, in an open economy no private saving will be crowded in as a result of a fiscal expansion. Their empirical method is to use a SVAR on four countries (UK,US, Canada Australia) and introduce a shock to government deficit and look at how the trade balance responds. They calculate the import content of domestic consumption and label the UK and Canada as more 'trade-open' countries and the US and Australia as more 'closed' countries. They then find that their empirical estimation matches their hypothesis in so far as that trade-open economies experience a larger impact on their trade balance. Short-comings

of their approach are that they do not consider spill-overs in their estimation and do not consider the impact that a currency-union could have on the relationship between relative impact on the differential between the domestic and international saving rates.

1.2.1 Twin Deficits and Currency Unions

The exchange rate regime that a country adopts affects the transmission mechanism of a fiscal policy change. The Mundell-Fleming model states a relationship between: i) a country's exchange rate regime ii) domestic fiscal policy and iii) a country's external balance or net exports. A fixed exchange rate regime reduces the extent to which an currency can adjust vis-à-vis other currencies in response to increased domestic demand. With a floating exchange rate regime, the nominal exchange rate can adjust to the increased domestic demand by appreciating the nominal value of the currency against other currencies. Countries that participate in a currency union have exchange rates that operate somewhere in between a fixed and floating exchange rate regime. Whilst the currency is free to fluctuate against other global currencies, the currency for each country has to remain, in essence, 'fixed' to the other countries in the union. They have a fixed nominal exchange rate to the other countries in the union. When a fiscal expansion takes place within a monetary union, it takes place on a domestic level and is induced based on the movements of the domestic economy. However, as the country is part of the currency union, the nominal exchange rate is not as free to adjust to the increase in domestic demand and increased government borrowing. The muted response of the exchange rate means that the domestic interest rates are not as sensitive to the government's increased borrowing. The lack of reaction of the interest rate can foster a lack of fiscal discipline as a country will have reduced costs of taking on more debt than a country which has a national currency. This ultimately impacts the effect of a fiscal expansion on external account of an economy, therefore impacting the response of the trade balance. The lack of

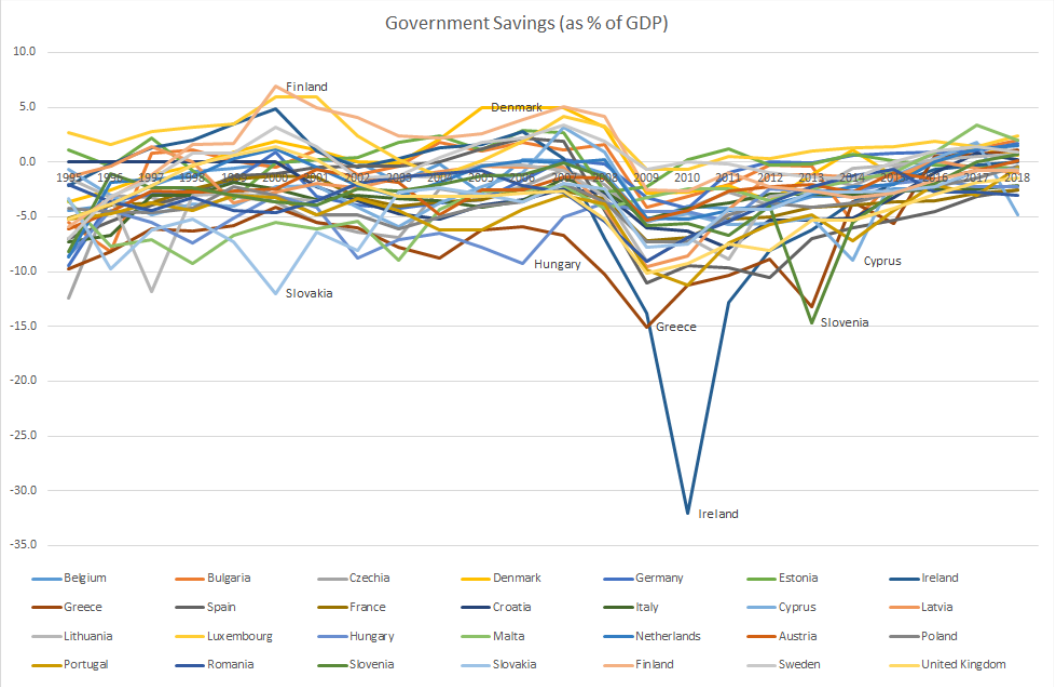
unity between fiscal policy and the monetary authority has been argued to also lead to a lack of fiscal discipline. The cost of not exercising fiscal discipline is shared between the other countries that share the currency. The other factor is that a shared currency causes countries to become more open as they have reduced cross-border transactional costs with other countries that have the same currency (Eichengreen 2010). However, the inability to change the nominal exchange rate in relation to domestic events means that it takes a longer time for the relative prices of goods to change in relation to an increase in domestic demand. A shared currency fixes the nominal exchange rate, so trade is only affected through movements in CPI and not the nominal exchange rate which in turn is determined by the interest rate.

Evidence also suggests that participation in a currency union fosters too much fiscal discipline (De Grauwe & Ji 2014). This is due to the lack of guarantee to government debt that can be provided by the central bank, therefore leading to markets that react more sensitively to government debt (De Grauwe & Ji 2014). The markets reaction to increased government debt leads to higher bond spreads for national governments making it more expensive for governments to borrow money.

A shared currency will have an affect on the speed of the spillover. When countries engage in a currency union, there is a higher level of integration of capital markets. This can provide a further source of contagion for the fiscal policy movement located in one country to affect neighbouring countries. The idiosyncrasy of fiscal policy means that a domestically sourced fiscal policy can affect the wages and inflation in the other countries that also participate in the currency union (Cooper, Kempf & Peled 2009). This poses questions for policy-makers about how to best handle the coordination of fiscal policy. During the crisis of 2008-2009, pressure was placed on government finances. Real output was falling leading to declining tax receipts but at the same time, social security obligations were growing. This lead to increased deficits as a proportion of GDP (This can be seen in Figure 1.3). Although there was

pressure on governments to reduce their debt levels, at the same time, many member states were in need of a growth stimulus. One way to achieve this was through a fiscal stimulus. There were issues of fiscal coordination as one country's stimulus could have been enough to help re-start the economies that were in need of a growth stimulus (Blanchard, Erceg & Lindé 2017) As the government sought to meet the payments of previous debt as well as deal with the declining domestic real economy, countries took on more fiscal deficits. This increased debt has neighbouring impacts on the neighbouring economies.

Figure 1.3: Total Government Savings over GDP for EU28, 1995-2018, Source:Eurostat



The traditional Keynesian view is that an increase fiscal expenditure would cause an increase in GDP owing to increased demand in the economy. This boost in expenditure in the economy leads to a boost in aggregate demand in the economy. The increase in aggregate demand within a new Keynesian model leads to an increase in domestic prices. This increase in domestic prices

relative to foreign prices leads to a terms of trade appreciation. By boosting the real price of domestic goods, there is an ensuing an appreciation of the real exchange rate.

$$\text{Real Exchange Rate} = \text{Nominal Exchange Rate} * (P_{domestic}/P_{foreign}) \quad (1.5)$$

There are limited studies that have taken place with a longer sample of the inclusion of the euro. The data used in this study is from 1995-2018: this means that a substantial portion of the data includes the period where the countries adopted the euro as well as the pre and post crisis years. The size of the country plays a role in determining how influential a shared currency is on twin deficits. A small country might not see a change in the twin deficits hypothesis as a result of adopting the euro however a large country might as the channels through which prices can adjust are slower as it can only happen through relative CPI's and not the nominal exchange rate.

1.2.2 Empirical Evidence of Twin Deficits

The empirical evidence of twin deficits paints a mixed picture where by some studies find empirical evidence to support twin deficits (Monacelli & Perotti 2008) and other notable studies find empirical evidence to support the opposite conclusion (Kim & Roubini 2008). Whilst reviewing previous studies, this section highlights that it is a) it is important to account for spillovers b) decomposing the trade balance into imports and exports in order to provide an important perspective on the source of the trade balance deterioration. Identifying the source of the deterioration could provide useful information to policy makers on how to address the trade balances caused by changes in fiscal expenditure.

Kim and Roubini (2008, 2003) conduct an empirical exercise on the

US using a SVAR approach with five variables. As US trade deficits worsened during the early 2000's this introduced calls for a reduction in government debt to help fix the current account. Their specification is real output, government deficit, trade balance, real interest rate and the real exchange rate (RGDP, GOV, CUR, RIR, RER). When applying a positive shock to government deficit (unanticipated increase in government deficit), their results show that the impact on the current account is actually positive. A phenomenon labelled as 'twin divergence'. The mechanisms behind this result is from a partial Ricardian behavior of private saving (that is, private saving increases) and a fall in investment (a crowding-out effect which was likely to be the result of an increase in the real interest rate), while the real exchange rate depreciation was mainly the result of a nominal exchange rate depreciation (Kim & Roubini 2008).

Monacelli and Perrotti (2010) use a structural VAR to find the response of the trade-balance to a shock in government expenditure. Their analysis covers four countries (Australia, UK, Canada US) . Their study finds evidence to prove the existence of twin deficits. In response to a positive shock in public expenditure, their results show that the trade balance deteriorates due to an appreciation in the terms of trade. Their general results for all four countries are

- GDP and private consumption both rise;
- The trade balance deteriorates, except in the US where the response is at in the short run and positive (although small) in the long run;
- The real exchange rate depreciates, except in Canada in the long run.

It is interesting to observe that the results of the study do not hold entirely for the US. As one of the largest economies in the world and furthermore the countries that has the highest trade with all the other countries in the world, the potential for spillovers on to other economies is large. The

existence of large spillovers could impact the transmission mechanism of the policy shock.

According to the World Trade Organization 2014 trade database, there are 19 countries (including China) that have the US as their leading export market and 26 countries that have the US as their leading import market. (This database considers the EU as one entity). There are potential spillovers that a fiscal shock might have on key trading partners. This in turn could effect the final impact on the US.

Trade-openness could have an impact on the behaviour of the trade balance. Trade openness refers to how open a country is to trading with other countries. The trade openness statistic is measured by the following equation.

$$\text{Trade Openness} = \frac{\sum Exports_{jROW} + \sum Imports_{jROW}}{GDP_j} \tag{1.6}$$

Where j refers to the country j and ROW refers to the rest of the world. Equation 1.6 says that trade openness is the sum of all exports from country j to the rest of the world added to the sum of all imports from the rest of the world to country j and then divided by the output of country j.

Corsetti and Müller (2006) looked in to the impact that 'openness' might have on twin deficits. Openness refers to the the preference that the domestic population have for consumption of domestic goods over foreign goods. They investigate the role that an international fiscal transmission mechanism might play in affecting the twin-deficits hypothesis. Their hypothesis is that the degree of openness within a country impacts the extent to which twin deficits can be observed. This mechanism comes from the degree of home-bias there is with domestic investment. They first create a two-country general equilibrium model that makes the argument that closed economies are likely to see a stronger crowding out effect on investment. As the deficit reduction has to either be reflected in the trade balance or a reduction in domestic

capital, the closed economies display a reduction in domestic capital.

Next, a SVAR is run on the same four countries as Monacelli and Perrotti (2010) which are: Australia, Canada, UK and the US. They find that the only country that does not exhibit twin deficits is the US. The US is also the most 'closed' of the four economies that they analyze. Countries that do not have a strong trade to GDP ratio would find that their trade balance is less sensitive to a fiscal expansion.

A further limitation to the studies mentioned already is that they look at the trade balance as one variable and therefore are not able to distinguish between the movements of imports and exports. By looking at imports and exports separately we have the added benefit of assessing whether the source of impact on the trade balance is from the demand side or supply side movements in the economy.

Beetsma, Guiliodiori & Klassens (2008) looks at the question of twin deficits and applies it to the case of the EU. A panel VAR is estimated on a dataset that includes fourteen of the EU member states. By using a panel approach, some of the issues with single country approach are resolved. The panel approach allows for the contagion to be accounted for. A second amendment is that imports and exports are used separately in the estimation. The trade balance is separated in to Imports and Exports respectively and used as two different variables in the VAR. This allows to identify specific sources of the trade-balance movement. The six variables used in their VAR are government spending, net taxes, exports, GDP, imports and the real exchange rate. They do not directly measure the impact to a shock to government deficits but just measure the response to solely a government spending shock. Their results show that a one-percent of GDP increase in government spending produces a total 1.6% increase in GDP. Furthermore, imports rise and exports fall leading to a deterioration of the trade balance by 0.5% of GDP in the first period and leads to a total fall of 0.8% of GDP. Their results thus prove the existence of twin deficits. Next, they split their sample of fourteen countries in

to trade-open and closed economies. They distinguish between countries which are deemed to have a friction-less trading environment are analyzed and the countries which have from those which a restrictive trading environment. Imports have a more sensitive reaction within closed economies but exports seem to be are more negatively affected in the open economies.

1.3 Methodology

In order to account for the behaviour of all the countries within the EU, a panel VAR approach is adopted. A panel VAR approach has many advantages. It allows for endogeneity to exist between the variables used in the estimation and it allows for cross-sectional interdepedency to be measured in the estimation. The panel consists of data for the 28 EU member states. The dataset is annual and runs from 1995-2018. The panel VAR is estimated using OLS. It has the following specification:

$$\Delta\widetilde{y}_{it} = B(L)\Delta\widetilde{y}_{it-1} + \varepsilon_{it} \tag{1.7}$$

where

$$\widetilde{y}_{it} = y_{it} - \bar{y}_i - \bar{y}_t \tag{1.8}$$

Where i refers to the different cross-sections in the data-set and t to each time-period in the data-set.

$$\begin{bmatrix} \Delta Fiscal_t \\ \Delta GDP_t \\ \Delta Imports_t \\ \Delta Exports_t \\ \Delta REER_t \end{bmatrix} = \begin{bmatrix} \sigma_{11} & \sigma_{21} & \sigma_{31} & \sigma_{41} & \sigma_{51} \\ \sigma_{12} & \sigma_{22} & \sigma_{32} & \sigma_{42} & \sigma_{52} \\ \sigma_{13} & \sigma_{23} & \sigma_{33} & \sigma_{43} & \sigma_{53} \\ \sigma_{14} & \sigma_{24} & \sigma_{34} & \sigma_{44} & \sigma_{54} \\ \sigma_{15} & \sigma_{25} & \sigma_{35} & \sigma_{45} & \sigma_{55} \end{bmatrix} \begin{bmatrix} \Delta Fiscal_{t-1} \\ \Delta GDP_{t-1} \\ \Delta Imports_{t-1} \\ \Delta Exports_{t-1} \\ \Delta REER_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \end{bmatrix} \tag{1.9}$$

The VAR is a five series VAR with the following specification:

$$[G_t - T_t, Y_t, X_t, M_t, REER_t] \tag{1.10}$$

$G_t - T_t$ is net taxes, Y_t is output, X_t is exports, M is imports, REER is the real exchange rate. The data for the trade balance includes both goods and services. This specification broadly follows that of previous literature (Kim & Roubini 2008).

A feature that is employed in this methodology is to split the imports and exports in to two separate series (Beetsma, Giuliodori & Klaassen 2008) as oppose to looking at the trade balance as a whole which is commonly done (Monacelli & Perotti 2008, Kim & Roubini 2008). The VAR opted for in this study is a structural VAR identified with a Cholesky decomposition. One limitation of the Cholesky decomposition is that the restrictions identified are not grounded in economic theory and instead based on ordering the variables depending on how endogenous they are to the other variables. Future research could conduct an estimation that has more rigorous economic theory in justifying the restriction. An alternative approach could be the sign var approach which restricts the direction of response to a variable, which allows for a theoretical motivation of restrictions without being too prescriptive about the size of these restrictions.

This allows for further insight through locating the source of the movement of the trade balance i.e. whether the change is driven by imports or exports. This allows for the relative sensitivity of imports and exports to be observed as well as having an insight in the the relative elasticity's of imports and exports.

The movement of exports is associated with a supply side response of the economy. The inclusion of the real exchange rate will allow us to see if the movement is driven by the movement in relative prices. If relative prices stay flat but there is an increase in exports, then there is relative grounds to conclude that there has been a boost in productivity increase the supply of exports (Uhlig 2005).

Once the reduced form VAR has been estimated, the next step is to

identify the deficit shock through applying restrictions on the error matrix. An unrestricted VAR framework is unable to estimate the parameters of contemporaneous responses of variables. There are too many parameters to be estimated and therefore two many unknowns. However by using theoretical assumptions, restrictions can be imposed on the error matrix in order to uncover the contemporaneous responses of the variables to each other. Impulse response functions are obtained by applying a 2.5% shock to the error term of the VAR. The observations are summed in order to obtain the cumulative response function (Blanchard & Perotti 2002). The error matrix in an restricted form as identified by using a recursive approach. As a Cholesky decomposition is being used to identify the shock, the order of the variables are placed in order of exogeneity. Government deficit is placed first, as this is dictated by policy-makers and not directly by the economy. Next is GDP as it responds to fiscal policy but responds to many other factors at the same time and therefore is ordered second. If the global economy is taken as exogenous to the domestic economy then exports will be ordered next as they are determined by the global economy to a greater degree than imports are. Next is imports and finally, it is the real Exchange Rate. Imports are ordered second as the domestic country is going to be the first to initially feel any of the impacts from the increase in government deficit and as imports are a function of the domestic economy, they are likely to react first.

$$X_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + ...A_i\varepsilon_{t-i} = \sum_{n=1}^{\infty} L_i A_i \varepsilon_i \tag{1.11}$$

Restrictions can be based on previous information about the behaviour of the variables to each other (Kim & Roubini 2008, Monacelli & Perotti 2010). The structure of the EU is such that countries cannot be looked in isolation especially when analyzing the trade balance. The level of the trade balance is in part determined by the economic activity of other countries. Thus, "a multilateral perspective is crucial, and failure to recognize this aspect of reality is likely to induce distortions in the evaluation of economic outcomes and erroneous policy decisions" (Canova & Ciccarelli 2013).

In seeking to capture the inter-dimensional affects, a panel structural VAR is estimated. Panel estimations allows us to draw on a wider number of observations which can improve accuracy.

The matrix containing omegas estimates parameters to contain the values of the coefficient between every singly country in the model and every single variable in the model. As such the impact of an isolated shock on all countries is taken in to consideration (Kim & Roubini 2008, Beetsma, Giuliodori & Klaassen 2008, Monacelli & Perotti 2010).

The lag length was chosen via the final prediction error criterion. This criterion is thought to be suited well to shorter time series of 60 or less observations. The results do appear to show some sensitivity to the lag length choice but not as much as to affect the overall direction of movement.

A fixed-effects transformation is conducted in order to account for any unrelated heterogeneity that may exist between the different panels in the data. Demeaning the data involves taking the average value for a variable for each cross-section across the whole time series and taking in away from each observation within each panel. A fixed effects transformation means that I make the assumption that the heterogeneity between countries remains fixed for the whole time period. In order to remove time-effects, the data is time-demeaned.

Five data series are used for the estimation. Three of them are sourced from national accounts data provided by Eurostat. These are GDP, Imports and Exports. The import and export series include both goods and services and measure all the transactions from the domestic (source) country with the rest of the world. Imports and exports are both expressed as a percentage of GDP. The fiscal deficit series is general government deficit divided by GDP which is government receipts minus government expenditure.

Government deficit, GDP, imports and exports are all used in the

logged real value. Other studies carry out cyclical adjustment on their data (Beetsma, Giuliodori & Klaassen 2006, Beetsma, Giuliodori & Klaassen 2008). A similar adjustment is not done in this estimation owing to a shorter time-frame. The real exchange rate is the real effective exchange rate. It is measured by relative prices of the domestic country against a group of 42 industrial countries that are trading partners. These include the EU28 plus 14 other industrial countries. By looking at the real effective exchange rate, the estimation is not dominated by the impact of nominal euro movements but rather the price competitiveness of countries. The variables are all expressed in logged first differences.

1.4 Results

The IRF's generated from the fiscal shock are displayed in the graphs below. The graph shows the response of all five variables in the estimation to the initial shock. The IRF's are generated for an eight year period. The fiscal shock is a 2.5% increase in government deficit. 2.5% is a one standard deviation shock to government deficit.

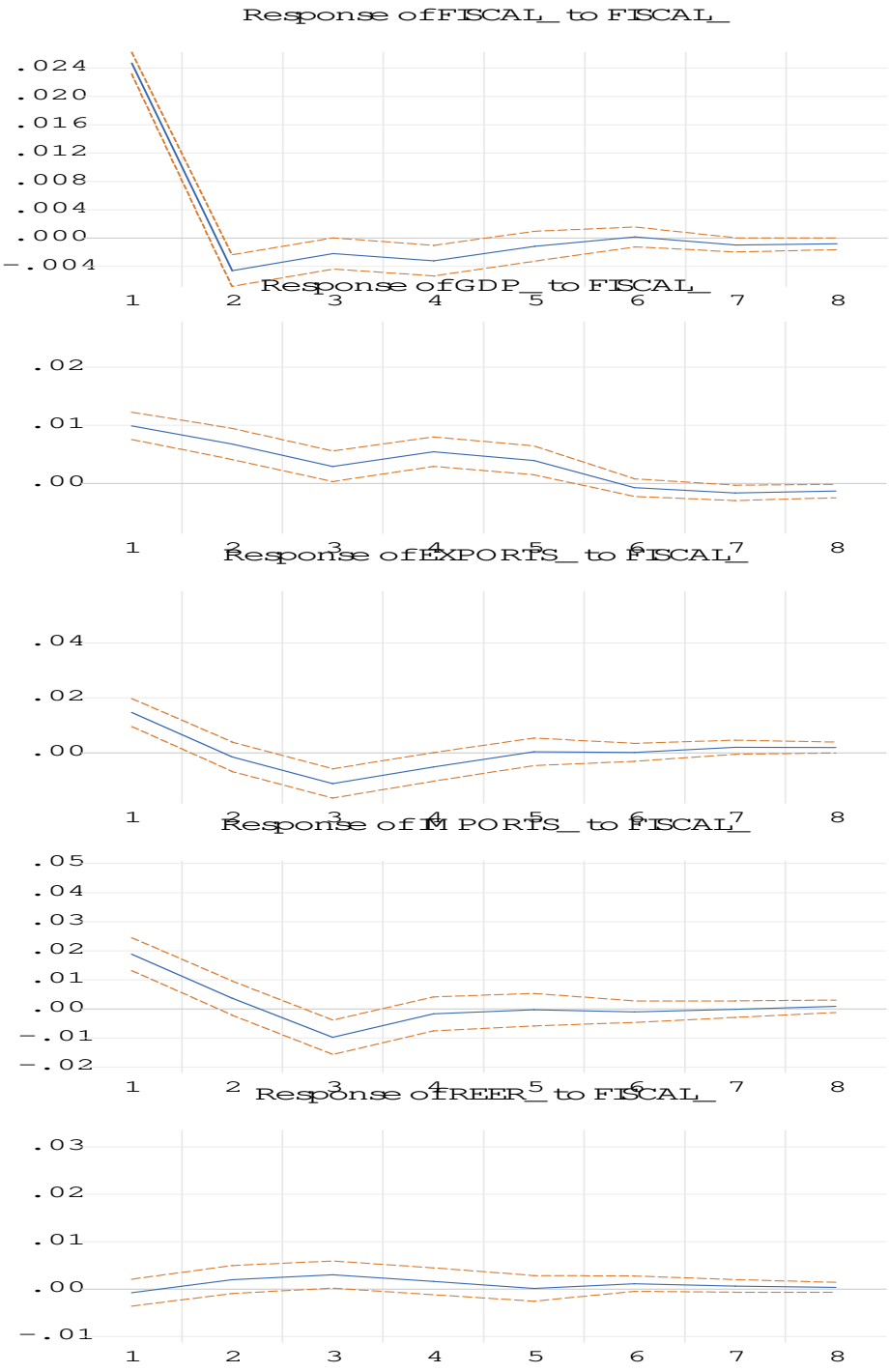


Figure 1.4: Impulse response functions

When looking at imports and exports, there is an initial increase in trade openness, as they both rise in response to increase in government deficit. When looking at specifically the trade balance, there is slight deterioration of the trade balance as imports rise to a greater degree than exports. However, this result is quite limited at around 0.4%. One other feature that is apparent is there is a mirroring in the response of imports and exports. They both rise initially and then experience a peak dip in year 3. This could be evidence of vertical specialization whereby exports feature an import content meaning that as exports fall, imports also fall as they are no longer needed as an input in to production. Further investigation would be needed to confirm this mechanism. The exchange rate rises upon impact of the fiscal shock, however this response is quite muted. This could be in contrast with standard economic theory that suggests that the real exchange rate should rise upon impact of a positive increase in government deficit. These results could be explained further. One explanation is that the rise in prices falls on non-tradable goods and not tradable goods which means that the effect on the real exchange rate is limited.

Figure 1.5 shows response of net exports that has been calculated by looking at the response of exports minus imports. The blue line shows the response of net exports in each year and the orange line shows the cumulative response of net exports. This is calculated by simply by taking away the impulse responses of imports from the impulse response of exports. The value is interpreted as the impulse response of net exports. Error bands are not included as they are already presented in their decomposed form in figure 1.4.

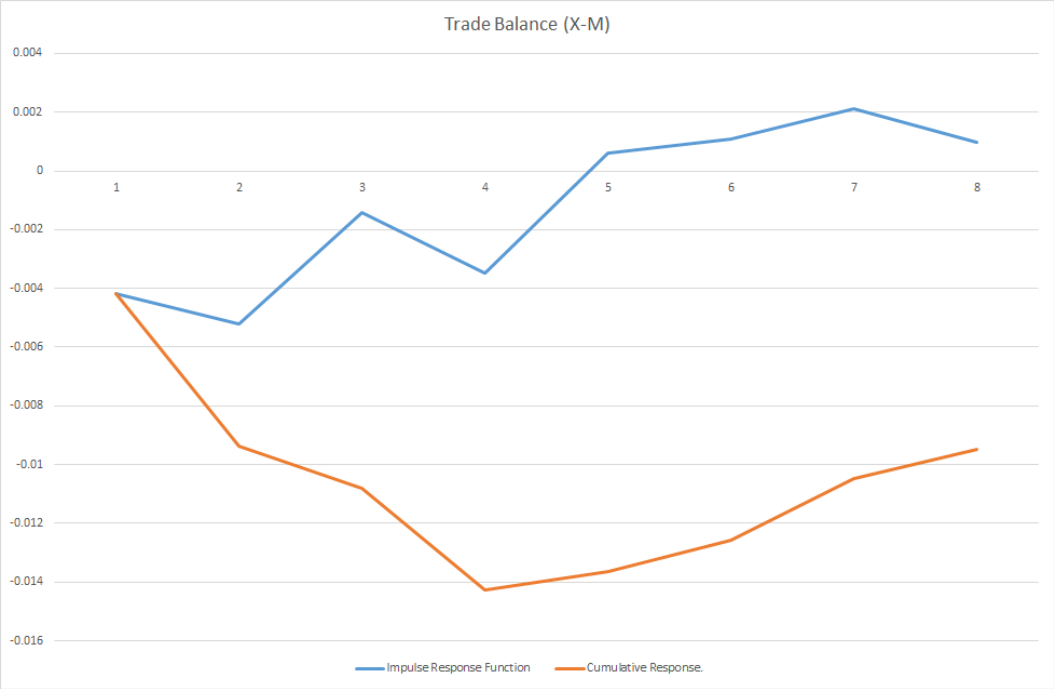


Figure 1.5: Response of Net Exports. X axis displays number of periods after initial shock.

The deterioration of the trade balance is partially consistent with the theory in so far as that exports fall in the second year, however, there is no sustained increase in imports. The results are partially consistent with Beetsma, Klassens and Giuliodori (2008) in so far as that they also find a decrease in the trade balance, however their result does not feature the mirroring of imports and exports and in fact imports and exports move in opposite directions in so far as that exports decrease and imports increase.

GDP rises and is higher than base in the first five years. As the fiscal shock returns to base, GDP becomes negative. It's initial rise is to 1% in the first year. Although there is a positive fiscal multiplier[6], it is much lower than the estimates in Beetsma, Klaasens and Giuliodiori (2008) who find that in

[6]This is the implied fiscal multiplier calculated from the cumulative response of output to a fiscal expenditure shock.

their estimation, the GDP multiplier is higher than unity for their benchmark estimation. When splitting their sample in to open and closed economies, they find that the GDP multiplier is much lower for open economies and it does not ever reach unity for the open economies. The estimates in this study would suggest GDP multiplier of around 0.4. The cumulative response of GDP is 2.5% which suggests a multiplier that is slightly larger than unity.

The real exchange has an initial rise in the first year but then remains below base for the remainder of the horizon. The fall of the real exchange rate goes against some economic theory that would suggest a rise CPI and therefore an appreciation of the real exchange rate. The rise in GDP and rise in exports suggest that there could be some increased productivity within the economy. If productivity has increased, then this could explain a fall in the real exchange rate as countries gain in price competitiveness. The confidence bands are asymptotic at 68% and are small enough that they do not suggest doubt in the overall direction of the results.

1.4.1 Euro-area and Non euro-area split

In order to have an idea of what impact the common currency might be having on the result, the benchmark panel dataset is split in to two and the panel VAR is re-estimated. The first group consists of 19 EU member states all of which have the euro. Countries that incorporated the euro later are still included in the estimation as they maintained a peg for years prior to the change[7]. The second consists of the remaining nine, of who all stick to national domestic currencies. Re-doing the estimation on a split sample of euro-area and non euro-area countries is can be informative on what the role of the common currency is in impacting the impact of fiscal policy.

[7]Lithuania Latvia Slovenia and Slovakia

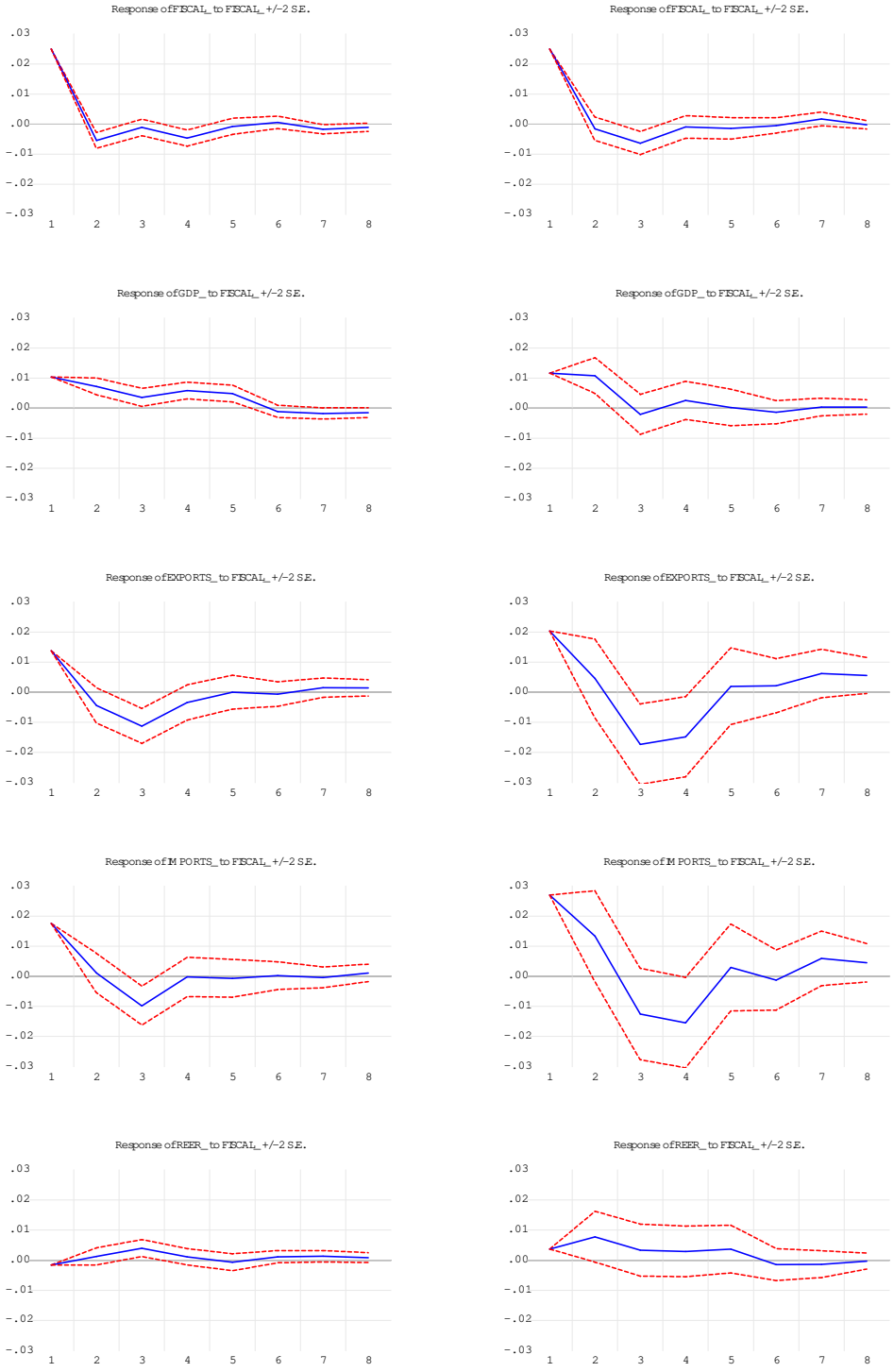


Figure 1.6: EA non EA split, x-axis shows number of periods after shocks.

The shock applied was a one standard deviation, the shocks to the EU19 and EU9 were then scaled to represent a 2.5% positive shock to the level of government deficit. The confidence bands is the Euro Area estimation are smaller than the non euro area estimation due to the larger number of countries in the sample.

There is not much difference between the EA and non-EA results particularly in the response of GDP. However, the direction of the results is similar in so far as that the directions of the trade balance move in similar directions and furthermore the imports and exports both increase and the increase in deficits is driven by the fact that imports rise more than exports. The extent to which we would expect qualitatively different results is arguable. There are a few factors that could impact the extent to which we could expect EU and non-EU results to be similar to each other. There is the floating exchange rate vs the fixed exchange rate, alongside the relative trade-openness that the regimes can bring. Floating exchange rate regimes are more likely to have more sensitive reactions of the imports and exports to a change in the exchange rate. However , in the case of the EU, the extent to which the other nominal currencies are influenced by the EU is quite large so, it could be expected that the responses could have a similar result. In these results we see that the direction of the results are the same, however the non-EA members have a slightly more sensitive reaction of the trade balance to a fiscal shock.

Figure 1.7 shows the accumulated response of the trade balance split between the EA and non-EA countries. The blue line shows the cumulative response of net exports for the countries in the EU that do not have the Euro. The orange line shows the cumulative response of net exports for the Euro countries. This is calculated by simply by taking away the impulse responses of imports from the impulse response of exports. The value is interpreted as the impulse response of net exports. Error bands are not included as they are already presented in their decomposed form in figure 1.4. The blue line shows the net exports impulse response function each year, and the orange

line displays the accumulated response of the trade balance.

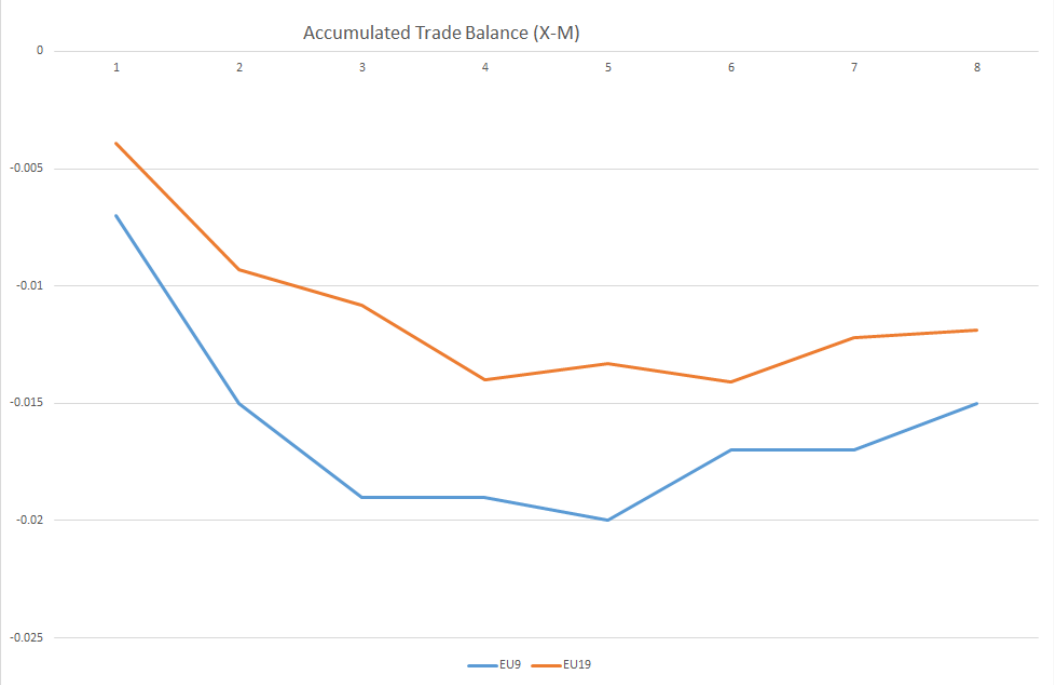


Figure 1.7: Accumulated Trade Balance response EU28 EU19

In the non euro-area estimation, there is a greater degree of sensitivity of the current account imbalances to the initial fiscal shock than in the benchmark estimation. When looking at the estimation of the 19 EA countries, the results shows a milder reaction of the trade balance which is almost half the impact than of the EU9 response in the first year. The euro-adopters have a deterioration of around 0.37% in the first year whereas the non Euro-adopters have a deterioration of 0.7%. The non Euro-adopters have a stronger response of the trade balance. This shows that the group of countries that do not have the euro have a lot higher impact on the external balance when a fiscal expansion is pursued. As the euro-area countries form the bulk of the countries in the benchmark estimation, it is unsurprising that the results are not too dissimilar to the benchmark estimation.

Table 1.1: Accumulated Response of GDP

	Accumulated Response of GDP (First Four Years)
Benchmark Estimation	2.50%
euro-area	2.75%
non euro-area	2.30%

Table 1.1 shows the accumulated response of GDP over the first four years. This could be likened to a domestic multiplier as we see how much GDP is boosted by as a result of the increase in debt. The initial debt increase is 2.5% of GDP and we see that after four years in the benchmark estimation, the accumulated increase of GDP matches the initial increase in the debt level. The euro-area GDP response has an accumulated value of 2.75% which would imply a slightly larger multiplier. The non-euro-area GDP response has an accumulated value of 2.3% which implies a smaller multiplier of an increase in fiscal debt. It is difficult to put these differences in multiplier or response of trade-balance purely down to the existence of a currency union. Selection in to a currency union could be endogenous. Furthermore, other geographical features of the countries have not been controlled for, including distance between countries and country-size. The panel-estimation indicates how the response of the trade balance to domestic policy is different in the countries that share the currency against the countries that have a national currency.

1.4.2 Robustness tests

In order to test the validity of the results, various robustness tests are carried out. These include changing the lag length, order of the variables and the type of data used for government deficit. The results are presented with asymptotic confidence intervals at 68%. The error bands are calculated by taking the standard errors of the estimation. 68% is suggested for VARs as oppose to 95% or 99% which is typically more common as 68% has posterior probabilities

that are often more useful (Sims & Zha 1999). Sims and Zha (1999) argue that characterizing likelihood shape, bands that correspond to 50% or 68% posterior probability are often more useful than 95% or 99% bands, and confidence intervals with coverage probabilities that are low, have posterior probabilities which are not close to their coverage probabilities. The confidence intervals are small enough to maintain the main tenets of the results. The larger number of observations in the benchmark estimation which includes all 28 member states means that there is a higher degree of confidence within the results obtained compared results to the euro-area / non euro-area split.

The first robustness test that is commented on is the sensitivity of the results to lag length. The model is re-estimated with only two lags as oppose to four. The main tenets of the results for any of the variables used in the estimation remain broadly unchanged and therefore sensitivity to the number of lags used is limited.

I next check if the results are sensitive to the order of variables within the model. I re-ran the empirical exercise with GDP and exports switched around as has been done in some of the literature. Again the main tenets of the results remain broadly unchanged. One limitation that the approach of this study has is that , influential panels cannot be detected. It is not clear from these results if one country is driving the results or whether these results are being driven equally by all the countries involved. Further research could investigate whether the results were being driven by the idiosyncratic responses of countries or by common responses. One to resolve this is to re-estimate the SVAR dropping countries that could potentially be influential in the estimation and see if the results hold. The model was re-run with Germany, France and the UK dropped out, the result appear to show no major change, results included in the appendix Figure 1.11.An approach outlined by Pedroni (2016) sets out a methodology that allows for the decomposition of panel estimations in to idiosyncratic and common responses. This is achieved by running individual SVAR estimation on each of the panels and then comparing

it with the common response achieved from the panel SVAR. This methodology was not available in this exercise due to limited time-series availability for all the countries in the sample. This would certainly be a useful exercise for the future in order to identify whether the pooled response or individual response of countries is driving a greater amount of the variation.

1.5 Conclusion

The literature regarding twin deficits in an open economy context is reviewed and it is proposed that the literature can go further in terms of accounting for cross-country spill over effects. The impact that trade-openness can have on twin deficits is analysed along with the impact that a shared currency might have on twin deficits. Currency unions could potentially affect the final impact of an increase in fiscal deficit on the trade balance.

The main contribution of this paper is to update the results from previous empirical studies conducted on the EU including updated data until 2018 for all member states which includes the enlargement of the Eurozone area. The estimation measures the response of the trade balance to a shock increase of government deficits. The results show a very slight deterioration of the trade-balance which is driven by both imports and exports rising upon impact but then later falling. As exports fall to a larger degree than the imports fall, this means that there is a negative impact on the trade balance. As the size of this deterioration is very small, more evidence would be needed to conclusively prove the existence of twin deficits. The results show that both imports and exports increase suggesting an initial increase in trade-openness as a as a response to an increase in domestic public deficit. An interesting feature is that imports and exports mirror each other in their responses which could suggest that there is a more direct link between goods and services that are imported and exported.

The existing dataset is then split in to countries that have the euro and countries that do not have the euro. The panel VAR is re-estimated on the two new datasets. This split allows for comparison of the response of the trade-balance to a government deficit shock, in countries that have a shared currency and countries that have a domestic currency. The response of the trade balance is slightly larger in countries that have their own currency. When looking at the response of GDP to a government debt shock, the cumulative response is larger amongst the euro-area countries at a 2.75% increase over four years compared to the countries which have a national currency which experience a 2.3% increase over the same time period.

1.6 Appendix

1.6.1 Data

- GDP - Real quarterly GDP , measured in millions of the country's national currency with a base year of 2010. Sourced from Eurostat.
- Trade - Imports and Exports in goods and services. Measured as a percentage of GDP. Sourced from national accounts data, Eurostat.
- Government Deficit - Net lending and borrowing. Measured as a percentage of GDP. Sourced from national accounts data, Eurostat.
- Real Exchange Rate - Real effective exchange rate using the deflator of 42 industrial countries that are trading partners.

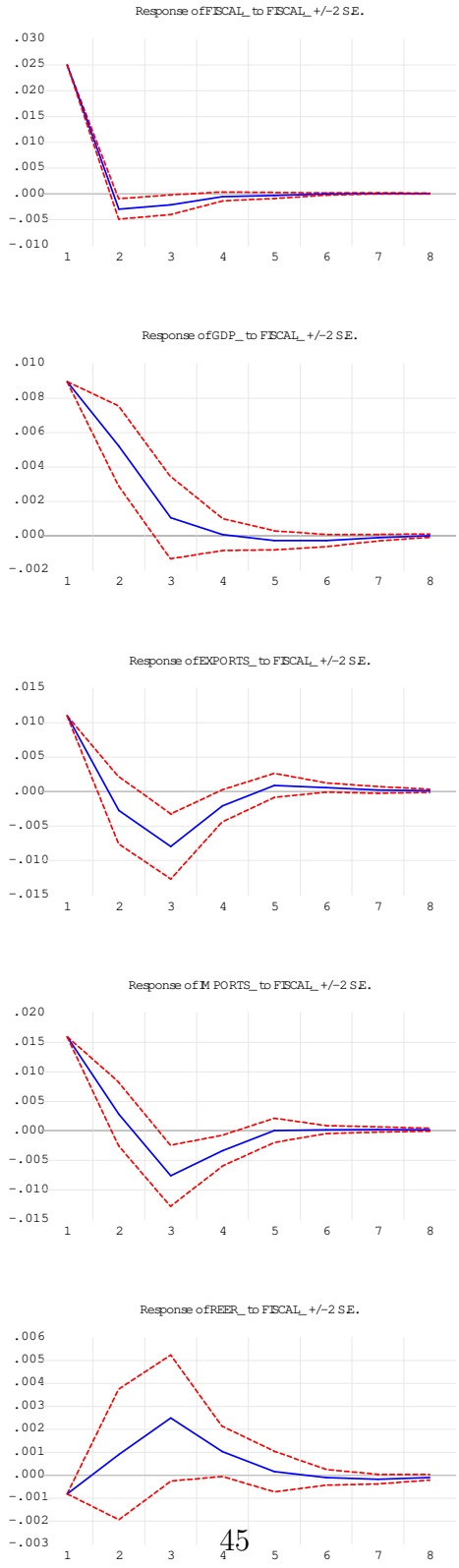


Figure 1.8: Impulse response functions with Two Lags.

One Standard Deviation Positive Shock to Fiscal Deficit. Response of Fiscal Deficit, GDP, Exports, Imports and the Real Exchange Rate.

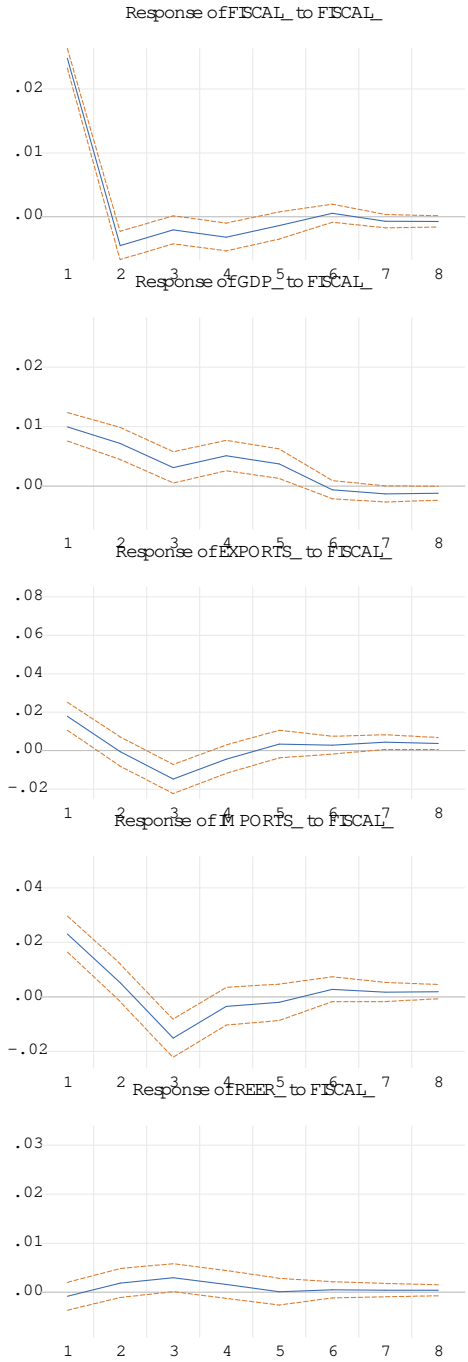


Figure 1.9: Impulse response functions with Goods Only.

One Standard Deviation Positive Shock to Fiscal Deficit. Response of Fiscal Deficit, GDP, Exports, Imports and the Real Exchange Rate.

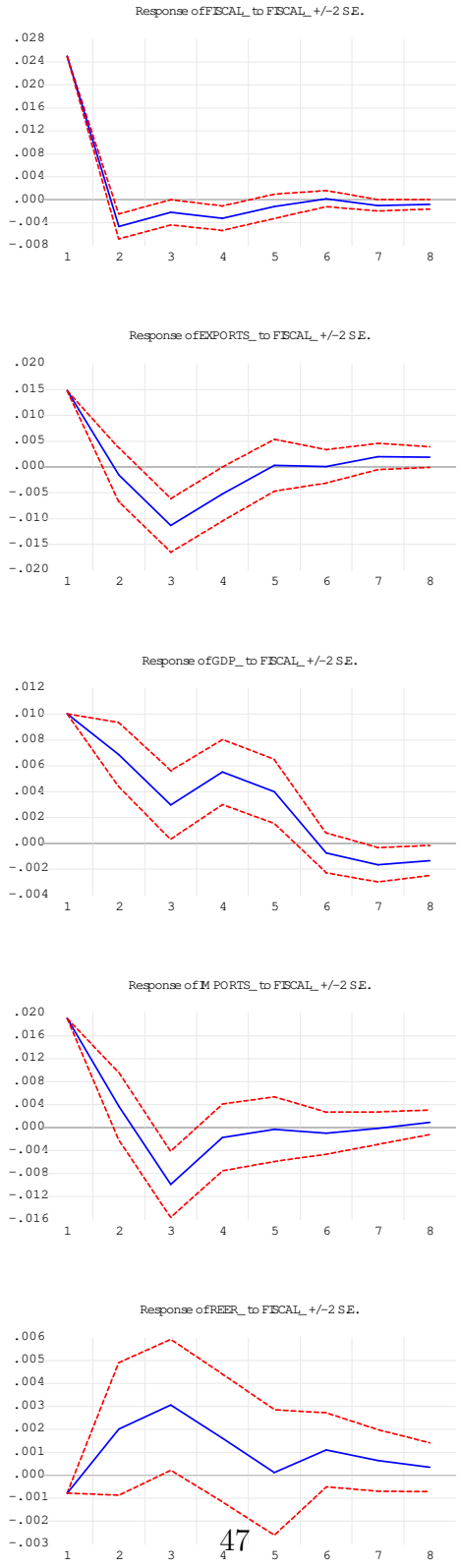


Figure 1.10: Impulse response functions with Alternative Variable ordering to Benchmark.

One Standard Deviation Positive Shock to Fiscal Deficit. Response of Fiscal Deficit, GDP, Exports

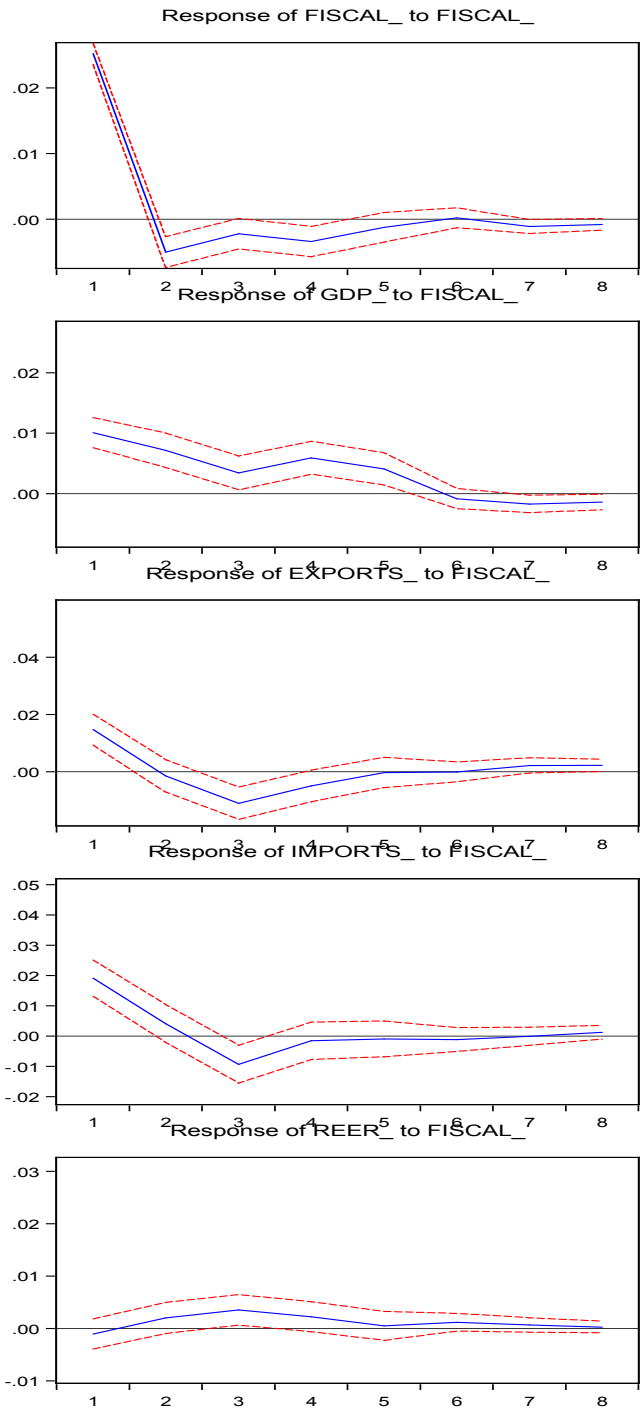


Figure 1.11: Impulse response functions, Panel estimation with large countries dropped.

Chapter 2

Investigating the effect of Trade on Business Cycle Synchronization: The Case of the EU.

Abstract

An ingredient of a successful currency union is synchronized business cycles. A perceived benefit of a currency union is increased trade. Therefore, the relationship between trade and synchronized business cycles becomes important to ensuring the stability of the currency union. This study investigates whether trade promotes the synchronization of business cycles, whilst paying attention to the debate that surrounds the extraction of business cycles themselves. An Unobserved Components Model that includes a Fourier transform is proposed as an alternative method to the Hodrick-Prescott filter. The effect of trade on the synchronization of these newly estimated business cycles is then estimated using a system of endogenous equations. Sectoral and financial linkages are included in to the model to account for endogeneity. The results strongly show that trade is significant in positively re-enforcing the synchronization of business cycles between countries. Sectoral linkages are also significant via a positive impact on trade. Finally, financial integration seems to be insignificant when looking at how to promote business cycle synchronization.

2.1 Introduction

Entering a currency union has the very direct benefit of reduced costs associated with trade. Allowing neighbouring countries to share the same currency has certain advantages that can help to boost trade. The main benefit associated with currency unions are reduced transactional costs with major trading partners. Further benefits can come in the form of currency stabilization which is particularly important for small open economies. Small open economies are subjected to speculative currency attacks. If a small open country shares its currency with other countries, then it is less vulnerable to currency speculation (Lane 2000), as movements in the currency reflect a wider group of countries. The Optimal Currency Area (OCA) literature has identified some of the key components required to maintain a successful currency union.

Synchronized business cycles have been identified as being important to OCA's. The relationship between trade and synchronized business cycles becomes increasingly important to ensuring the stability of the currency union. This study investigates whether trade promotes the synchronization of business cycles. Sectoral and financial linkages are included in to the model to account for endogeneity. Attention will be paid to the cycle extraction methods and it is shown that the unobserved components model (UCM) approach can improve the fit of the estimated business cycles. By improving on the estimation of business cycles, there is greater accuracy when measuring business cycle synchronization which can therefore lead to a more accurate estimation of the determinants.

The results of this study show that trade is significant in positively re-enforcing the synchronization of business cycles between countries. Sector alignment is significant via its positive impact on trade. Finally, financial integration is insignificant when looking at how to promote business-cycle synchronization. A concentration of production within the same industries does not directly contribute to more synchronized business cycles. Finally, finan-

cial integration appears to have a significant direct impact on cycle correlation, however the coefficient is small at 0.01 and negative.

The framework adopted in this study allows us to incorporate for the endogeneity between the independent variables. The results show that similarities in sector-specialization has a positive impact on the amount of bilateral trade that occurs between two countries. This could suggest an important role of intra-industry trade if countries are trading within the same sector. Financial Integration has a positive and significant impact on improving the alignment of sectors. Furthermore, the results show that financial integration also promotes trade between countries.

One of the key contributions is to investigate the impact that the choice of cycle extraction method has played in influencing existing results in this field. The benchmark method of business cycle extraction is the Hodrick-Prescott filter. By using a cyclical extraction method based on the Kalman Filter, the argument is made that such a filter is much less presumptive about the behavioural properties of the underlying growth trend. As a result, previous studies might have overstated the impact of trade on the alignment of business cycles. The first contribution made, is that the UCM (Unobserved Components Method) proposed in this paper has a better fit to the data than the Hodrick-Prescott filter[1]. The method is empirically proven with a lower AIC model fit. The benchmark estimation is re-run using the exact same data and model specification but this time the dependent variable is the correlation of business cycles extracted with Hodrick-Prescott filter. There are some modest observable changes in the results, overall suggesting that remaining agnostic with respect to the data generating process of the underlying cyclical component helps improve the fit of the model. Firstly, the coefficient on trade is larger implying a slightly bigger magnitude of the effect of trade. Secondly, the financial integration becomes more significant and finally the R^2 is lower from the estimation for the cycle equation.

[1]The model fit is judged according to the AIC criterion

One of the downside risks of embarking on a shared currency is that , there is some degree to which synchronized output movements are required. This allows for cyclical policy to be conducted at a more centralized level, as the "one-size-fits-all" rule in a currency union means that one policy should be an adequate measure for all the countries participating in the union(Alesina, Barro & Tenreyro 2002). The Euro Convergence criteria (also known as the Maastricht criteria[2]) sets out four main criteria for countries to meet before having the Euro currency. The criteria have been set out to help ease transition in to the Euro and so that the country can successfully transition to adopting the monetary policy of the ECB.

The business cycle of a country refers to the expansionary and recessionary episodes that occur around the long-run growth trend. The closer together in time, these expansionary and recessionary episodes are, the more synchronized two countries business cycles are. The causes of business cycle synchronization are of both academic and policy interest for a variety of reasons. This includes more accurate policy impact estimation and also it is of importance in deciding optimal currency areas (OCA). In order to maintain an optimal currency area, one key ingredient is the synchronization of business cycles. This is partly so that monetary policy can be conducted on a basis that is optimal for every state involved. Furthermore, this means that a floating value of the currency is a better representation of the economic and business environment within each state and therefore becomes a more accurate representation of the current economic events in that country. If the main benefit of embarking in a currency union is trade and one of the outcomes of a successful currency union is synchronized business cycles, the question becomes: what is the impact of trade on business cycle synchronization? A key factor to the success of a currency union is not just output convergence but real business cycle convergence and therefore synchronized business cycles. If the monetary policy cannot adequately address a countries business cycle situation then it is difficult to maintain domestic price stability. This could pose risks for the

[2]https://europa.eu/european-union/sites/europaeu/files/docs/body/treaty_on_european_union_en.pdf

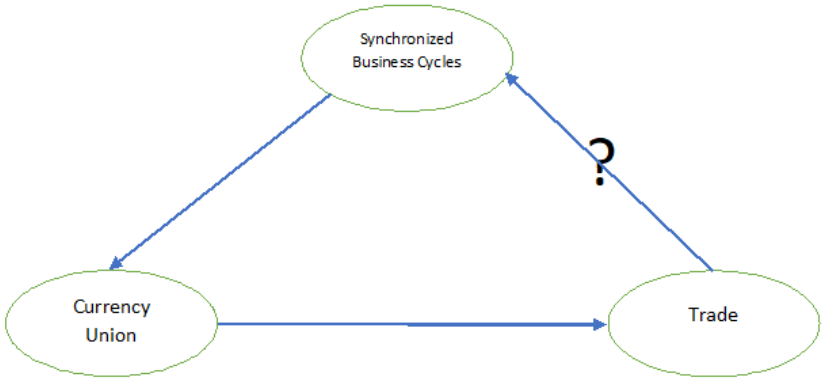


Figure 2.1: The Cycle of Currency Union Stability

stability of the currency union itself.

Variables that measure institutional similarity are included in the empirical exercise. These variables are an index employment protection law that allows for a cross-comparison of employment protection laws between two countries. Secondly, an index of Product Market Regulation was included. This allows to cross compare Product Market Regulation. Another variable that is introduced is a discrete variable that measures the number of shared systemically important banking institution that are shared by two countries. This is to show a similarity in banking institutions and therefore highlights possible ease of transferring assets and an existing degree of financial integration. If a country has a large bank whose parent bank is large in another country, then this country pair will adopt a dummy value of 1.

One key area in which this study seeks to expand on existing studies is in the cycle extraction method itself by using an UCM Decomposition as outlined by Harvey(1990) which has previously been applied in a European context (Macchiarelli 2013)[3]. By improving the accuracy with which business

[3]Macchiarelli(2013) investigates business cycle similarities between Central Eastern European countries and the Euro-area

cycles are estimated, there is greater accuracy in measuring synchronization and therefore empirically testing the determinants. By including every member state of the EU, this study aims to capture the dynamics of the newer member states who might display a different behaviour, owing to their size or the increased volatility within their business cycles.

To signpost, the three main contributions of this study are:

- 1) To find that trade positively impacts business cycle synchronization in the applied case of the EU.
- 2) By using an UCM model that includes a fourier transform, this paper shows that a better estimation of business cycles in the EU can be achieved. The results of the estimation using the UCM imply that previous studies may have understated the impact of trade on cycle synchronization.
- 3) To find that sectoral-specialization does not directly impact the synchronization of business cycles but has an indirect affect through positively impact the amount of trade that occurs.

Section 2 reviews the literature that investigates the impact that trade, sector specialization and financial integration has on promoting business cycle synchronization between countries. Studies that account for the impact of all three determinants simultaneously are introduced and discussed. Section 3 will introduces the discussion of cycle extraction methods and outlines the UCM model employed to extract business cycles in this study. Section 4 will discusses the second stage of the estimation which involves the three staged least squares estimation of the system. Section 5 will outline the main tenets of the results and Section 6 will conclude.

2.2 Determinants of Business Cycle synchronization

The evidence on the effect of trade on business cycle synchronization is inconclusive. In this literature review, I look at the existing studies on the effect of Trade, Sectoral-specialization and Financial integration on the synchronization of business cycles between countries. I look at papers that discuss the effects of each of these factors individually on output synchronization. I will then go on to explain the approach of papers that look at combinations of these factors simultaneously.

2.2.1 Trade

Gravity models try to predict the amount of bilateral trade that will occur between two countries (Isard 1954). The gravity literature puts forward that countries that are closer in distance, output levels and other macroeconomic features are more likely to trade with each other. Frankel and Rose (1998) conduct a study that shows that a shared currency can promote trade between countries and further find that trade between countries promotes growth convergence. The study uses the gravity framework to look at how trade affects output. Their results show that the only channel through which currency unions promote growth is via their positive effect on trade. Their results show no direct impact of currency unions on growth but only an indirect impact through trade.

There is an intuitive reason that the effect of trade on business cycle integration is positive. This positive relationship, comes in the form of contagion. Two countries that trade together have a direct economic link to each other. In a two country model with international trade, a negative domestic shock originating in country i will reduce the demand of exports for country

j . This means that trade provides a source of contagion for a shock in country i to affect the shock in country j. Depending on the relevant size of the domestic import and export multipliers, the scale of the impact on the rest of the economy will be determined. This reduction in demand for imports from country i will affect country i's major trading partners.

This fall in trade is could have repercussive effects through the rest of the economy for both country i and country j.

However, there are alternative mechanisms that suggest an inverse relationship between trade and cycle synchronization. Ricardian theory suggests that trade occurs in industries where countries have a comparative advantage. As a result, trade encourages specialization of domestic production in industries where countries have a comparative advantage. If countries are specialized in different industries they have different technologies and supply inputs as well as output markets. As a result, they are less likely to react in the same-way to identical exogenous shocks. Furthermore, there is likely to be divergence in the exchange rate profiles owing to movements in input commodity prices.

2.2.2 Sector Specialization

Sector specialization refers to the cross-country comparison of the main industries that contribute to total domestic production. If two countries both have 90% of their output produced by the automotive industry, then they would be very close in their sector specialization. If one country had 90% of their production in agriculture and the other country had 90% in the automotive industries, these countries would be further apart in sector specialization. There is an argument for a positive relationship between sector-specialization and business-cycle synchronization i.e. the closer the industries of production are, the higher the degree of cycles synchronization between two countries. One reason proposed is that similar industries are likely to have similar reac-

tions to the same exogenous shock. If the same industries are dominant in a country then this can act as a source of cycle-convergence as the industries are likely to induce symmetry in the macroeconomic response of the economy to the exogenous shock (Fidrmuc 2004). This could therefore lead to more synchronized output fluctuations. Furthermore, as these industries probably have similar global supply and demand links, exchange rate movements and other global shocks are likely to have pronounced impacts on particular industries therefore leading to increased similarity in economic responses of countries.

Sector-specialization could affect cycle synchronization through a different channel which is trade. Two countries that have a high focus of production of goods within the same industry , are likely to have less need to trade with each other. As trade is driven by comparative advantage and production efficiency's, if countries have a comparative advantage in the production of a particular good then production in that country is likely to be oriented around that industry.

Sector-specialization within a country will affect how much it trades internationally. The traditional argument poses that countries have similar industries, are likely to be producing similar goods in which case the likelihood of trade falls. As trade is lower, it is then assumed that business cycle synchronization is also less likely.

Some studies find that intra-industry trade is more significant than inter-industry trade. Davis (1995) shows that intra-industry trade is prevalent and countries that specialize in the same industries are more likely to trade with each other. A theoretical framework is created using the Heckser-Ohlin model to show how intra-industry trade can be explained via comparative advantage and the relative technological capabilities of countries. On the one hand, it depends on the strength of inter-industry trade versus intra-industry trade. As result, countries with production in similar sectors are likley to trade more with each other.

Sector specialization can impact the amount of international trade between two countries. At the same time sector specialization can impact cycle synchronization through the inducing symmetry in shock propagation. Any estimation that seeks to investigate the impact of trade on cycle synchronization would carry some endogeneity unless the simultaneous impact that sectoral specialization has on cycle convergence and trade (Imbs 2004).

2.2.3 Financial Integration.

The impact of financial integration on business cycle synchronization is the least tangible of the relationships explored in this study, and the evidence is far from definitive. The literature has the least consensus as to what the direction of the relationship should be. Some studies find a negative impact of financial integration on business cycle synchronization (Backus, Kehoe & Kydland 1992, Heathcote & Perri 2002, Obstfeld 1992). Kalemli-Ozcan, Sorensen Yosha (2001) use a panel approach to find that banking integration is significant and negatively impacting the business cycle correlation between countries. Financial integration encourages different investment portfolios and specialization in different types of financial products. As a result, this leads to different business cycles. Some papers argue that the relationship is endogenous i.e. countries with different risk profiles are more likely to be financially linked (according to the common wisdom of risk-sharing and portfolio diversification) leading to further output divergence.

Some studies find a positive relationship between financial integration and cycle synchronization (Kose & Yi 2006). Kose and Yi (2006) find that the international real business cycle can help promote the positive relationship between trade and output co-movement. The basis for the positive link is grounded in the existence of contagion. If countries are financially linked and one country experiences a financial shock, the propagation of this shock through the links with it's country traders, is likely to impact the linked

economy in a negative way too.

2.2.4 Simultaneity

As sectoral and financial linkages are likley to impact both trade and cycle convergence simultaneously, it is important that any estimation, accounts for the impact of these mechanisms. The approaches used by Frankel and Rose (1998) accounted for endogeneity in two stages through using an instrumental variable regression. This works on the assumption that the endogeneity between the dependent and independent variables do no occur simultaneously and that there is a time-lapse between the two channels. Imbs (2004) argued it is possible for the effects of changes in sectoral production to affect trade volume and output levels instantaneously. Therefore, a system of equations that allows for this simultaneity to be accounted for - hence, escaping the usual endogeneity issue - is estimated. The system of equations accounts for the effect of trade on output synchronization and the effect of industry specialization on both trade and output synchronization. Imbs (2004) applies this approach at the state level in the USA and finds that trade is positive in promoting business cycle synchronization and that sectoral similarities help in promoting both trade and output synchronization. One limitation of Imbs study is that it takes place on an intra-national scale within the US. There is a degree of similarity that takes place on federal level. There is some control that the centralized government has on all of the states. This is a further source of endogeneity between the dependent and independent variables. There is no control for similarity in output fluctuations that might be caused by synchronization in fiscal policy. There could be some positive bias in the result owing to this universal fiscal policy.

By applying this approach to an international context , this error is somewhat reduced as different governments, have different fiscal regimes. These fiscal regimes will be have the sole purpose of maintain the economic

output of that particular entity rather than the whole area. Therefore, this error of fiscal policy driving synchronization is removed. Imbs overcomes this with a re-estimation on an EU sample that re-confirms the results.

Dees and Zorrell (2011), add to the existing approaches by adding a third endogenous variable which is financial integration. They propose that financial integration can affect business cycle synchronization and trade simlutaneously.

This study builds on from the framework of Dees and Zorrell (2011). A system of endogenous equations will be estimated on a dataset of 28 EU countries in order to quantify the impact of trade on cycle convergence. The EU is an interesting case as it is a sample of countries that has almost completely free trade and therefore no adjustments have to be made to account for explicit trade restrictions. The method of extracting business cycles will be further investigated. Inter alia, this study will look at how cyclical extraction methods can determine the outcome of the results. On top of which a small addition is made to the existing framework in order to improve upon the existing results.

2.3 Cycle Extraction Methods

As business cycles play an important role in OCA literature, much discussion surrounds the best way in which they should be measured. In the empirical studies mentioned thus far, a range of methods have been used to measure business cycles. Frankel and Rose (1998) acknowledge the discussion around the methods of cycle extraction and employ four different extraction methods in order to address the concern of sensitivity of the result. These are : first differencing, removing the last fourth quarter, Hodrick-Prescott filter and the Hodrick-Prescott filter with a seasonal adjustment.

Imbs (2004) and Dees and Zorrell (2011) use the Hodrick-Prescott filter to extract business cycles. In order to be accurate in extracting the cyclical component , an assumption must be made about what the underlying data generating process for structural growth is. This refers to the assumption of whether underlying growth follows a linear , stochastic process. Baxter and King (1999) found that linear de-trending or first-differencing as a method of removing trends was not desirable for business cycle extraction.As a result , band-pass filters are presumed to be a stronger method.

The current benchmark in the literature is the Hodrick-Prescott filter. The Hodrick-Precott is an econometric smoothing technique that penalizes the cyclical component of a time series and then assuming that everything that remains is the trend component of a time series.

$$\min_{\tau}(\sum_{t=1}^{T}(y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2) \tag{2.1}$$

The first term of the equation is the sum of the squared deviations $d_t = y_t - \tau_t$ which penalizes the cyclical component. The series y_t, is made up of a trend component τ_t, a cyclical component c_t, and an error component , ϵ_t such that $y_t \ = \tau_t \ + c_t \ + \epsilon_t$. The second term is a multiple λ of the sum of the squares of the trend component's second differences. This second term penalizes variations in the growth rate of the trend component. The larger the value of λ, the higher is the penalty (Kim 2004).

Whilst a useful technique in econometrics, one limitation is that the Hodrick-Prescott filter does not adequately account for shocks in the time-series and merely interprets them as part of the underlying trend component. Also, the Hodrick-Prescott filter estimates a global trend. This trend is then removed from the original series and the residuals are assumed to be the cyclical component of the series. Therefore the only definition or criteria of the cyclical component is that it is not part of the underlying trend. Making no assumptions on the DGP underlying the cycle, is another critique as the assumptions placed on the cycle are strong. If λ is equal to infinity then the

Hodrick-Prescott filter becomes an estimation of a pure linear trend. If lambda equals zero then the filtered series is equal to the original series. Therefore it is essentially the choice of the λ parameter that places the underlying growth trend in between being a completely linear series or equal to the raw series. This highlights two issues, one is that the cyclical behaviour is essentially the residual from the trend, but secondly the strength in the assumption placed on the trend component based on the choice of the lambda. This could be a problem when measuring cycle synchronicity as the cycles are just the remainder of the raw series minus the trend.

Limitations of the Hodrick-Prescott Filter have been outlined by King Rebelo (1993) the main one being that the filter has a poor performance in series with low frequency spectral density. Ravn and Uhlig (2006) have also weighed in this discussion, proposing a different value for the smoothing parameter for annual data. Three of the reasons that Hamilton (2018) outlined were: "(1) Hodrick-Prescott filter introduces spurious dynamic relations that have no basis in the underlying data-generating process. (2) Filtered values at the end of the sample are very different from those in the middle, and are also characterized by spurious dynamics. (3) A statistical formalization of the problem typically produces values for the smoothing parameter vastly at odds with common practice". Another very strong assumption that is made when using the Hodrick-Prescott filter is that structural growth is linear (Hamilton 2018).

Unobserved Components Model (UCM) is a method that allows for the formal estimation of both the cyclical and trend components (Harvey,1989). it allows for an estimation of a trend that is time varying and therefore places different weights on observations depending on how far away they are from the current observation. It allows for a trend that is locally estimated. It is less presumptive in terms of the restrictions that are placed on the form that both the underlying and cyclical components. In this section, I advance on previous studies by applying various forms of an unobserved components model to extract business cycles. To overcome the problems as outlined by Guay

and St.-Amant (2005), this study will propose an alternative way in which to extract cycles. The main basis of this approach is to adopt a unobserved components model, which uses a structural approach in which to extract the cyclical components of the business cycle. Later sections will measure the impact that this approach has against the Hodrick-Prescott Filter which is the benchmark[4].

UCM models decompose a time-series in to four components. A trend component, a seasonal component, a cyclical and an irregular component: Let y_t be the raw time-series that is being decomposed. It is assumed to contain a trend component ,μ_t , a seasonal component ,γ_t, and an irregular component, ε_t . The trend component is locally estimated by the following equation:

$$y_t = \mu_t + \gamma_t + \varphi_t + \varepsilon_t \tag{2.2}$$

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \tag{2.3}$$

$$\beta_t = \beta_{t-1} + \zeta_t \tag{2.4}$$

$$t = 1, 2, ...T$$

η_t and ζ are assumed to be serially and mutually uncorrelated with zero mean and variance σ^2 $(\eta_t, \zeta_t \sim NID(0, \sigma^2_{\eta\zeta}))$ μ_t represents the slope of the trend and β_t represents the level of the trend. Both follow a stochastic process (Fomby 2008)[5].

The seasonal component is determined as follows:

$$\gamma_t = \sum_{s-1}^{j=1} \gamma_{t-1} + \omega_t \tag{2.5}$$

[4]AIC allows for multi-model comparison.

[5]Note that equation (2) - (4) nest the HP filter for values of q = 1/lambda, where q is the news-to-noise ratio (see Harvey and Jaeger, 1993).

The cyclical component follows a trigonometric process and is estimated with a series of sinusoidal functions :

$$\begin{bmatrix} \varphi_t \\ \varphi_t^* \end{bmatrix} = \rho \begin{bmatrix} cos\lambda_c & sin\lambda_c \\ -sin\lambda_c & cos\lambda_c \end{bmatrix} \begin{bmatrix} \varphi_{t-1} \\ \varphi_t^* {}_{-1} \end{bmatrix} + \begin{bmatrix} \nu_t \\ \nu_t^* \end{bmatrix} \tag{2.6}$$

Where $0 < \rho < 1$ is a damping factor and keeps the cyclical process stable.

Nine variants of the Kalman filter are run on the GDP time series. The model structure as outlined in Macchiarelli (2013) is followed. In this study UCM models are run on GDP and inflation time series of CEE countries to see if the dynamics are related. The information criteria, and the AIC in particular is then used to select the best model, based on model fit. The first three models start with the basic form of a trend cycle decomposition and then various restrictions on the variance of the level and slope component are added to see if they provide a better model fit. The models for the cyclical component are estimated using an ARMA 2 process.

- Model 1 is the structural decomposition with the variance on the level fixed at zero but the variance on the slope remains determined by the model.
- Model 2 is the structural decomposition with the variance on the slope fixed at zero but the variance on the level remains determined by the model.
- Model 3 is the structural decomposition with the variance on the level and slope both fixed at zero.

  The specification as outlined in (Macchiarelli 2013) is followed. The next group of models work by replacing the stochastic equation for a trend with a data generating process that is based on the assumption of a finite number of minima and maxima within the series. The stochastic

trend in the earlier model is replaced with a more general specification that includes a Fourier transform. This is the Fourier approximation allows us to represent a cycle as a series of sinusoidal functions. This means that a non-linear assumption can be placed on the underlying structural growth. I run three further models on the raw data but this time I incorporate a first order Fourier expansion. The Fourier expansion allows for time-series to be split into composite waves and the assumption is that the trend may also follow a non-linear and there might exists cyclicality in structural growth. By incorporating this flexible functional for to determine the trend, we allow for the possibility that there are multiple peaks and troughs in the time series. This is a more realistic determination of the real business cycle.

$$\mu_t = \sum_{h=0}^{2} \delta_{i,h} t^h + \sum_{k=1}^{n} \alpha_{i,k} sin(\frac{2\pi kt}{T}) + \sum_{k=1}^{n} \beta_{i,k} cos(\frac{2\pi kt}{T}) \tag{2.7}$$

Where k is the order of the expansion. Where $n < \frac{T}{2}$ and n refers to the number of frequencies contained in the approximation and t = 1, ..., T is a linear trend. Hence, the following 6 models are estimated:

- Model 4 is a first order Fourier approximation
- Model 5 is a first order Fourier approximation with a time trend
- Model 6 is is a first order Fourier approximation with a quadratic time trend The final three models incorporate second order Fourier expansion in the trend.
- Model 7 is a second order Fourier approximation
- Model 8 is a second order Fourier approximation with a time trend
- Model 9 is is a second order Fourier approximation with a quadratic time trend.

The nine models are run on quarterly pre-seasonally adjusted logged GDP for all 28 countries. The data runs from 2000q1-2017q4.

Although the model specification allows for a seasonal component to be extracted, pre-seasonally adjusted data is used as seasonal holidays and working day adjustments are further accounted for on top of seasonality. All nine models are run on the GDP series for each country. The model that has the best fit is selected based on the Akaike information criterion (AIC). The cycle is then extracted using the model that has the best fit. Model 4 was the best fit for most countries, the estimated cycle for Model 4 is extracted for all 28 member states[6]

The first-order Fourier expansion without a time trend appears to be the best fit for most of the countries in the sample (Model 4)[7]. The prevalence of the fourth model as the model of best fit is different to previous papers (Macchiarelli 2013) who finds that a variety of models fits best for the 10 countries in the sample. This could be because of the time sample that is used includes the crisis and post-crisis periods. The second order Fourier expansions do not perform as well as the rest of the models. The model that performs the weakest is a second order Fourier expansion with a quadratic time trend.

Figure 2.2 shows the extracted cycles for all 28 member states. The graph shows that there is increased synchronicity that is attained during the downturn of the cycle. There seems to be a lot more variance in the post-crisis period than the pre-crisis period. Ireland stands out in this graph as having a better than average post-crisis recovery. Once I have chosen the correct cycles for each of the countries, I then obtain a correlation for the cycles on a bilateral basis for all the country pairs.

The majority of the country pairs exhibit pro-cyclical business cycle

[6]Table 2.7.1 in the appendix shows the results for all nine models across all 28 countries. Luxembourg, Poland and Romania did not have Model 4 as the best fit

[7]However, this difference is marginal as the AIC remains around the same level for both model 3 and model 4.

synchronization. However, unlike with the use of the Hodrick-Prescott filter the correlations of the cycles extracted using the UCM show counter-cyclical business cycle relationships. This is the case for ten of the 377 country pairs. They are listed in table 2.1.

Country I	Country J	Cycle Correlation
CYPRUS	UK	-0.23606
CYPRUS	ESTONIA	-0.19899
CYPRUS	LITHUANIA	-0.1963
CYPRUS	LATVIA	-0.17553
ESTONIA	GREECE	-0.12043
ESTONIA	PORTUGAL	-0.10516
CYPRUS	HUNGARY	-0.09379
LITHUANIA	PORTUGAL	-0.06551
LATVIA	PORTUGAL	-0.05293
PORTUGAL	UK	-0.00071

Table 2.1: Correlation coefficients of Countries that exhibit counter-cyclical behaviour.

The median value for the correlation of business cycles in 0.59. Countries within the EU appear to already have some synchronicity (Dées & Zorell 2011). When looking at an EU-only sample, the variation in the dependent variable is much more limited compared to when observing a global data-set. Factors of geography are likely to promote synchronicity in the kind of exogenous shocks that these countries face. However, the positive side is that purely EU dynamics are captured which reduces the risk of outliers affecting the result. The harmonized practices of national data reporting across the EU, means that there is more consistency when cross-comparing data compared to using data on a global scale.

In Table 2.2 , the model fit between the to filtering techniques are compared. In order to provide a fair comparison of models, using the same

degrees of freedom, I estimate the the kalman filter with the parameters fixed to the levels. This makes it equal to the estimation of the Hodrick-Prescott filter. Table 2.2 the superior fit that the UCM provides for all countries according to the AIC.

	AIC FOR UCM	AIC FOR HPFILTER
AUSTRIA	-12.26	-10.43
BELGIUM	-12.55	-10.46
BULGARIA	-11.23	-8.89
CROATIA	-11.52	-8.65
CYPRUS	-11.07	-8.70
CZECH	-11.68	-8.77
DENMARK	-11.17	-9.57
ESTONIA	-9.76	-7.29
FINLAND	-10.73	-8.91
FRANCE	-12.96	-10.52
GERMANY	-11.51	-9.57
GREECE	-10.55	-7.96
HUNGARY	-11.31	-8.90
IRELAND	-8.87	-7.49
ITALY	-12.20	-9.70
LATVIA	-10.15	-7.06
LITHUANIA	-9.60	-7.58
LUXEMBOURG	-10.05	-8.86
MALTA	-10.12	-9.14
NETHERLANDS	-11.94	-9.72
POLAND	-11.05	-9.86
PORTUGAL	-11.63	-9.56
ROMANIA	-10.02	-8.33
SLOVAKIA	-10.04	-8.67
SLOVENIA	-11.15	-8.48
SPAIN	-13.22	-9.08
SWEDEN	-11.30	-9.25
UK	-12.42	-10.46

Table 2.2: AIC Values for UCM and HPFilters compared

	BIC FOR HPFILTER	BIC FOR UCM
AUSTRIA	-10.428	-12.104
BELGIUM	-10.463	-12.361
BULGARIA	-8.8907	-11.076
CROATIA	-8.6474	-11.36
CYPRUS	-8.6984	-10.913
CZECH	-8.7688	-11.522
DENMARK	-9.5654	-11.008
ESTONIA	-7.2906	-9.5968
FINLAND	-8.9114	-10.573
FRANCE	-10.517	-12.8
GERMANY	-9.5686	-11.404
GREECE	-7.9634	-10.387
HUNGARY	-8.8989	-11.152
IRELAND	-7.4847	-8.7136
ITALY	-9.7003	-12.036
LATVIA	-7.0592	-9.9888
LITHUANIA	-7.5823	-9.444
LUXEMBOURG	-8.861	-9.9402
MALTA	-9.141	-10.003
NETHERLANDS	-9.7161	-11.778
POLAND	-9.8549	-11.153
PORTUGAL	-9.5639	-11.478
ROMANIA	-8.3289	-9.9319
SLOVAKIA	-8.6735	-9.8814
SLOVENIA	-8.4802	-10.992
SPAIN	-9.0782	-13.06
SWEDEN	-9.2512	-11.145
UK	-10.46	-12.391

Table 2.3: BIC Values for UCM and HPFilters compared

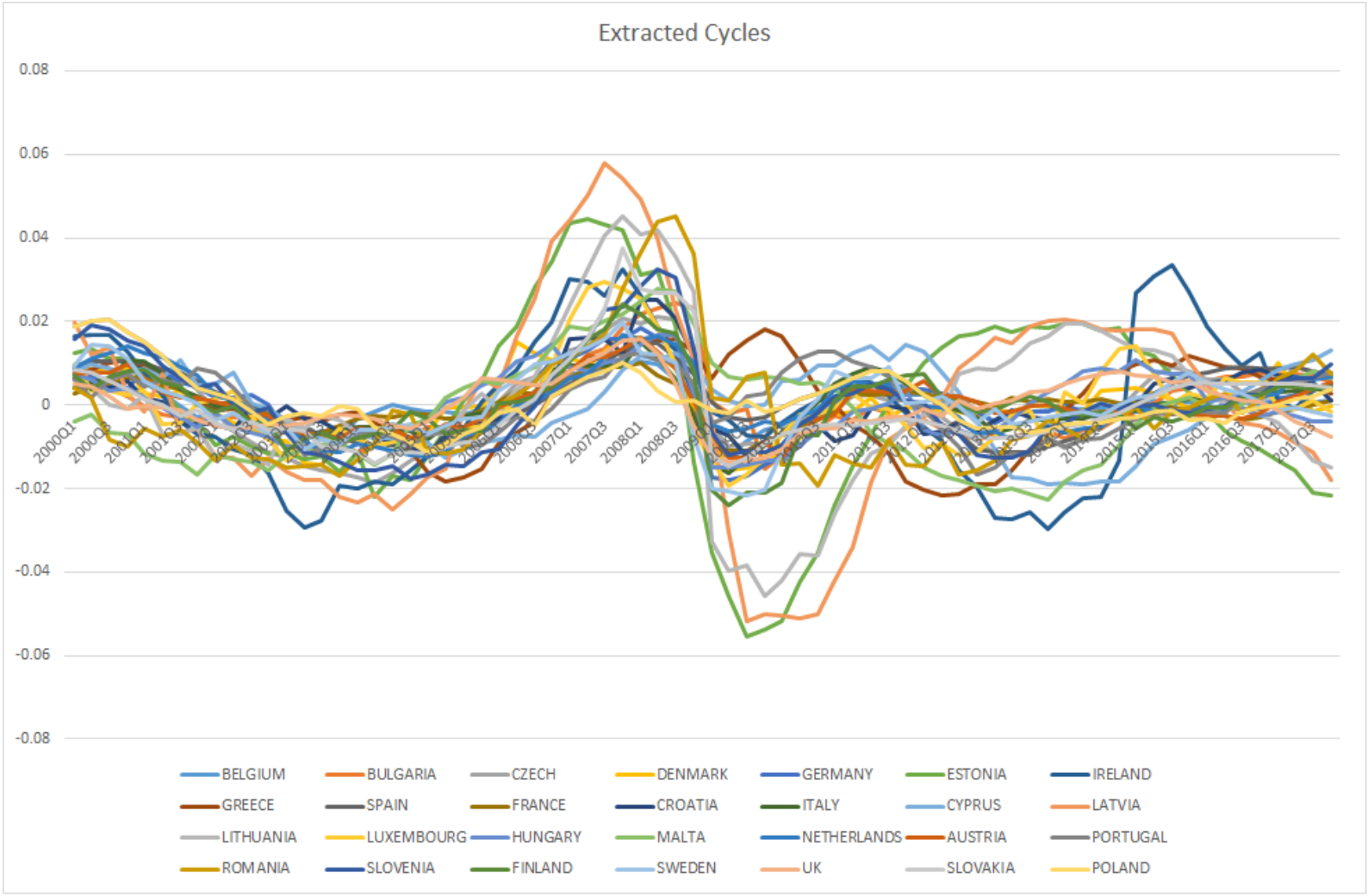


Figure 2.2: Extracted Cycles for all 28 EU Member states 2000q1-2017q4

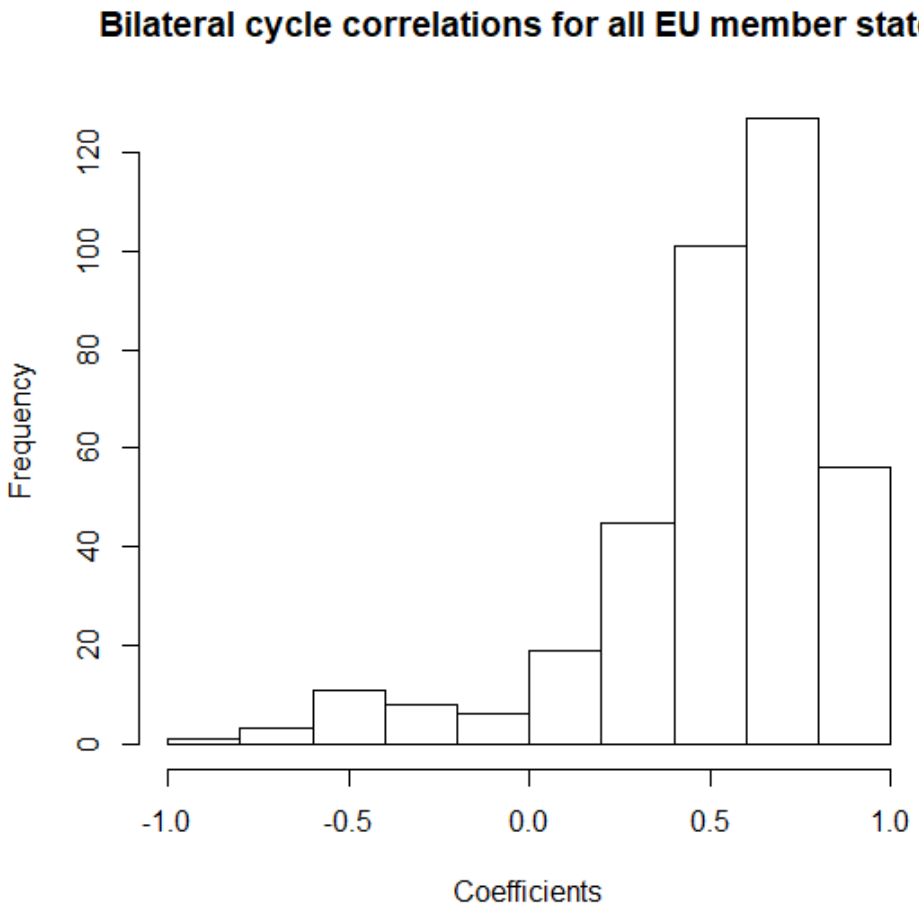


Figure 2.3: Correlations of UCM filtered Real Business Cycles

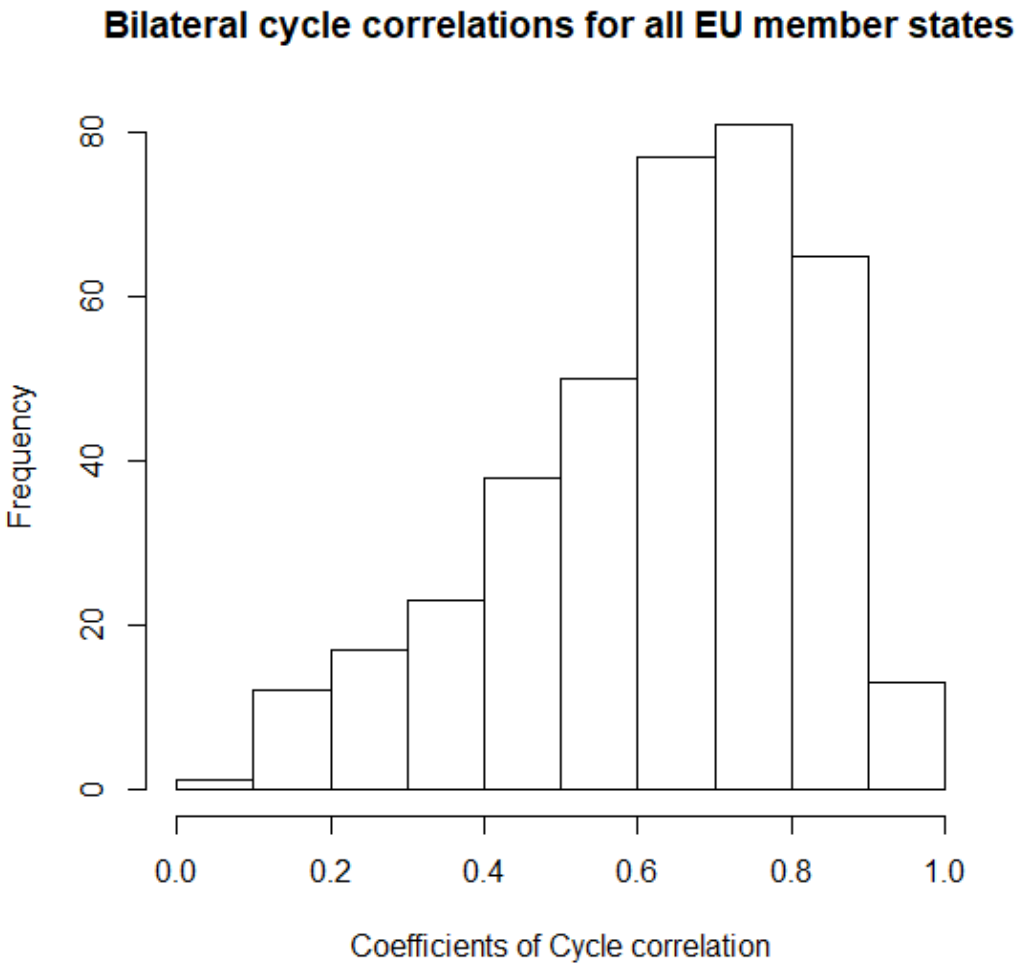


Figure 2.4: Correlations of Hodrick-Prescott filtered Real Business Cycles

2.3.1 Estimation

The estimation methodology adopted in this study follows on from Imbs (2004) and Dees and Zorrell (2011). The estimation is a system of four equations endogenous equations that are estimated simultaneously.

Outlined below are the four equations that are used in the system:

Business Cycle Integration Equation:

$$\rho_{ij} = \alpha_0 + \alpha_1 \text{Trade Intensity}_{ij} + \alpha_2 \text{Sector Specialization}_{ij} + \alpha_3 FDI_{ij} + \varepsilon_1 \quad (2.8)$$

Trade Integration:

$$\begin{aligned} \text{Trade Int}_{ij} &= \beta_0 + \beta_1 \text{Sector Specialization}_{ij} + \beta_2 \text{FDI}_{ij} \\ &+ \beta_3 \text{Distance}_{ij} + \beta_4 \text{Currency Dummy}_{ij} + \beta_5 \text{Border Dummy}_{ij} \\ &+ \beta_6 \text{EPL}_{ij} + \beta_7 \text{PMR}_{ij} + \varepsilon_2 \end{aligned} \quad (2.9)$$

Sector Integration Equation:

$$\begin{aligned} \text{Sector Specialization}_{ij} &= \gamma_0 + \gamma_1 FDI_{ij} \\ &+ \gamma_2 (Y_i - Y_j) + \varepsilon_3 \end{aligned} \quad (2.10)$$

Financial Integration:

$$FDI_{ij} = \delta_0 + \delta_1 (Y_i + Y_j) + \delta_2 \text{Bank Shared}_{ij} + \varepsilon_4 \quad (2.11)$$

There are three approaches used to estimate the main model. These are the: two staged least squares, three staged least squares and seemingly unrelated regressions. All three approaches are used when endogeneity exists between the main dependent and independent variables.

The two staged least squares (2SLS) approach works by regressing an endogenous variable on the main dependent variable. Then, by using the residuals of this equation as the main dependent in the final estimation.

The three staged least squares (3SLS) approach estimates the endogenous variables first and then uses the residuals to estimate the main equation (much like the 2SLS). However the error terms from the initial regressions are used to adjust the error term in the main equation. The three staged least squares approach often provides a better model fit than the two staged least square approach and thus is often preferred. The seemingly unrelated regressions (SUR) approach estimates the all the equations simultaneously and uses the error matrix to adjust the estimated residuals.

The three approaches are similar in structure but they make slightly different assumptions about the nature of the relationship between the endogenous variables. All three methods will be used in order to get the best model fit and furthermore, it can act as a robustness check as to the validity of the results.

Table 2.4: Correlation matrix of all Endogenous Variables

	Cycle	Tradeint	Sector	FDI
Cycle	1.00	0.40	-0.16	0.20
Tradeint	0.40	1.00	-0.27	0.57
Sector	-0.16	-0.27	1.00	0.10
FDI	0.20	0.57	0.10	1.00

2.4 Data

The analysis will be conducted using bilateral observations between all unique country pairs within the EU. The main dependent variable is the business cycle correlation index which is depicted by ρ_{ij}. It is the correlation between the

business cycles of two countries where each cyclical component is extracted as outlined in the previous section. There are three other endogenous variables : Trade intensity, Sector Specialization and Financial integration and 11 exogenous variables.

The time-series that most of the data was collected for is 18 years from 2000-2017. As cycles that typically occur over a 6 year period [8] , as defined by NBER, collecting data over a longer time frame means that we are collective averages over a few cycles as oppose to either the upturn or downturn period of a cycle.

Bilateral trade intensity is the main independent variable in the estimation and is being measured by:

$$\text{Trade Intensity}_{ij} = \frac{(X_{ij} + M_{ij}) * Y_{EU}}{Y_i + Y_j} \tag{2.12}$$

This is the sum of total imports and exports divided by the sum of GDP in both countries and the number of units in the time frame. The value of bilateral exports and imports is the most direct measure of the integration of the goods and services markets of two countries. It is weighted by the relative size of the countries in proportion to the EU. This measure of trade intensity is often used in the literature (Dées & Zorell 2011, Frankel & Rose 1998, Imbs 2004). The source of the trade data is from the national accounts data including both goods and services.

In order to account for external factors that might impact the amount of trade between two countries, a group of control variables are included in the estimation. Geography plays a role in determining trade flows via it's impact on the cost of transporting goods. Bilateral distance between the two countries' capital cities is included as a control variables.[9] A dummy variable to indicate whether two countries share a land border is included. This is

[8]The NBER's Business Cycle Dating Procedure: Frequently Asked Questions

[9]Obtained from CEPII : $http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp$

thought to be a trade determinant as it implies a combination of geographical closeness along with other kinds of cultural ties. These cultural ties could include shared language that make trade more likely. These two geographic variables fixed throughout the whole time-sample.

Countries that share a currency have reduced transactional costs associated with international trade. Reduced costs come from the reduced risk of unexpected nominal rates changing and administrative costs associated with changing currencies. As a result, a Euro index is included to control for the fact that some countries have shared currencies which can affect the amount that is traded with each other. If both countries have the euro then the currency dummy is at 1, and is 0 in all other cases[10].

The currency dummy is thus weighted by the number of years in the sample that the country has had the euro. This is so that the effects can be weighted by the proportion of the time series that the country had the euro. The last member to join was in 2015 and therefore has only had the euro for three years in the sample. Next, I multiply the dummy by the sum of the proportion of euro area GDP that the two countries share. This is so that the larger number of smaller countries do not bias the results. So the currency is dummy is essentially weighted by country size.

$$\text{Euro Index} = \frac{t_n}{T} * \frac{Y_i + Y_j}{\sum_{i=1} Y_i} \tag{2.13}$$

The next two variables included in the estimation seek to measure similarities in the regulatory environment between the two countries. The levels of regulatory closeness between the two country can be interpreted to measure some degree of structural integration. Structural integration is thought to promote trade integration because it eases the ability to transfer goods over borders via reduced costs. Campos and Macchiarelli (2016) predict that the

[10]If unweighted, this indicator says nothing about the timing of adoption, thus weighting countries that have joined early as much as countries that are late comers.

higher the amount of regulation, the more the likely the country is to be peripheral and therefore implies lower levels of synchronized business cycles. This study does not make a direct theoretical link between the structural reforms and the business cycles but instead makes a link via their effects on trade. Lower levels of structural policies are thought to help trade as it reduces the stringency of tests that goods have to go through in order to be traded in that country. As a result, when two countries have low structural barriers via low product regulation, this is thought to increase the likelihood of trade. A more theoretical motivation for including this measure could come from the gravity model. The gravity model predicts that the closer together two countries are in GDP and other economic and socio-economic factors, the more likely they are to trade with each other. If regulation can be interpreted as an indicator of structural alignment between the two countries then, it could be used to predict the amount of trade that occurs between the two countries. The two variables that have been included are Product Market Regulation and Employment Protection Law.

Employment Protection Law (EPL) is an index of labour market flexibility in a country. [11] The flexibility or the labour market is thought to increase the ease of conducting business in a foreign country as it is linked to the risk attached with the initial investment.The difference between the indicators for both countries is used as the variable. Product Market Regulation (PMR) [12] is an index that is created by the OECD and reflects the ease of doing business. This index includes aspects such as administration involved with product creation. It captures the ease of doing business in a country. The ease at which a foreign country can conduct business located in another a country is a big determinant of the incidence of foreign investment.

[11]This database includes data on strictness of employment protection legislation for overall, regular and temporary employment.

[12]The economy-wide indicators of policy regimes in OECD countries have been estimated for 1998, 2003, around 2008 and 2013.

These indicators summarize a wide array of different regulatory provisions across countries.

The sectoral-specialization index is given by:

$$\text{Sectoral Specialization index} = \frac{1}{N}\sum_{n}^{N} |s_{in} - s_{jn}| \tag{2.14}$$

Where n is number of industries and N is the sum across all industries. s is the sector in which the gap is being measured. i and j refers to the two different countries. s is measured by the percentage of Gross Value Added (GVA) to the economy that is contributed by each industry. The index then measures how divergent the industrial composition of GVA is. The higher the value of the sectoral specialization index the more divergent the sectors of the countries contributing to the output of the economy are. The lower the index, the more similar the countries profile of industries contributing the most to GVA are.

The creation of the Sectoral-Specialization index, already provides some insight in to the distribution of industries across the EU. The Industry that has the largest share in terms of value across the EU is Wholesale and retail trade, transport, accommodation and food service activities.

The data to compute the Sectoral-Specialization is obtained from Eurostat and is annual data that covers the period 2001-2016. The data includes the gross value added (GVA) for each industry for each country. There are eight industries for which Eurostat calculates the value added.[13]. The difference in shares between the two countries is summated and then divided by the number of industries and the number of years. The data is annual from 2000-2016. This index was first developed by Imbs (2004).

[13](1.Agriculture, forestry and fishing 2.Industry (except construction) 3.Manufacturing 4.Construction 5.Wholesale and retail trade, transport, accommodation and food service activities 6.Information and communication Financial and insurance activities Real estate activities Professional, scientific and technical activities; administrative and support service activities 7. Public administration, defence, education, human health and social work activities 8.Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies)

The exogenous variables are: the multiple of log GDP and also the log difference of GDP. The log difference of GDP is used because it is thought that countries with different levels of output are less likely to have similar sectors.

For financial integration, FDI data is used to act as a measure of the financial links between two countries. The series is formed by a pure summation of all the FDI that has taken place between the two countries over a 16 year period. The data is from Eurostat. [14] Concerns about sensitivity of the results depending on the financial instrument used, means that various other measure have been used. These include IMF's capital restrictions database (Binici, Hutchison & Schindler 2010) created a database of capital restrictions. The first reason is that it is the only measure that can act as a measure of a financial relationship between two countries and is does not work on estimating the similarity between two indicators and assuming integration[15]. Secondly, the data availability for FDI for all the countries is the sample and going back as far as 2001 is the most complete. There are however, some limitations to FDI data. The first being that it is not the most comprehensively measured indicator and therefore is subject to measurement error. For financial integration, I use FDI data to act as a measure of the financial links between two countries. The series is formed by a pure summation of all the FDI that has taken place between the two countries over a 16 year period. In order to account for institutional factors that can influence the amount of FDI that occurs between countries, variables are included that account for institutional similarities between two countries , such as the similarity of banking institutions, the presence of systemically important banks, as well as labour market variables (Employment Protection Legislation and Product Market Regulation) which typically correlate with the ease of doing business in a country.

[14]

[15]If measures of correlation are used rather than exact causation then the incidence of mis-specification error occurs as correlation could be caused by third part. Bilateral FDI overcomes this problem

A dummy variable is included to account for whether two countries have similar banking institutions. It is a legal requirement for countries to declares which banks are systemically important in their financial system.[16] Systemically important cross-border bank. This is an indicator that shows if the banking institutions deemed as systemically important to a country are linked. For example if a country has deemed an institution as systemically important and another country has deemed an institution as systemically important and these two institutions which are in two different countries are part of the same banking group, then the value for this country pair would be 1. The designation of banks as being systemically important is formal EU requirement as per the ESRB. These banks are deemed as systemically important to the country and is held by a bank that is systemically important to the other country.

2.4.1 Dealing with Third Country effects

The studies that have been cited have taken place in either a US only context or a global context. One issue that appears when using an EU case is the possibility that two or more countries maybe re-acting to a third country simultaneously. For example if two countries have large exposure to the US, then there is the possibility that a movement in the US could be causing the synchronicity of the two EU countries and this imply that these countries have become further integrated with each other when in fact they are only correlated with each other due to the third country (Kose & Yi 2006). In this study , there is no formal adjustment for this mechanism. The main reason being, the average portion of trade that is occurs within the EU is 60%. The country that has the lowest intra-EU share is Malta with around 44%. If 60% on average occurs within the EU, this leaves 40% to be determined by the rest of the world. For all of the countries within the EU, their major trading partners are other EU countries. Given this scale, this study assumes that

[16]

the possibility of third country effect having a significant bias on the results is limited as most of the behaviour and exposure to other countries is already captured by the existing sample of countries. This will be however left for further exploration in future work.

2.5 Results

Table 2.5 presents the full set of results in the benchmark estimation. The word on the left of the colon, relates to the equation and the word on the right is the variable of which the coefficient relates to (i.e. Cycle: Tradeint is the coefficient of Trade Intensity in the equation that estimates the determinants of Cycle Correlations). The first three columns are the results for the model specification as per Imbs (2004), namely without the inclusion of the Financial integration channel included. The right three columns include the financial integration channel as well as the two variables that measure institutional similarity in the trade equation (PMR and EPL). Furthermore, the results of the three different estimation methods, 2SLS, 3SLS and SUR, are displayed for both model specifications.

	2SLS (Imbs)	3SLS (Imbs)	SUR (Imbs)	2SLS	3SLS	SUR
Cycle: (Intercept)	-0.36^{**}	-0.63^{***}	-0.39^{***}	-0.51^{***}	-0.85^{***}	-0.42^{***}
	(0.13)	(0.12)	(0.11)	(0.15)	(0.14)	(0.12)
Cycle: Tradeint	0.08^{***}	0.10^{***}	0.08^{***}	0.09^{***}	0.12^{***}	0.08^{***}
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Cycle: Sector	-0.01	0.00	-0.01	0.00	0.01	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Trade: (Intercept)	21.64^{***}	22.33^{***}	22.30^{***}	18.72^{***}	19.25^{***}	19.25^{***}
	(0.74)	(0.72)	(0.73)	(0.69)	(0.67)	(0.68)
Trade: Sector	-0.15^{***}	-0.22^{***}	-0.22^{***}	-0.24^{***}	-0.32^{***}	-0.31^{***}
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Trade: Distance	-1.21^{***}	-1.27^{***}	-1.27^{***}	-0.97^{***}	-1.04^{***}	-1.03^{***}
	(0.10)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)
Trade: Currency	5.53^{***}	5.77^{***}	5.74^{***}	1.84^{*}	1.85^{*}	1.68
	(1.00)	(0.97)	(0.98)	(0.93)	(0.89)	(0.91)
Trade: BorderShared	0.59^{*}	0.37	0.45	0.44^{*}	0.26	0.36
	(0.24)	(0.23)	(0.24)	(0.21)	(0.20)	(0.20)
Sector: (Intercept)	5.48^{***}	6.26^{***}	6.26^{***}	7.94^{***}	8.85^{***}	8.86^{***}
	(0.91)	(0.91)	(0.91)	(1.02)	(1.02)	(1.02)
Sector: Diffgdp	0.03	0.07	0.07	0.04	0.10	0.10
	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Sector: Multgdp	-0.09^{*}	-0.14^{***}	-0.14^{***}	-0.22^{***}	-0.28^{***}	-0.28^{***}
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
Cycle: FDI				-0.01^{*}	-0.02^{***}	-0.01
				(0.01)	(0.01)	(0.00)
Trade: FDI				0.20^{***}	0.23^{***}	0.22^{***}
				(0.02)	(0.02)	(0.02)
Trade: EPL				-0.10^{*}	-0.10^{*}	-0.10^{*}
				(0.05)	(0.04)	(0.04)
Trade: PMR				0.03	0.07	0.06
				(0.04)	(0.04)	(0.04)
Sector: FDI				0.13^{***}	0.15^{***}	0.15^{***}
				(0.03)	(0.03)	(0.03)
Financial: (Intercept)				-15.11^{***}	-15.28^{***}	-15.26^{***}
				(1.68)	(1.68)	(1.68)
Financial: BankShared				1.13^{*}	1.14^{*}	1.16^{*}
				(0.51)	(0.50)	(0.50)
Financial: Sumgdp				1.45^{***}	1.46^{***}	1.46^{***}
				(0.11)	(0.11)	(0.11)
Cycle: R^2	0.15	0.12	0.15	0.14	0.09	0.15
Trade: R^2	0.51	0.50	0.50	0.64	0.64	0.64
Sector: R^2	0.02	0.01	0.01	0.07	0.07	0.07
Cycle: Adj. R^2	0.15	0.11	0.15	0.14	0.08	0.15
Trade: Adj. R^2	0.50	0.50	0.50	0.64	0.63	0.63
Sector: Adj. R^2	0.01	0.01	0.01	0.07	0.06	0.06
Num. obs. (total)	1131	1131	1131	1508	1508	1508
Financial: R^2				0.35	0.35	0.35
Financial: Adj. R^2				0.35	0.35	0.35

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 2.5: Results from Benchmark Estimation

Table 2.5 presents the coefficients of the main endogenous results in the benchmark estimation carried out in section 4. The endogenous variables are along the left-side column and the dependent variables along the header column. The effect of trade on business cycle synchronization is 10% with a pvalue of 0.01. The coefficients presented in Table 2.6 below are the averages across all three estimations types (2SLS, 3SLS and SUR). There are slight differences between the three estimations, however they all have similar significance levels and signs of coefficients. The full results of each of the specification types are presented in the appendix. Trade has a positive relationship on business cycle synchronization. The positive and significant result that trade has on business cycle synchronization is inline with previous studies (Frankel & Rose 1998, Imbs 2004, Dées & Zorell 2011).

	Cycle	Trade	Sector
Trade	0.09***		
Sector	0.00	-0.24***	
Financial Integration	-0.01*	0.20***	0.13***
Rsquared	0.14	0.64	0.07

Table 2.6: Estimated Coefficients from Benchmark Estimation. Results of the two staged least squares.

The coefficient of trade on the Cycle equation is positive and significant at $p < 0.001$. These results show that trade can play a positive role in promoting synchronization between the cycles of countries. This matches the results that previous studies in this literature has achieved (Imbs 2004, Dées & Zorell 2011). This result can be interpreted as supporting the explanation that contagion between countries via trade is a source of achieving cycle synchronization.

The coefficients of Sector specialization and Financial Integration are both insignificant on the synchronization of cycles. Although Sector specialization appears to have no direct impact on Cycle synchronization itself, it appears to be significant in promoting trade. Although the coefficient is nega-

tive, as the Sector Specialization index measures differences in countries' sector specialization, this result implies that the closer together the industries of two countries are, the more likely they are to trade. One explanation of this is that countries participate in intra-industry trade and that this trade plays a greater role in cycle synchronization that trade that takes places across different sectors. This result supports Davis (1995) who confirms the importance that intra-industry trade plays in explaining aggregate trade patterns. Furthermore, these results also suggests a role for vertical specialization. If similar sectors are engaged in increased levels of international trade, then this could imply that cross-border trade can be explained by multi-stage production. Yi (2003) investigates the role that vertical specialization can play in explaining the increase in international trade. The result that similar sectors trade more with each other within the EU could go towards supporting the existence of vertical specialization and therefore could support the findings of Yi (2003).

The impact of financial integration on both trade patterns and sector patterns is somewhat contradictory. Financial integration has a positive impact on trade but a negative impact on increasing sectoral alignment between countries. As financial integration is measured by FDI, it is possible that the FDI will be used to further increase exports to other countries. Furthermore, the increase in FDI may make a country more internationally competitive leading to increased trade with other countries. The result that is contradictory is that FDI promotes sectoral divergence as the coefficient on the sectoral differences is positive. This is a result which certainly deserves further investigation.

The ambiguity surrounding the final impact of financial integration is further proved by the estimation results. The results of the direct impact of financial integration on business cycle synchronization is significant when using the 2SLS and becomes even more significant with 3SLS meausure but becomes insignificant when using the SUR. Furthermore it is the only endogenous variable to have such variation in the significance of the results across

the different estimation methods. Financial integration is the weakest of the endogenous variables. However, FDI is playing significant and positive role to promoting cycle-synchronization through the other endogenous variables in the model. The impact of FDI on both sectoral-specialization and trade is both positive and strongly significant. The adjusted R^2 for the financial integration equation is 35%. Financial integration has the highest variation in the data used in the literature, so the result is sensitive to the choice of data used to measure financial integration (Dées & Zorell 2011). However, FDI is the most commonly used as a measure of financial integration.

The results are steady across all three specifications of the model. The coefficient remains around the 10% mark. The results is significant across all the estimations at p=0.01. The scale of the trade coefficient is strongly in line with (De Grauwe & Mongelli 2004) who also estimate a coefficient of 7%. These results contradict studies that argue that increased trade may lead to a divergence of business cycles due to trade being a sign of efficiency differences.

Next, the coefficients of variables that are not endogenous in the model will be explained.

The currency dummy is significant and positive. This result confirms previous studies that show that a shared currency promotes trade. The significance from these results is somewhat limited as it has the lowest significance of the exogenous variables. A recent study by Frankel and Rose (2010) proved that these results with post EMU data are insignificant.

Closer geographical distance is a significant and positive determinant of Trade intensity. A shared border is also positive and significant as a determinant of trade but to a smaller degree than distance. The variance in the land-size of countries is such that the distance between three countries could be smaller than the distance between larger countries' capital and it's neighbour.

The Cross-border banking index has a positive and significant coefficient in determining FDI. This result suggests that countries that share the same systemically important banks have a higher incidence of conducting investment in the other country. The EPL index is significant and negative. As the EPL measures the difference in the employment protection laws of countries, this result implies that the closer together the labour protection laws are in two countries, the more likely they are to trade with each other. The PMR however is insignificant in determining trade.

The model was run using three different methods, 2SLS, 3SLS and SUR. The results of the three different estimations are used as a measure of robustness. The positive and significant impact of trade on cycle synchronization is consistent across all three model estimations. The signs and significance of the endogenous equations remain consistence across all three estimations of the model.

Table 2.7: Model Fit Tests

	AIC	BIC	LogLik
2SLS	3,916.730	4,023.101	-1,938.365
3SLS	3,906.803	4,061.041	-1,924.402
SUR	3,915.150	4,069.387	-1,928.575

Table 2.7 shows the AIC, BIC and log likelihood estimations respectively. They show that the three staged least squares estimations perform the best according to AIC and the log likelihood , however the seemingly unrelated regression approach has the best fit according to the BIC.

2.5.1 Sensitivity of Cycle Extraction Method

To investigate the impact that cycle sensitivity has on the estimation the model is re-run with the dependent variable that is the correlation of the countries' business cycles that have been extracted using the Hodrick-Prescott filter. The first step is to apply the filter to log seasonally adjusted GDP series. For the λ which is the cyclical penalizing parameter, I use the value of $\lambda = 1600$ which is the standard in the literature for quarterly data (Ravn & Uhlig 2002). The pairwise correlation of the Hodrick-Prescott filtered cycles are calculated for the 17 year period for all unique country pairs of the EU. None of the countries in the sample exhibit a negative correlation and therefore none of the cycles exhibit a counter-cyclical relationship to each other. As all the other variables used in the system of equations remain the same, the main differences are expected to be seen in any of the estimation equations that have ρ_{ij} in them.

	2SLS (Imbs)	3SLS (Imbs)	SUR (Imbs)	2SLS	3SLS	SUR
Cycle: (Intercept)	0.16	−0.01	0.10	0.01	−0.20	0.03
	(0.10)	(0.10)	(0.09)	(0.11)	(0.11)	(0.09)
Cycle: Tradeint	0.04***	0.05***	0.05***	0.06***	0.08***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Cycle: Sector	−0.02**	−0.01*	−0.02*	−0.01	−0.00	−0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Trade: (Intercept)	21.64***	22.18***	22.15***	18.72***	19.12***	19.12***
	(0.74)	(0.73)	(0.73)	(0.69)	(0.68)	(0.68)
Trade: Sector	−0.15***	−0.22***	−0.22***	−0.24***	−0.31***	−0.31***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Trade: Distance	−1.21***	−1.25***	−1.25***	−0.97***	−1.02***	−1.02***
	(0.10)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)
Trade: Currency	5.53***	5.57***	5.57***	1.84*	1.68	1.58
	(1.00)	(0.98)	(0.99)	(0.93)	(0.90)	(0.92)
Trade: BorderShared	0.59*	0.47*	0.51*	0.44*	0.35	0.40*
	(0.24)	(0.23)	(0.24)	(0.21)	(0.20)	(0.20)
Sector: (Intercept)	5.48***	6.26***	6.26***	7.94***	8.84***	8.84***
	(0.91)	(0.91)	(0.91)	(1.02)	(1.02)	(1.02)
Sector: Diffgdp	0.03	0.07	0.07	0.04	0.10	0.10
	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Sector: Multgdp	−0.09*	−0.14***	−0.14***	−0.22***	−0.28***	−0.28***
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
Cycle: FDI				−0.01**	−0.02***	−0.01**
				(0.00)	(0.00)	(0.00)
Trade: FDI				0.20***	0.23***	0.22***
				(0.02)	(0.02)	(0.02)
Trade: EPL				−0.10*	−0.09*	−0.10*
				(0.05)	(0.04)	(0.04)
Trade: PMR				0.03	0.06	0.05
				(0.04)	(0.04)	(0.04)
Sector: FDI				0.13***	0.15***	0.15***
				(0.03)	(0.03)	(0.03)
Financial: (Intercept)				−15.11***	−15.24***	−15.23***
				(1.68)	(1.68)	(1.68)
Financial: BankShared				1.13*	1.15*	1.15*
				(0.51)	(0.50)	(0.50)
Financial: Sumgdp				1.45***	1.46***	1.46***
				(0.11)	(0.11)	(0.11)
Cycle: R^2	0.13	0.11	0.12	0.13	0.10	0.13
Trade: R^2	0.51	0.50	0.50	0.64	0.64	0.64
Sector: R^2	0.02	0.01	0.01	0.07	0.07	0.07
Cycle: Adj. R^2	0.12	0.10	0.12	0.12	0.09	0.13
Trade: Adj. R^2	0.50	0.50	0.50	0.64	0.63	0.63
Sector: Adj. R^2	0.01	0.01	0.01	0.07	0.06	0.06
Num. obs. (total)	1131	1131	1131	1508	1508	1508
Financial: R^2				0.35	0.35	0.35
Financial: Adj. R^2				0.35	0.35	0.35

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 2.8: Results with Hodrick Prescott Filter

The results of the Hodrick-Prescott filter are presented in Table 2.9. The coefficients are the averages across all three estimation methods (2SLS, 3SLS and SUR).

	Cycle	Trade	Sector
Trade	0.06***		
Sector	-0.01	-0.24***	
Financial Integration	-0.01**	0.23***	0.13***
Rsquared	0.13	0.64	0.07

Table 2.9: Estimated Coefficients from Estimation using the dependent variable of HP Filtered Cycles

The coefficient on the trade variable remains positive and significant at p=0.01. The main tenets of the results remain broadly unchanged with results of trade remaining significant and remaining in its scale.

Other results that remain unchanged are all the components of the trade equation (2). The currency result remains significant at p=0.1. The value of the coefficients also remain at around the same value.

The use of the Hodrick-Prescott filter causes modest changes to the results previously obtained. The coefficient of sectoral-specialization remains significant and negative, however there is a sharp drop in the value of the coefficient. It falls from 0.18 to 0.06. The coefficient scales remain the same for the effect of trade on cycles.

The most significant of the changes to the results in the baseline estimation is that FDI now becomes significant in the estimation and furthermore the value of the coefficient increases from 0.01 to 0.03.

The coefficient of FDI appears to be very significant when using the Hodrick-Prescott Filter cycle correlation as the dependent variable at p=0.01. The UCM show a reduced level of significance at p=0.1. First, this shows

the lack stability in the results achieved for the effect of FDI. Secondly, it shows that cycle extraction methods has an influence the estimation results (Canova 1998).

Table 2.10: Model Fit Tests

	AIC	BIC	LogLik
2SLS	3,733.721	3,840.092	-1,846.861
3SLS	3,727.875	3,882.112	-1,834.937
SUR	3,732.573	3,886.810	-1,837.286

When looking at the model fit through the AIC, BIC and Log Likelihood, compared to that of the benchmark estimation, there would appear to be a better model fit using the Hodrick-Prescott Filter. However, this result could in part be because the variation in the dependent variable of pairwise cycle correlation coefficient is lower than in the benchmark estimation.

2.6 Conclusion

The OCA literature identifies the synchronization of output as a component to deliver stable currency unions. Identifying the determinants of business cycle synchronization can help to identify ways in which cycle-synchronization between countries can be further increased. A contribution is made to the literature by uncovering GDP cyclical fluctuations by adopting a trend-cycle decomposition model which allows the trend to be either stochastic or deterministic i.e. of the non-linear type. The extracted cycles already provide some insight in to how synchronicity within the EU has changed over the past decades. In particular, the increased synchronicity that was attained during the recession of 08/09 is made clear. Once cyclical components are derived, the relationship between trade and output synchronization is further investigated.

By using a system of endogenous equations, the effects of trade on output synchronization are empirically estimated. The system of equations allows for the simultaneous estimation of the impact of Sectoral integration and financial integration both on trade and output synchronization. The results show a significant and positive relationship between trade and correlation of business cycles. Sector-specialization indirectly promotes an increase in the correlation of business cycles by promoting increased trade between countries.

This study incorporates a discussion of the cycle extraction methods that are used in this area of literature. The addition of the different cyclical extraction method has not had a significant impact on the main tenets of the result however it understates the mechanism of intra-industry trade as a mechanism of output convergence as the coefficient is much lower when using the benchmark Hodrick-Prescott Filter. The use of different cyclical extraction method uncovers the ambiguity surrounding the impact of financial integration on business cycle synchronization.

2.7 Appendix

2.7.1 Data

- GDP - Real quarterly GDP , measured in millions of euros with a base year of 2010. Sourced from Eurostat.
- Trade - Imports and Exports in goods and services. Measured in millions of euros in real terms with a base year of 2010. Sourced from Eurostat.
- Bilateral Capital Distance - CEPII.
- Sectoral Specialization index - Gross value added and income by A*10 industry breakdowns
- EPL - Employment Protection Law Sourced from OECD. Runs from 1985-2013.
- PMR - Product Market Regulation, Sourced from OECD. Runs from 1998-2013.
- FDI - FDI data is obtained from UNCTAD Bilateral FDI.

Country	Selected Model	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
AUSTRIA	4	-12.05	-12.03	-12.04	-12.26	-12.25	-11.83	-11.82	-11.81	-9.08
BELGIUM	4	-12.40	-12.30	-12.23	-12.56	-12.55	-12.07	-12.07	-12.06	-9.09
BULGARIA	4	-11.07	-11.15	-11.15	-11.23	-11.22	-11.07	-11.08	-11.07	-9.35
CROATIA	5	-11.35	-11.35	-11.40	-11.52	-11.51	-11.35	-11.36	-11.34	-9.55
CYPRUS	4	-10.83	-10.95	-10.95	-11.07	-11.06	-10.87	-10.88	-10.87	-9.25
CZECH	4	-11.58	-11.46	-11.46	-11.68	-11.67	-11.36	-11.38	-11.36	-9.19
DENMARK	4	-11.13	-11.13	-11.13	-11.17	-11.15	-10.95	-10.96	-10.95	-9.07
ESTONIA	4	-9.51	-9.50	-9.50	-9.75	-9.74	-9.33	-9.36	-9.35	-8.90
FINLAND	4	-10.49	-10.49	-10.51	-10.73	-10.72	-10.39	-10.38	-10.36	-8.96
FRANCE	4	-12.70	-12.59	-12.57	-12.96	-12.95	-12.39	-12.38	-12.51	-8.80
GERMANY	4	-11.43	-11.44	-11.50	-11.51	-11.50	-11.07	-11.06	-11.05	-8.70
GREECE	4	-10.26	-10.37	-10.37	-10.55	-10.53	-10.27	-10.30	-10.29	-8.76
HUNGARY	4	-11.11	-11.18	-11.18	-11.31	-11.30	-11.07	-11.10	-11.09	-9.11
IRELAND	4	-8.73	-8.77	-8.81	-8.88	-8.87	-8.63	-8.63	-8.62	-8.09
ITALY	4	-11.95	-11.74	-11.73	-12.20	-12.18	-11.60	-11.60	-11.59	-8.80
LATVIA	4	-9.90	-9.85	-9.85	-10.15	-10.13	-9.64	-9.73	-9.71	-9.05
LITHUANIA	4	-9.40	-9.46	-9.46	-9.60	-9.59	-9.33	-9.35	-9.41	-8.76
LUXEMBOURG	4	-9.90	-9.99	-10.04	-10.05	-10.03	-9.79	-9.79	-9.77	-8.90
MALTA	4	-10.02	-10.10	-10.10	-10.12	-10.11	-9.92	-9.93	-9.90	-9.28
NETHERLANDS	4	-11.77	-11.82	-11.82	-11.94	-11.92	-9.39	-11.68	-11.67	-8.96
POLAND	1	-11.25	-11.22	-11.22	-11.05	-11.03	-11.02	-11.01	-11.00	-9.03
PORTUGAL	4	-11.53	-11.57	-11.57	-11.63	-11.62	-11.45	-11.48	-11.46	-9.05
ROMANIA	3	-9.88	-9.99	-10.03	-10.02	-10.01	-9.91	-9.92	-9.91	-8.81
SLOVAKIA	4	-9.87	-9.93	-9.97	-10.04	-10.03	-9.84	-9.84	-9.83	-8.91
SLOVENIA	4	-11.07	-10.90	-10.90	-11.15	-11.14	-10.79	-10.80	-10.79	-9.28
SPAIN	4	-13.47	-12.66	-12.66	-13.22	-13.21	-12.77	-12.77	-12.76	-8.88
SWEDEN	4	-11.08	-11.09	-11.09	-11.30	-11.29	-10.86	-10.86	-10.85	-9.03
UK	4	-12.49	-12.25	-12.25	-12.42	-12.41	-9.79	-12.10	-12.08	-8.78

Table 2.11: Akaike Information Criterion for nine models estimated for the decomposition

Chapter 3

Does Trade Promote International Convergence in Demand Side Persistence

Abstract

This study develops a novel index that measures business cycle facts, consistent with the recent literature. The index develops a scalar measure of the persistence of the demand-side response to a supply-side shock. Demand-side responses are estimated using a bi-variate VAR that is motivated by an aggregate supply and aggregate demand model. The speed of adjustment is then measured by measuring the persistence of the demand-side response. This value then forms the Persistence index. The measure allows for analysis of how suitable countries are for a currency union based on the idea of symmetry. The scalar index allows for the estimation of the determinants of symmetry. The effect of three different components as identified by the Optimal Currency Area (OCA) literature are tested to see if they are significant in determining the value of the Persistence index. The three blocks measure trade-openness, labour market flexibility and financial conditions. The results show that trade-openness is positive and significant in driving symmetry thus implying that trade is a conducive to a stable currency union.

3.1 Introduction

The Optimal Currency Area (OCA) literature identifies a group of macroeconomic conditions that are conducive to maintaining a successful currency union (Mundell 1961). One of the identified conditions is *symmetry* between the economy's of countries. Symmetry refers to the similarity of macroeconomic responses of supply and demand within an economy. The macroeconomic symmetry can be identified as the correlation of output and employment within an economy, or the correlation of output and price movements within and economy (De Grauwe 2018). The higher the degree of symmetry, the less costly it is for a country to join a currency union (De Grauwe & Mongelli 2005). A high degree of asymmetry means that ; in the wake of supply-side shocks, the central bank will have to trade-off between output stabilization and inflation stabilization, hence making it more difficult to stabilize prices in a currency union (Silva & Tenreyro 2010, Fidrmuc & Korhonen 2003), and spurring growth homogeneously. In a currency union, countries forego independent monetary policy in favour of a common policy. Ensuring the stability of the currency union thus requires that one monetary policy be suitable for all countries involved (Rose & Van Wincoop 2001). The largest currency union currently in existence is the eurozone. The ECB currently dictates monetary policy that governs 19 countries simultaneously. In order for this to be successful, economic integration between countries is a necessary, albeit not sufficient, component as it allows for the monetary policy to remain effective for all the countries in the union by minimizing its costs. In order to look at whether the countries of the EU have the effective conditions for a single monetary policy, this study develops an index that measures the responsiveness of demand to supply shocks.

This study develops a novel index which measures the degree of symmetry within an economy. The index is based on measuring how quick the response of demand is to an exogenous shock in supply. The speed of the response of demand to a supply-side shock is interpreted as symmetry as if de-

mand reacts quickly to movements to supply then the behaviour of demand can be seen to be mirroring supply-side movements, therefore exhibiting symmetry. AD-AS theory suggests demand-side shocks are temporary, whereas supply-side shocks are permanent. As a result, idiosyncratic supply-side shocks are potentially more harmful to a currency union than idiosyncratic demand-side shocks. Therefore, this study focuses on measuring responses to supply-side shocks. First a bi-variate SVAR with GDP and prices is estimated. In order to identify the supply-side shocks, a restriction is placed on the error matrix which means that long run response of demand shocks is zero but that the response of supply-side shocks are permanent (Blanchard & Quah 1988). A exogenous shock is then introduced to supply and the impulse response functions (IRFs) are then generated for the response of demand. Once the IRFs have been generated, the next step is to investigate a method that would be suitable in measuring the speed of the demand response. The coefficient of the AR1 process of the IRF is measured. The coefficient of the AR1 process is then used as the value of the persistence index. The closer the value is to 1, the higher the persistence and therefore the higher the degree of correlation of output and prices. The higher the persistence index, the more suitable the macroeconomic environment is to adopt a currency union - with respect to symmetry.

The persistence index is estimated on a quarterly basis for the years 2008-2017 and it shows us how the EU has converged and diverged over the past ten years. One of the main observations from the persistence index is the increased persistence and convergence between economies that was achieved in the post-crisis periods, which is the reflection of a global (or anyway) euro-area wide shock(s). The index created, explicitly measures the speed of adjustment of economies in response to exogenously identified shocks. Previous studies measure symmetry in a way that relies on looking at a country's relationship with an anchor country e.g. Germany (Bayoumi & Eichengreen 1992). This index does not require however, identifying a numeraire, as it represents an absolute, rather than relative, measure of persistence. Bayoumi and Eichengreen

(1992) first suggested looking at the dispersion of supply-side shocks' correlation in order to define core and periphery states or countries. This argument has been taken on and further expanded, by means of long-run supply side restrictions, by Campos and Macchiarelli (2016). The rationale for looking at supply-side shocks developments is that monetary policy, which is centralized in a currency union, is typically impaired in the presence of asymmetrical shocks. The approach to measuring symmetry builds on an existing approach by Bayoumi and Eichengreen (1992, 2018). Their study measures the correlation of supply and demand disturbances in order to measure the level of symmetry within an economy. The contribution of this study is to develop a novel way in which to measure the integration between countries by creating an index of persistence. The index of persistence builds on the approach of the aforementioned studies but instead of looking at the correlation of the responses and the degree to which supply and demand mirror each other, thus being more explicit about the measurement of the speed of adjustment.

Once the index has been created, a fixed-effects panel OLS is used to empirically estimate the determinants of symmetry. Three blocks of variables are used in the estimation. These blocks have been chosen according to factors identified by the OCA literature. These include, a block of variables that measure openness through looking at the amount of GDP that is comprised of international trade. Openness is another feature that has been identified as an OCA component. Understanding the impact that trade has on symmetry means that we can investigate whether endogeneities of OCA exist. This is where the pursuit of a single component needed for an OCA helps to reinforce the existence of the other components needed for an OCA (De Grauwe & Mongelli 2005, Frankel & Rose 1998). A second block investigates whether financial variables impacts the index and finally, a block that measures the labour market is estimated. The results show that trade is positive and significant in increasing symmetry however capital flows are significant and negative in promoting symmetry. The results show a limited impact of financial movements on promoting symmetry.

The results of this research can be used by policy makers to re-confirm the importance of trade in ensuring a successful currency union. Currency unions have become of increasing interest in recent history. First, the increase in the levels of international trade is well documented: one reason for this growth is merely from accounting and the fact that there is an increasing number of countries. In 1947 the number of countries was just 76 and now there are 193 countries (Alesina, Barro & Tenreyro 2002)Classified as member states of the United Nations.. As countries are increasing the number of transactions that are international and cross-borders, the increased transactional costs owing to different currencies and risk of currency movements are becoming a more prominent. One way to overcome these costs is by participating in a currency union. The largest currency union in existence today is the Euro with 19 member states. The question of integration in the EU first became of major academic interest with the decision to adopt a shared currency. Understanding what were going to be the benefits and costs for a shared currency union was of policy interest and still is today, in the light of the post-crisis adjustments. The index itself provides some interesting descriptive statistics about demand persistence in the EU which has risen. During the crisis, the symmetry index shows that on average countries exhibited a slower demand-side response with the average value of the persistence index falling from the years 2008-2010. However since 2010, the average value of the persistence index across the EU has risen.

To signpost the main contributions of this study are:

- An empirical estimation of the demand-side response to a supply-side shock.
- Measuring the persistence of the response in order to create a scalar index of persistence.

- Employ a panel estimation to empirically investigate the determinants of the index of persistence.

Section two looks at the important role that symmetry plays in the OCA literature. Section three will outline the macroeconomic model used to represent supply and demand of the economy, and then introduce the methodology used to estimate the demand-side responses. This is then followed by a discussion of measures of persistence used in the literature before explaining why the AR(1) coefficient will be used as a measure. Section four presents the index of persistence and includes some initial analysis on the behaviour of the index over time. Section five introduces the model used for the panel estimation. Section six presents and discusses the results of the panel estimation. Section seven concludes.

3.2 Literature Review

3.2.1 Endogeneities of OCA's

Three components that have been identified to maintaining a successful OCA are: symmetry, integration and flexibility (De Grauwe & Mongelli 2005). Flexibility refers to labour market flexibility and the ability of wages to adjust quickly to price movements. This includes the geographical mobility of labour and the ease of which labour can move across regions (Mundell 1961). Integration refers to two economies that have integrated markets which is usually quantified by a greater number or value of transactions between the two economies. These include: financial, goods or services markets. Symmetry is thought to be important to maintaining an OCA, a lack of symmetry or asymmetry increases the costs of participation in a currency union (Fidrmuc & Korhonen 2003). This increased cost comes from the increased impact that the loss of autonomous monetary policy will have on the economy (Mundell 1961).

Symmetry between countries is particularly important for monetary policy. A central bank that follows a simple Taylor rule approach, aims to bring demand in line with long run supply. However, the extent to which this can be done via monetary policy differs from country to country. Therefore, the speeds of adjustment dictate the adequate monetary policy response in order to achieve a stable demand level. When symmetry in a currency union is not high enough, the single monetary policy will not be adequate to adjust many output gaps among the member states simultaneously. Given that different macroeconomic factors have been identified for a successful OCA, the relationship between the different factors is also important. De Grauwe proposes that there is trade-off for OCA's in so far as that if one of the components is not present i.e. symmetry, then another component must be present to a greater degree in order to compensate. This trade-off is represented graphically in the figure below:

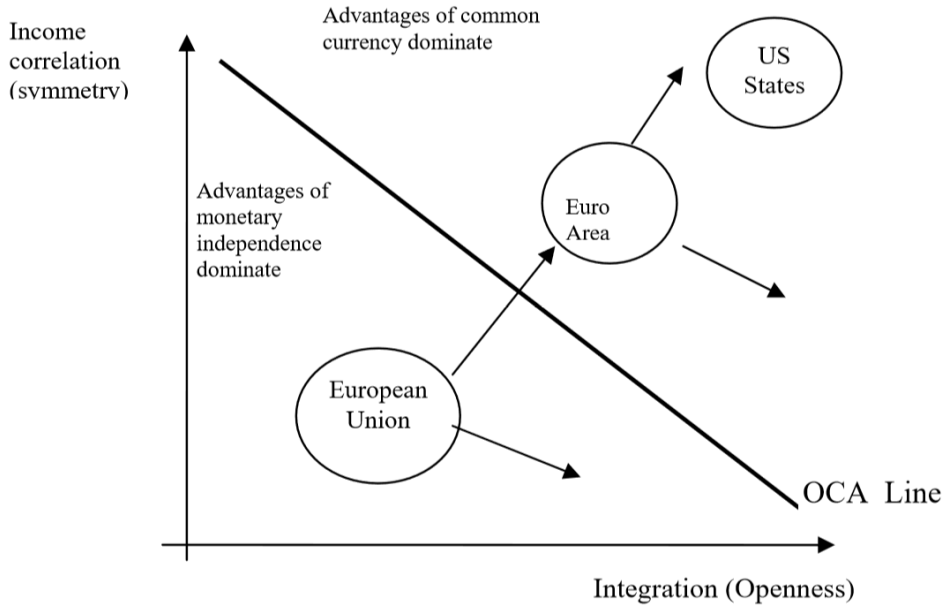


Figure 3.1: OCA line

De Grauwe and Mongelli (2005) outline a concept called the OCA line which can be seen in Figure 3.1. The OCA line plots the combinations of Symmetry (Income Convergence) and Integration (Trade openness) for which the benefits of adopting the same currency outweigh the costs. If a large degree of symmetry exists, then the countries markets do not need to be as integrated as they are already subject to similar kinds of macroeconomic shocks, therefore reducing the costs of a currency union. However if a small degree of symmetry exists, then countries must have integrated markets in order for the benefits of a currency union to remain outweighing the costs[1]. Whilst identifying the components of OCA's is important, it is equally important to understand the relationship between the different required OCA components. If the pursuit of one component leads to an increase in the existence of the other component then this is positive for OCA's as it means that an OCA have an endogenous way of increasing stabilization. However, if the pursuit of one component, leads to a decrease in another component, then this could bring about a balancing act whereby the different components of OCA's need to be pursued to a certain degree in order for the countries to remain on the right of the OCA line. The endogoneities of OCA's looks at whether the introduction of a currency union can bring about ex-post the the macroeconomic conditions required for an optimal currency area.

A large number of empirical studies have been conducted to empirically estimate the impact that trade openness has on income correlation. Trade is used to measure integration (openness) and income correlation is used to measure symmetry. One of the early papers to investigate this was Frankel and Rose (1998) who look at the impact of trade on income correlation. They find that trade has a positive impact on income correlation. A further group of studies investigate the impact of increased trade-openness on income correlation using different country samples, measures of income correlation and different instrumental and control variables. In a review of the literature, Rose (2008) analyses the results of twenty empirical studies that have anal-

[1] A mathematical representation can be found in De Grauwe and Mongelli (2005)

ysed the relationship between trade and business cycle synchronization. The twenty studies confirm the positive impact of trade on business cycle synchronization with beta's ranging from 0.01[2] to 0.13[3]. A group of studies have introduced sectoral linkages to see if this impacts the endogeneities of OCA's (Imbs 2004, Dées & Zorell 2011).

Lane (2000) argues that the failure of currency unions comes from asymmetric shocks, the examples that are cited are the Italy and UK's exit from the European Exchange Rate Mechanism (ERM)[4] and latin America currency changes. However the extent to which the problem of asymmetric shocks is still a problem is contested as increases in global trade and increased connectedness of global financial markets means that the business cycles of all countries have become more synchronized. The idea that a shock can be purely idiosyncratic and not be simultaneously faced by other countries is arguably less of a concern. Lane (2000) considers a uniform shocks and investigates the idiosyncracity of the responses. A supply-side shock is likely to impact all countries and, the only mechanism in the short term in which to address the response of demand to a supply-side shock is monetary policy. If countries have the same demand response to a common supply-side shock, then this means that a common monetary response can be generated. However, if responses differ, then it would be difficult to justify that countries are better off with a common monetary policy (Dwane, Lane & McIndoe 2010).

3.2.2 Measuring Symmetry

The list below outlines in brief the measures of symmetry that are commonplace within the OCA literature:

[2]Calderon Chong and Stein (2007)

[3]Baxter and Kouparitsas(2005)

[4]Lane (2000) argues that the cause of the UK's exit from the ERM was in part down to the asymmetric shock of Germany reunification

- How similar (or symmetrical) the income of two countries are (Income convergence)
- The synchronization (or symmetry) of business cycles between two countries. This definition also includeS how similar two countries are in their reaction to an exogenous shock. (Business cycle convergence:)
- The symmetry of supply and demand within in an economy. The more symmetrical the demand and supply side behaviours are, the more symmetry the markets have. This is positive because it means there is a fast speed of adjustment to any external shocks that might affect either the demand or the supply side.

The first measurement of synchronization discussed is income convergence. If two countries adopt the same currency, then it is thought that their income levels will converge over time. Sources of this convergence are increased trade, convergence of prices through contagion and both adopting the same monetary policy

The measurement of symmetry has been analyzed from a structural approach by looking at the symmetry of exogenous macroeconomic shocks. As economies are subject to external and exogenous macroeconomic shocks, it is the way that these economies behave in response to a shock that determines their suitability for a currency union. Asymmetric shocks can cause a lot of problems as they cause sources of volatility of relative incomes of two countries. Countries' incomes are to some part determined by the income of other countries, and asymmetric shocks can introduce changes in to the relative incomes of countries with other countries (Lane 2000). If the same exogenous shocks dissipates throughout both economies in a very similar way, then these economies are well suited for a currency union. One reason is that very often monetary policy is used to target exogenous shocks, so if the behaviour is similar then the monetary policy can be adequate.

The aim is to observe how symmetrical the demand and supply side

behaviours are. The more symmetrical the demand and supply side behaviour are, the more efficient markets are because their speed of adjustment to structural shocks is higher. Therefore they are likely to have less deviations from potential output. In this study the definition of symmetry will be the same as Bayoumi and Eichengreen's (1993) which refers to how symmetrical supply and demand are.

Bayoumi and Eichengreen (1992) developed an approach to look at whether the relationships between the economies of EU member states were strong enough to withstand a shared currency. They look at the asymmetry of macroeconomic shocks to decide whether countries are suitable for a currency union. The higher the correlation of the supply with the demand response, the lower the costs of joining a monetary union are deemed to be. Their study cross-compares 11 regions in the US and 11 countries within the EU. US states have a higher level of correlation of aggregate supply and demand disturbances meaning that they are more suited to a currency union than the EU. They found that the EU displayed slower responses which they deemed to be a reflection of lower factor mobility. They found that when comparing the EU to the US, the EU displayed more idiosyncratic responses that the US to the same shock. This implies that there are lower conditions for a monetary union than the US. However, there was a core group of EU countries that displayed more homogeneous responses than the US. Their suggestion was that within the EU, countries could be split in to two separate tranches, core and periphery (Bayoumi & Eichengreen 1992, Bayoumi & Eichengreen 2018). Their conclusion is that these core group of countries would be good in a monetary union together. By looking at the correlation of aggregate supply and aggregate demand disturbances with Germany, they are able to group the member states of the EU in to core and peripheral groups. Their methodology uses the Cholesky decomposition to identify supply and demand shocks to the economy and look at the correlation of disturbances of the impulse response functions. They measure the between country correlation of supply and demand disturbances. The definition of asymmetry in this study just refers to the scale and

correlation of the disturbances and does not explicitly measure the speed of adjustment. The approach introduced by Bayoumi and Eichengreen (1992) has further been used in empirical studies to test the suitability of countries to either join or maintain a currency union (Fidrmuc & Korhonen 2003).

Campos and Macchiarelli (2016) revisit this question twenty five years later and update Bayoumi and Eichengreens results until 2015. They look at whether there have been changes in the core and peripheral EU groups that were initially identified. In addition their study adds a methodological contribution that allows for a more robust interpretation of the results. In order to identify a potentially new set of core and peripheral countries, a further test is conducted. The restrictions placed on the estimation matrix in the form of a lower cholesky decomposition are tested for over-identification. Their assumption is that the greater the number of times that the restriction that supply is 1 is rejected, the least persistence the markets are deemed to be. They find that the group of countries that now form the core have slightly changed in the past 25 years.

These two papers investigate the core and peripheral countries based on how symmetrical are based on their developed index. In this study I develop a method that formally captures the speed of adjustment through measuring the persistence of the demand-side responses. I generate the IRFs and then use methods to measure the persistence in their responses to investigate the time it takes for demand to response to a positive supply shock.

Measuring the size of the disturbance provides a partial picture of the degree of symmetry. The size of the disturbance need not be an issue if the country's economy can adjust quickly to this exogenous shock. The speed of adjustment is equally important. The speed of adjustment indicates how quickly an economy will react to a disturbance. The speed of adjustment was introduced in Bayoumi and Eichengreen (1992) , where they measure the speed of adjustment by generating impulse response functions for their SVAR and then comparing the final third of the horizon to the mean of the whole

response. The measure in this study differs in two ways. Firstly, rather than comparing the final third, the ar1 coefficient is estimated as it provides an indication of how much of the supply side shock is present in the next period of the impulse response of demand. Seeing the presence of the supply-side shock in the response of demand can provide a measure of how much symmetry there is in the economy. Secondly, rather than measuring the response of supply to a supply side shock as in Bayoumi and Eichengreen (1992), the study looks at the response of demand to a supply side shock, to measure the symmetry between supply and demand.

Whilst there are similarities between scale and duration, different features and rigidities within the economy will affect how long it takes for one time exogenous shock to dissipate. This could be an important dimension alongside the scale of the shock itself as persistence is more likely to be indicative of the level of economic frictions. The recursive estimation of the demand-side responses to a supply-side shock are maintained in this study, however the quantification of the responses takes a slightly different form. To quantify the responses, literature is borrowed from time series and in particular applications to data with long memory. The persistence of the response of the demand to a supply-side shock will be measured. Whilst scale and correlation can be informative of the speed of adjustment , they do no provide any explicit measure of how fast an economy will react to a supply-side shock. Information can only be inferred from comparison with an anchor country. For papers that look at the EU, the anchor country typically used is Germany. More specifically, this refers to the correlation of supply and demand-side disturbances to a numeraire country. The approach that is developed in this paper does not need an anchor to be interpreted and works as a standalone measure where closeness to 1 is deemed as a measure of perfect factor mobility and high speeds of adjustment and therefore symmetry.

The next contribution of this study is to introduce the concept of persistence by explicitly measuring the decay of the shock. As oppose to

looking at the volatility of the supply and demand disturbances as an indicator of the scale of the response, this study focuses on the decay of the response.

3.3 Identifying the demand-side responses.

3.3.1 Motivation

Demand and supply shocks are identified using new Keynesian model. Blanchard and Quah use the Stanley Fischer variant of the new Keynesian model to identify their shocks. Their equations reduced the movement of supply and demand to be based on the movement of unemployment and output. As prices are equal to wages plus productivity, it is short step to reduce the model to represent supply and demand disturbances as a movement of prices and output respectively. Output and prices are the two variables determine each other. The model is derived from a new Keynesian model where the factors of input are capital and labour respectively. The return on wages determines prices and productivity determines output. As shocks to productivity are deemed to be structural, this means that supply side shocks are deemed to permanent and require large adjustments. Restrictions are placed on the long run response of the error matrix. The motivation for the identification of the aggregate supply and aggregate demand-side shocks comes from the canonical aggregate supply and aggregate demand model. In this section a model is formally outlined to explain the transmission mechanism between supply and demand. In the model aggregate demand represented by Y_t. Aggregate demand is determined by the long run potential output of the economy, Y_{pot}, the deviation of prices from their long run level ,$\pi_t - \pi_*$, and an error term, ε_t. Aggregate supply is represented by the price level, Y_t and is dependent on the past year's price level,π_{t-1}, the change in output from it's previous year $Y_t - Y_{t-1}$,and also with an error term ν_t.

$$Y_t = Y_{pot} + A(\pi_t - \pi_*) + B\varepsilon_t$$

$$\pi_t = \pi_{t-1} + \phi(Y_t - Y_{t-1}) + \nu_t$$

By introducing an exogenous positive shock to π_t, we are introducing a positive aggregate supply shock to the economy. If domestic markets are symmetric, then then the shock introduced to π_t should have an instantaneous effect on Y_t. An instantaneous effect on Y_t would suggest that a) the role of the error term is reduced and that the only deviation from Y_{pot} is represented by price movements. In order for demand to be symmetric, the movement of demand must reflect the movements of output.

So the greater the movement of Y_t in response to a shock on π_t, the more symmetrical that we can deem the markets to be as demand is responding one for one to supply. In the model above the parameter that is measuring persistence is A. The higher A is, the higher the persistence of the economy and therefore output changes to the deviation of supply from its long-run level. Measuring A allows us to know what the adjustment of demand would be to a supply-side shock.

The model represented in the equations above is reduced to a two variable model that is represented by a moving average process.

The data generating process (dgp) assumptions made, are that GDP and Inflation follow a bi-variate auto-regressive approach that looks like the following:

$$\Delta y_{1t} = \alpha_1 \Delta y_{1t-1} + \alpha_2 \Delta y_{2t-1} + \epsilon_{1t-1}$$

$$\Delta y_{2t} = \beta_1 \Delta y_{2t-1} + \beta_2 \Delta y_{1t-1} + \epsilon_{2t-1}$$

Once the vars have been estimated, I then apply a positive 1% exogenous shock to the deflator which can be translated as a negative shock to

prices. Impulse response functions are then generated. The IRFs are obtained for 26 quarters. This is interpreted as a medium-term response as it is 6.5 years.

As we are interested in the final impact on demand purely from a supply-side shock, the responses are decomposed in to supply and demand responses by imposing restrictions as done in related literature (Bayoumi & Eichengreen 1992, Bayoumi & Eichengreen 1997, Campos & Macchiarelli 2016). The decision to make demand shocks temporary and supply shocks permanent comes from a new Keynesian motivation. Whilst this motivation is widely used in the literature, it is not without controversy. It could be possible that demand side shocks could also have bottle necks on an economy in a way the supply side does for example with movements in oil prices. If this is the case then, the symmetry of demand shocks would equally be important in this analysis. Two ways in which demand could have a long run impact is if the assumption of orthogonality between supply and demand shocks does not stand. If demand shocks do impact supply shocks then it is possible that demand could have a permanent effect through impacting supply. One way in which this could be the case is in the case of unemployment caused by business cycle fluctuations that lead to workers then becoming structurally unemployed. This shortcoming is mentioned by Bergman (2005). It is also possible that demand has a direct permanent effect. One example could be oil prices which is typically demand driven but could lead to a permanent impact on the economy. These are criticisms of the identification approach of Blanchard and Quah. The strength of the argument that demand is temporary comes from the real business cycle approach and many studies use the restrictions as identified by Blanchard and Quah for their theoretical merits. Whilst there are credible criticisms, the new Keynesian approaches and shocks as identified by Blanchard and Quah (1989) equally have theoretical credibility and are also widely accepted. (Bayoumi & Eichengreen 1992, Kim & Roubini 2008, Beetsma, Giuliodori & Klaassen 2008).

An exogenous shock to inflation is applied to the var. In order to uncover the demand and supply side responses separately, the irfs are decomposed in to their permanent and transitory components. The permanent component is interpreted to be the long run impact on supply. The transitory components are interpreted as the demand-side fluctuations above or below long run growth. In order to uncover these different components, the Blanchard and Quah (1989) decomposition is applied. This is a lower Cholesky decomposition with one restriction applied which is that in the long run, changes to output are zero.

$$\varepsilon\varepsilon' = \begin{bmatrix} \sigma_{11} & 0 \\ \sigma_{12} & \sigma_{22} \end{bmatrix}$$

This restriction on the variance co-variance matrix ensures that the long run response of demand to a supply-side shock is zero. The shocks as identified by Blanchard and Quah (1989) are not without their controversy that require a prescription as to the exact relationship of the economic variables to each other. If these initial predictions and restrictions placed on the responses of prices and output are incorrect, then this could lead to large errors in the estimated impulse responses. One way to overcome this problem is to use the sign restriction approach, as specified by Uhlig (2005). The sign restriction approach does not require as strong as restriction on the matrices as the Blanchard and Quah (1989) approach as no numerical restriction on the parameters is placed. Instead they require merely a restriction on the sign of the relationship of the variable, i.e. demand responds negatively to negative supply-side shocks. Uhlig's approach to computing this is to estimate the VAR and compute the impulse responses. A matrix of the same size is drawn at random multiple times and if the random matrix matches the specified signs of the movement in relation to the original calculated VAR then the response is accepted, if it does not the response is rejected. The number of accepted and rejected draws provides the final response of the variable. Further research could use Uhlig's exact approach and see whether the index measured

according to this application has different implications for symmetry within the EU. Recreating the sign restriction approach with the available set of data in this study has reduced effectiveness owing to the shorter data sample and the reduced number of variables. Uhlig's study uses six variables. The sign restriction approach is more effective with a larger number than two variables within the VAR.

3.3.2 Response Estimation

The two key variables are output and inflation. I construct a bi-variate VAR which contains the two variables: output and inflation. For output, the real quarterly GDP series is used. For the prices variable, π_t, the GDP deflator is used. It is calculated by dividing the nominal GDP series by the real GDP series. The GDP deflator is used rather than CPI because it is has a wider economy coverage than CPI, which just covers consumption goods. The series cover a twenty two year time period between 1996q1-2017q4. The series are sourced from national accounts data available on Eurostat. The data are obtained pre-seasonally adjusted. The series are logged and first-difference.

The Augmented Dickey Fuller test is run on the data series individually to check for stationary. The series are all stationary. Despite the stationarity of the series, tests are still run to detect a change in the mean.

The sample from 1996-2017 contains some significant economic events, in particular the great recession of 2008. In some countries this means that their time series contains structural breaks. In order to detect these structural breaks , the test introduced by Bai and Perron (2003). The breakpoints detected are in for the following dates.

Country	Date of Breakpoint
Belgium	2008Q1
Czechia	1999Q2 2004Q2 2007Q4 2013Q3
Denmark	No breakpoints detected
Germany	No breakpoints detected
Estonia	2007Q1 2010Q2
Ireland	No breakpoints detected
Greece	2008Q1 2013Q1
Spain	2008Q1 2013Q3
France	2000Q4
Italy	2008Q1 2013Q1
Cyprus	2008Q1 2011Q2 2014Q3
Latvia	2007Q3 2010Q4
Lithuania	2007Q4
Luxembourg	No breakpoints detected
Hungary	2006Q4 2012Q4
Netherlands	2000Q4 2005Q1 2008Q2 2013Q2
Austria	2008Q1
Poland	No breakpoints detected
Portugal	2000Q1 2008Q1 2012Q4
Romania	2000Q3 2008Q3 2012Q3
Slovenia	2008Q2 2013Q2
Finland	2007Q4
Sweden	No breakpoints detected
UK	2008Q1 2011Q2

Table 3.1: Detected Breakpoints in between the years 2000-2018

Table 3.1 shows the dates for which breakpoints were detected for each country. There are some countries for which no breakpoints were detected at all (Luxembourg, Sweden, Germany and Denmark, Poland and Ireland)[5].

[5]As the series are all first-differenced and logged, it could be the case that this initial

Although no breakpoints are detected for Germany and Ireland , dummies are inserted for the years 2008Q1 till 2013Q2 to account for the Euro area crisis. Ireland had a particularly large drop in output during the recession. One explanation for the lack of detection is the volatility of the irish GDP over the whole time horizon which means that the mean is already accounts for a lot of the volatility in the series. Table 3.1 clearly shows us that the group of Central Eastern countries experienced the crisis earlier than other countries within the EU. It can be seen that the first detected breakpoints for Latvia, Estonia, Finland and Hungary are during 2006/07 whereas for many of the other member-states, the first detected breakpoints are during 2008. Those countries however recovered much faster that their southern EU counterparts, as the double-dip recession in EMU countries was exacerbated by the sovereign debt crisis and contagion that erupted since 2010. Once the breakpoints have been detected, the time series are adjusted accordingly. Dummy variables that take on the value 1, after the first breakpoint and zero after the second[6].

As the lag length test is applied to each individual country and re-applied every time period, there is a trade-off between choosing the accurate lag length for each of the separate vars being estimated and ensuring consistency across countries and time. The AIC is applied to the full length series. The lag selection is then fixed for each of the recursive vars across time. The AIC criteria is chosen because it has properties that make it the most accurate at selecting the lag length for shorter time lengths. Four lags are used in the estimation.

With the adjusted time-series, VARs are estimated recursively for each individual member state. Starting from 2008Q1. The initial VARs are estimated from the window 1996Q1-2008Q1 and then are re-estimated with a rolling-window until 2017Q4. One limitation of this approach is that it does not take in to account contagion between countries. As an exogenous shock in

data manipulation has removed the breakpoints owing to the crisis.

[6]No adjustment is made for the breakpoints detected before 2005. This is the case for Czechia, Portugal, Romania, Netherlands and France

one country is likely to have an impact on neighbouring countries which will in turn impact the final response on the initial country. Using only domestic data for each VAR means that these contagion effects cannot be captured.

The VAR is re-applied each quarter. The initial data-set starts in 1996q2 and the first impulse is applied at 2008q1. IRFs are obtained for each of the 40 quarters in the time between 2008q1 and 2017q4.

$$\begin{bmatrix} \Delta y_{1t} \\ \Delta y_{2t} \end{bmatrix} = \begin{bmatrix} \sigma_{11} & \sigma_{21} \\ \sigma_{12} & \sigma_{22} \end{bmatrix} \begin{bmatrix} \Delta y_{1t-1} \\ \Delta y_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \tag{3.1}$$

Impulse response functions are obtained by applying a 1% shock to the error term of the VAR. The observations are summed in order to obtain the cumulative response function.

$$X_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + ...A_i\varepsilon_{t-i} = \sum_{n=1}^{\infty} L_i A_i \varepsilon_i \tag{3.2}$$

Where $X_t = [\delta Y_t, \delta \pi_t]$ and A represents the matrices containing the shocks.

Long run restrictions identified in this way do have their criticisms as it can be difficult to estimate at the long run horizons. The sources of this bias have been explained in detailed by Erceg (2005) in an analysis of the use of restrictions in the identification of technology shocks. There are two sources of bias. One is the 'R bias' that comes from the slight inaccuracies of the moving average estimation when the data sample is short. This contributes to biases at long horizons of the estimation. The second source of the bias comes from the inaccuracies in converting the reduced form to a structural form. This is because the data generating process is an approximation to the true data generating process. As the length of the horizon grows, these inaccuracies become larger. This bias is labelled the 'A bias'. Further research could use the approach that Erceg (2005) uses to estimate the size of the bias and decompose it in to the A and R bias respectively.

3.3.3 Measuring Persistence

This section discusses the various prevailing methods used to measure the persistence of inflation in order to decide on an approach that would be adequate in the context of this study and measure demand persistence. The literature on the methods used to measure the persistence of inflation is larger than the literature on measuring demand persistence. Therefore, methods that are used to measure inflation will be analyzed and the chosen method will be applied to measuring the persistence of demand. The assumption is being made that demand is a mean reverting process. The following discussion investigates the merits and shortcomings of various approaches before deciding that the the sum of the AR(1) coefficient is the most suitable way to describe the memory of the process. Persistence refers to the duration of time after an initial shock that the subsequent effects can be seen in the economy . The aim is to see how long it takes for the series to return to the base after an exogenous shock. This gives us an indication of the adjustment speeds in the economy. The memory refers to how much of the current behaviour can be explained by a past action. The memory of the IRF tells us how much the demand-side response can be explained by the permanent supply-side shock. The greater the persistence of the demand-side response, the greater reflection of supply, the demand-side is. Therefore, the higher the persistence, the more flexible markets are deemed to be as the permanent supply-side shock can be seen in the demand-side response.

Diebold and Rudebusch (1989) look at the persistence of aggregate output but are interested with measuring the memory of output. The existence of large persistence in inflation is assumed to be a sign of a sluggish reacting economy, as it assumed that inflation shocks should dissipate quickly in a flexible economy. When looking at the demand-side response to a supply-side shock, the existence of persistence in the response is interpreted as a sign of an economy with flexible markets. This is because the demand is responding to a unit shock in supply. The greater the response in demand, the more reactive

demand is to a permanent structural supply-side shock. If there was very little response from the demand-side then this would imply that demand was not reacting to supply side movements , which would be interpreted as rigidity's in the demand-side of the economy (Diebold & Rudebusch 1989).

The IRFs displaying the response of demand to a shock in supply have now been obtained for 26 quarters. In order to understand the speed of the demand response in a cross-comparative way, a method that measures persistence is proposed. Most measures of persistence within macroeconomics are developed within the context of looking at the persistence of inflation mostly for the US (Pivetta & Reis 2007).

By explicitly measuring the decay of the IRF , we can formally measure the speed of adjustment. The methods investigated in this section include the: The largest auto-regressive root, The sum of auto-regressive (AR) coefficients and the half life. The AR coefficients suits the task of measuring demand-side persistence the most as it conveys the most direct information regarding the behaviour of the decay of the series. The amount that the IRF of demand is affected by the positive shock that is applied to the supply side, is the measure of persistence. The aim is to measure the decay of the IRFs. One issue with using the IRF is that it can last for an infinite number of horizons and the length is free to specify.

Three methods will be introduced in the discussion and their relative merits (Pivetta & Reis 2007):

- Largest Auto-regressive root
- Sum of Auto-regressive roots
- Half Life

Much attention has been paid to how inflation behaves in the face of a shock with many focused on measuring impulse response functions as a way

of measuring the behaviour.

Pivetta & Reis (2007) conduct a study that looks at the persistence of US inflation since 1965. They find that US inflation has been persistent and broadly unchanged for their whole time period. The methods of the persistence measure are the ones proposed by Dosche & Everaet (2005) introduce a discussion of methods used to measure persistence that involve generating IRFs and investigating their properties.

The first measured discussed is the Largest Auto-regressive root (LAR). If the process is the following :

$$x_t = \theta_1(1 - L_1)x_1 + ...\theta_h(1 - L_h)x_h$$

Where $h < t$, then the LAR is the value for which θ is the largest. This is because the value for which theta is the largest becomes the biggest determinant of the behaviour of the process. Therefore, this scalar measure provides information on the persistence of the process, and allowing for the most persistent lag to be counted.

The second measure discussed is the sum of the coefficients of the AR process. Although the IRFs are generated from a multivariate model, we are interested in the uni-variate persistence in the process.

The IRF is assumed to follow an AR(1) process that is specified in the following way:

$$y_t = \rho y_{t-1} + \varepsilon \tag{3.3}$$

The parameter ρ is the first order auto-regressive coefficient and is assumed to capture the rate decay of the IRF. If there is an AR process that is larger than one, then the measure will just include summating the different ρ values. In order to create a scalar measure, take the sum of ρ and use it to measure the decay. Various computations using ρ have been suggested as better alternatives to capture persistence.

The third measure is the half life. The half life describes the amount of time it takes for an IRF to fall to half of its initial value. It follows on from the equations above. ρ^h is a IRF after h periods. So therefore we are interested in solving the following equation.

$$\rho^h = 1/2 \tag{3.4}$$

It then follows that the half life is computed with the following equation:

$$h = \frac{ln(1/2)}{ln(\rho)} \tag{3.5}$$

Auto-regressive processes with an order 1 display short memory and initial shocks dissipate very quickly. The half life is a common method used is measuring the persistence of inflation (Rose & Van Wincoop 2001, Dossche & Everaert 2005). The half-life measures the time it takes for an IRF to return to half of the initial value of the shock. It measures the number of quarters for which the shock remains above half of the value of the shock. It is useful in that, unlike other measures, it provides a value in the number of units of time. This is slightly more tangible than auto-correlation coefficients and can be easier when communicating policy implications (Pivetta & Reis 2007).

To calculate the half life, the observation at the last period in the IRF horizon is divided by the value in the first period of the IRF. The natural logarithm of this number is calculated. The number represents the number of quarters it takes for the demand to return to half of its level after the shock. The half life would tell us the number of quarters it takes for inflation to return to 50% of the initial deviation from base. In a cross-comparative setting such as the one used to create an country index, the half-life may exaggerate the difference between the persistence of countries as countries that a linear or even concave decay will have a half life that is quite a bit higher than countries that display exponential decay.

For highly persistence behaviour the half-life could reach infinite values and therefore no much relativity can be achieved between economies that

have very and not very persistence processes. Furthermore, economic shocks so often fluctuate around the baseline for a few quarters before returning exactly to the mean. The half life measure assumes that the initial decay of the series is a one-time occurrence. However, the duration of the adjustment period is not accurately depicted by the half life. This is because IRF responses are not typically monotonic in their decay and they typically show fluctuations (Robalo Marques 2004).

A less commonly used which has merits in measuring persistence is discussed next. Marques(2004) prescribes an alternative approach that is successful in capturing the the persistence of the series after the initial return to base.

$$\widehat{\gamma} = 1 - \frac{n}{T} \tag{3.6}$$

This approach counts the number of times that the series crosses the baseline within a certain time-frame. It has the benefit of being more accurate in describing oscillating responses. As inflation is a mean-reverting process, it can be expected to cross the mean, a number of times following a shock. The measure can be useful for cross-comparison amongst a group of countries but the mean-reversion count cannot be a stand alone measure. A highly persistence series would have a high count on the mean reversion measure and the vice-versa. One limitation of the mean-reversion measure is that if the series does not return to base in the time-frame of the IRF then the value of the measure will be zero. This can be difficult to interpret as it is not known whether the series was close to returning to base or if it is far off.

The method that is chosen is the sum of the auto-regressive roots. However as there is only the calculation of one auto regressive root, the method just becomes the coefficient of the AR(1) process. It provides a fair comparison of persistence in a cross-comparative setting such as the one used in this study of multiple countries.

To summarise, the Persistence Index is estimated using the following steps:

1. The structural VARs are estimated for each member state using the B&Q identification for every quarter in the time-series.

2. Impulse responses are generated each quarter that have a horizon of 26 quarters.

3. The first order autoregression coefficient of the impulse responses are estimated.

4. The coefficient of the first order autoregression is taken as the value of the index in that quarter.

3.4 The Persistence Index

The index is a time-series that covers forty quarters (2008q1-2017q4) for 24 member states. Figure 3.2 shows the upper median and lower quartiles for the persistence index for the 24 countries in the sample. During 2008-2010, there was a decrease in the average levels of persistence. These years coincide with the years of the crisis. After this initial decrease in persistence, the average persistence gradually increases for the rest of the time-frame. This could be an indication the that policy measures taken during the crisis years helped to contribute to permanently more friction-less markets. The higher the persistence index, the lower the cost of entering the currency union. This is because there is a higher degree of symmetry between supply and demand. The index suggests that the EU28 would face lower costs of entering a currency union in 2017 than in 2007.

The distribution of persistence index can serve as an indicator as to how converged the economies of the EU are. The values of the index relative to other other countries can be interpreted as the degree of convergence there is within the EU. The closer the relative values of the index, the more converged the EU is. The lower quartile has experienced the same kind of

movement in the beginning periods of the time frame but has reduced in the subsequent periods. The levels of persistence during the crisis and its increase in the subsequent periods imply that the policies that were implemented by national governments may have played a positive role in helping to increase the operation of markets and therefore increased their adjustment speeds.

Figure 3.2: Median, Upper and Lower Quantiles of the persistence index

The second dimension along which figure 3.2 is of interest is the relative persistence amongst countries. In particular, whether there has been a trend in how close together the countries are in terms of their persistence. Figure 3.2 shows that the indexes are closest together during 2008-2009, this was the result of global or euro-wide shocks. It is followed a drop in persistence, possibly owing to idiosyncratic responses on the fiscal side. This result is

not new as the synchronicity of the business cycles during the crisis is well documented (Dées & Zorell 2011). After the crisis, the divergence of the lower quartile from the upper two quartiles is large in scale and furthermore seems to be following a downward trend, up until 2011. Taking the proposed index as a measure of symmetry, however, does suggest that the latter presents a trend which has been overall upward sloping roughly since 2012.

3.4.1 Comparison with previous indexes

We now compare the persistence index with previous results in the literature. The first comparison made is with the NORD index (Campos & Macchiarelli 2016). This index looks at eleven of EU countries over an eight year time frame. The NORD starts off with the same methodological approach in which a supply-side shock is identified and implemented as per Bayoumi and Eichengreen (1992). They then apply a supply-side shock using the Blanchard and Quah decomposition. However, they apply a restriction to the long run response of supply which is that it is permanent in the long run. This therefore tests if the supply-side shock is permanent, with this restriction being applied horizontally across countries. A bootstrap is then used to count the number of times that this restriction on the supply-side is over identified. An index is then created based on the number of times the restriction fails to pass the over identification test. The higher the index, the more flexible markets are deemed to be as supply-side shocks are permanent rather than temporary. The persistence index looks at the AR(1) coefficient of demand to see whether demand reacts to a supply-side shock to empirically quantify the flexibility of markets. A comparison of both indexes are provided below. The NORD indexes are for the years 2008-2015, so the comparison is restricted to these years only.

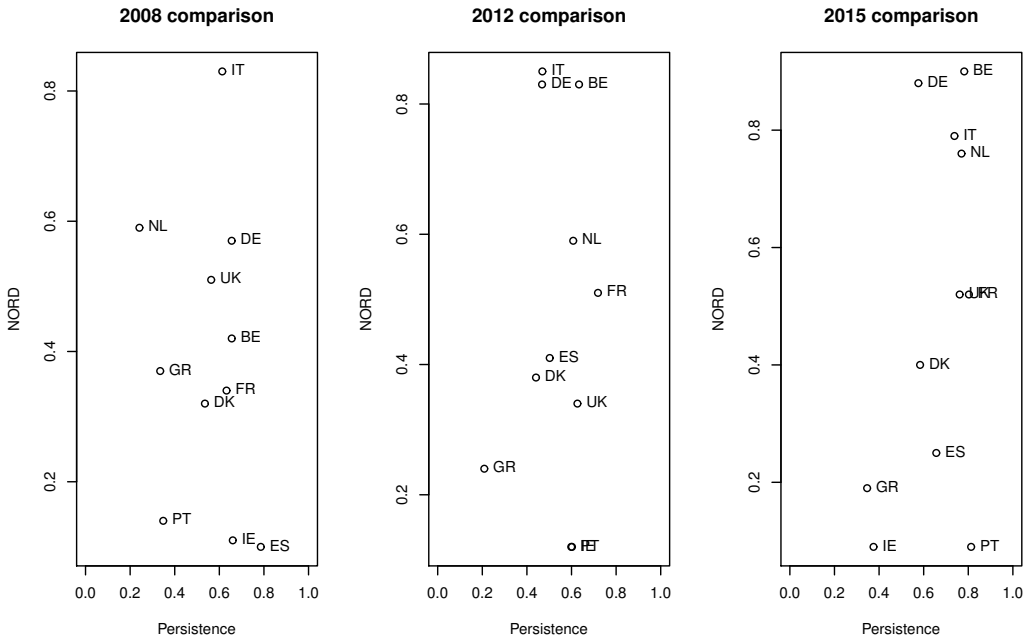


Figure 3.3: NORD and Persistence Index Comparison

Figure 3.3 above displays the relationship between the NORD and Persistence indexes for the years 2008, 2012 and 2015 respectively. There is a modest degree of correlation between the two indexes. The countries that appear to have the most responsive demand-side IRFs are Spain and France. This is different to the results achieved in Campos Macchiarelli (2016) who find that the most responsive countries are Belgium and then Germany. The correlation between these indexes is strong for some countries , in particular Germany and Spain. However, there are some countries that perform quite differently between the two indexes. The NORD index is conditioned on annual data and therefore 25 years. The Persistence index is conditioned quarterly data from eleven years. It contains a lot more dynamic behaviour, which may go someway to explain some of the changes. Whilst in theory there should be some cross overs between the NORD index and the Persistence index, there are some subtle differences in their concepts of supply that may

generate differences in the persistence for countries.

Direct comparison cannot be made with the NORD index for two reasons. The NORD index covers a twenty five year rolling window, whereas the persistence index covers an eleven and three quarters year window recursively. This means that there is a smaller time-frame window in which to average out volatility. Secondly, the NORD index is annual, whereas the persistence index is created is estimated using quarterly series. This is mainly owing to data constraints , particularly for the central eastern European countries, with which data is has a limited availability. Using quarterly instead of annual data does introduce a greater degree of volatility to the estimation. Nevertheless, we are still able to compare the measures of the two indexes.

3.4.2 Full Country Sample Results

This sections analyses the index on a country-level basis.

Figure 3.4 shows the maximum, minimam values along with the median, upper and lower quartiles values of the persistence index over the ten year period for each country.

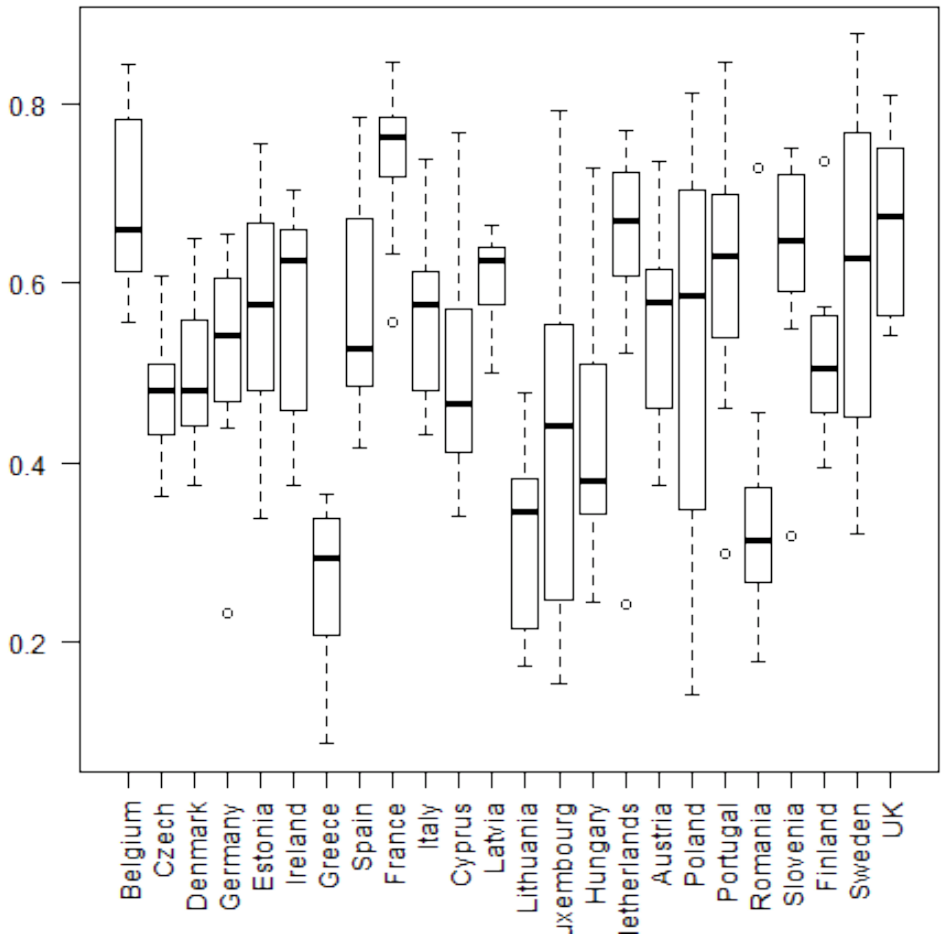


Figure 3.4: Country level Quantiles

Figure 3.5 displays the individual country level results. One observation is that the indexes display alot more volatility towards the beginning of the time-frame. This may not be a surprising result as the beginning of the time-frame coincides with the crisis. Although the series was adjusted for in the initial estimation there was still increased volatility in GDP and inflation owing to the crisis. Greece has the lowest persistence measure on average, however upon inspecting the dynamics of the index this is driven by the early

part of the time-frame. The persistence index for Greece then in fact becomes extremely high around 2013 and almost reaches one. France and Austria have particularly stable indexes that hover around a constant period for the whole time period.

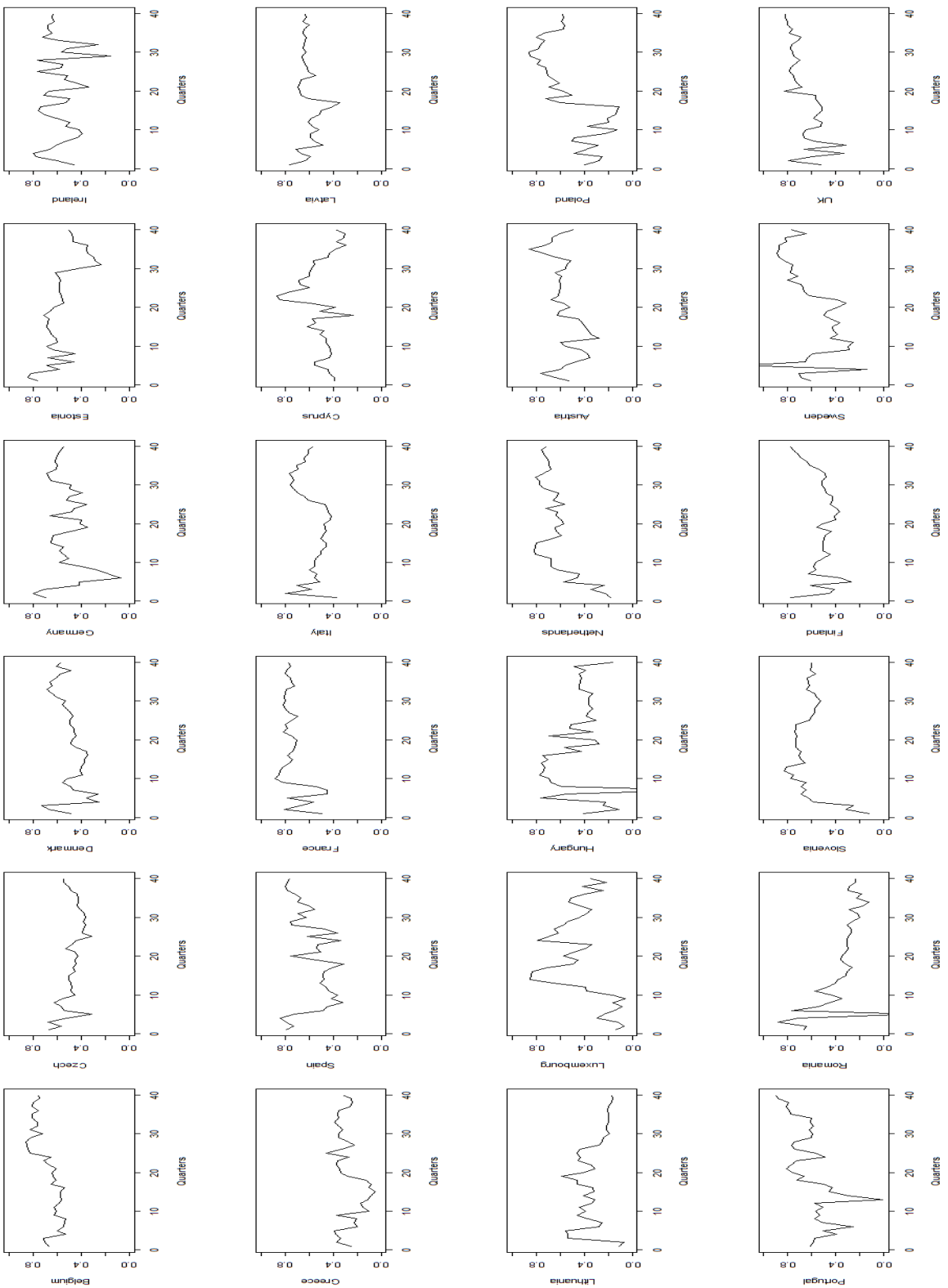


Figure 3.5: Persistence index for individual Countries

Now, we can look to the full country sample and investigate what the persistence measure shows us about symmetry in the EU.

The table entitled : 'Descriptive Statistics Persistence index 2008-2017' displays a range of statistics for the twenty four countries in the sample and the ten years. The quarterly index is converted in to an annual index. The annual values are calculated from a four quarter average. The averages for each country and each year are presented along the right column and the bottom row respectively along with the standard deviations. The averages allows us to look at whether markets are becoming more persistence in an absolute sense, however the standard deviation allows us to look at relative symmetry.

When looking at the averages and standard deviation across time for the EU, there are diverging trends. The average persistence has increased over the 10 year periods. Whilst this fluctuates at this level from around 2011, it has positively increased since 2008. This implies that on the whole, economies have become more symmetric. The standard deviation has fluctuated from year to year and it is difficult to discern a particular trend. 2008-2011 has the highest standard deviation.

Now, individual country responses are analyzed. There is no specific geographic concentration of the most persistence markets. The country with the most symmetrical economies according to their total averages are France and Austria. The countries with the lowest total averages are Greece and then at about 10 points higher is Finland. One result that is different is the performance of Germany which to towards the bottom of the first quartile. Furthermore, some small open economies have highly persistent results. These include Lithuania , Latvia and Slovenia. As small countries that have a high proportion of GDP that is determined by external trade, this could imply that increased trade and openness leads to more persistent markets.

Table 3.2: Descriptive Statistics Persistence index 2008-2017

Statistic	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Belgium	0.688	0.102	0.557	0.618	0.781	0.844
Czech	0.472	0.071	0.363	0.437	0.506	0.609
Denmark	0.496	0.086	0.375	0.447	0.554	0.649
Germany	0.519	0.123	0.234	0.476	0.599	0.655
Estonia	0.565	0.130	0.338	0.501	0.659	0.756
Ireland	0.578	0.112	0.375	0.484	0.659	0.705
Greece	0.273	0.087	0.088	0.220	0.338	0.366
Spain	0.582	0.132	0.418	0.488	0.668	0.786
France	0.740	0.085	0.558	0.727	0.783	0.847
Italy	0.573	0.098	0.432	0.496	0.611	0.738
Cyprus	0.501	0.130	0.340	0.416	0.563	0.768
Latvia	0.607	0.049	0.500	0.577	0.640	0.664
Lithuania	0.321	0.099	0.174	0.239	0.377	0.478
Luxembourg	0.423	0.209	0.155	0.261	0.540	0.794
Hungary	0.443	0.162	0.245	0.347	0.491	0.728
Netherlands	0.630	0.157	0.242	0.609	0.720	0.771
Austria	0.557	0.106	0.374	0.483	0.613	0.736
Poland	0.523	0.228	0.143	0.363	0.693	0.813
Portugal	0.606	0.153	0.299	0.541	0.698	0.847
Romania	0.351	0.153	0.178	0.272	0.367	0.728
Slovenia	0.627	0.128	0.319	0.592	0.719	0.751
Finland	0.521	0.092	0.394	0.468	0.554	0.735
Sweden	0.612	0.192	0.321	0.462	0.767	0.878
UK	0.666	0.101	0.542	0.570	0.748	0.811

3.5 Estimating the determinants of Symmetry

Now that we have a scalar index of persistence over time, it can now be used in an estimation in order to help to quantify the extent to which other factors in the economy affect symmetry. The list of possible determinants are identified from the OCA literature. The empirical estimation allows to investigate how the other determinants identified in the OCA literature such as flexibility and integration, impact symmetry.

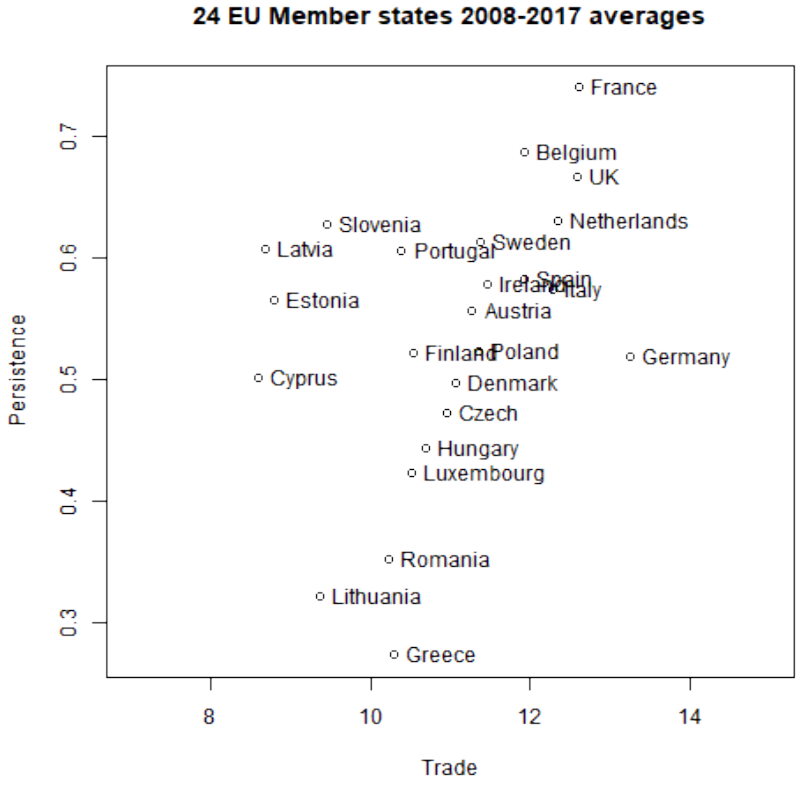


Figure 3.6: Persistence Index and Trade scatter-plot.

Figure 3.6 above shows the correlation between a country's total trade divided by GDP and the persistence index. A positive relationship between the

two can be seen. Trade plays an important role in the OCA literature. Trade affects the symmetry of supply and demand through it's affect on reducing nominal price rigidities. Therefore allowing for a shock to prices to be remedied through the external balance.

The index will be used in two ways in the estimation. The determinants of the index itself will be estimated. This means measuring how openness, financial indicators and flexibility contribute to increasing the speed of the demand response to the supply-side shock. The second way in which the index will be used is to measure convergence. This means measuring how similar the demand-side response of countries are to each other. This will allow for an understanding of how OCA criteria can help countries behave more similarly to each other in light of a similar shock. Three separate estimations are run in order to measure both the determinants of persistence itself, and the determinants of symmetry. In the first estimation, the dependent variable is persistence index as it is. In the second estimation , the dependent variable is the persistence index for each country divided by the EU average. This estimation allows for the determination of deviations from the EU average to be estimated. This can be interpreted as estimating the determinants of convergence, as the closer together the responses of the different countries are, the less costly the formation of a monetary union becomes.

In the third estimation, the dependent variable is country specific persistence index divided by Germany's Persistence index. Germany is a common anchor used to measure the convergence of EU countries, as it is the largest economy in the EU which is a predominant trading partner for most of the EU member states. This estimation allows again for the measurement of symmetry, however it does not have the problem of correlation between the country specific index and the anchor as rather than calculating an average, another country is used as the anchor.

A list of potential determinants of symmetry are identified from the optimal currency literature. These determinants are categorized in to three

broad areas. They are: Openness, integration of financial markets and flexibility of labour markets.

The first group of variables being discussed are the group of variables that belong to the openness category. The openness category is primarily concerned with measuring how open an economy is with the rest of the world with respect to trading its goods and services. The main independent variable in this category is trade openness.

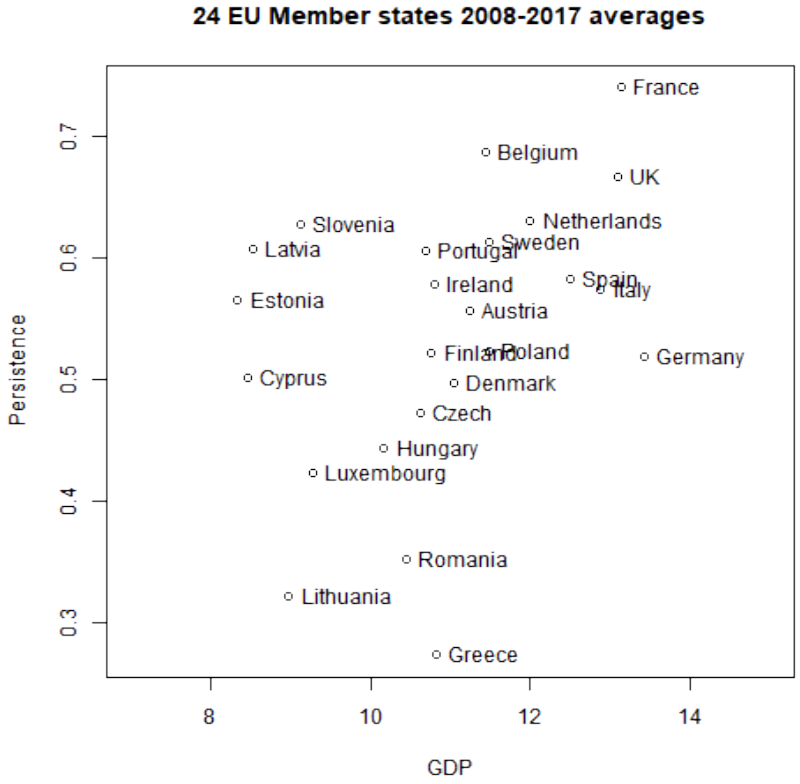


Figure 3.7: Persistence Index and GDP scatter-plot.

Figure 3.7 shows the relationship between a country's GDP and the persistence index. The observations are averages across the whole ten year time-frame for the member-states. There is a positive relationship. There is a

group of smaller economies that emerge to the left, who have a relatively high persistence index despite having lower GDP's. These are Slovenia, Latvia, Cyprus and Estonia.

In order to control for gravity model effects, the amount of trade is divided by the country's GDP (Frankel & Rose 1998). Prices are controlled for through the inclusion of the real interest rate and CPI. One area that has been increasingly used to control for trade is capital flows across borders. As capital flows affect the relative prices of goods, they can impact the levels of international trade. The IMF's measure of a country's net capital balance with the rest of the world is included as a control[7].

19 of the member-states of the EU have the same currency or adopt the euro during the time frame of the data. In order to control for the fact that many countries have the same currency, a dummy for the euro is included.

The second block of determinants being investigated are the financial determinants. The financial environment within a country can affect the speed of adjustment to macroeconomic shocks. The variables used for the financial determinants are 3 month inter-bank rate and CPI. The 3 month inter-bank rate measures the rate at which banks lend money to each other. This estimation is likely to be dominated by the results of the countries that are denominated in the euro. This is because there is one fixed inter-bank rate for all EU19.

The third block of determinants are labour markets determinants. The labour market has affects on how shocks dissipate through the economy. If unemployment is high, there is more slack in the labour market should domestic demand pick up. The variables used in the estimation is the rate of unemployment which is denoted by 'labour rates'. Unemployment is likely to affect the persistence of demand as it reduces the amount that can be consumed. A negative shock to prices means that consumption should go up.

[7]IMF's Balance of Payments statistics. Full details in appendix

However, if unemployment is high then there is no extra income to be spent on consumption. Furthermore, high unemployment can also be interpreted as a sign of labour market inflexibility. The more flexible the labour markets are the easier it is for demand to adjust to a supply-side shock. The second variable that is being used is unit labour costs and it is measured as an index. It would be expected that lower unit labour costs would coincide with more symmetry as it means that labour can easily adjust to movements in supply.

Table 3.3: Summary Statistics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Persistence	240	0.54	0.17	0.09	0.42	0.66	0.88
Trade	240	34.16	4.60	24.90	31.60	37.84	43.31
labour rates	240	9.27	4.75	2.93	6.18	10.70	27.48
Unit Labour Cost	240	102.93	6.83	91.38	100.00	104.29	141.25
interbank	240	1.29	2.02	−0.515	0.18	1.41	12.38
Flows	240	42.86	1.08	35.36	42.76	43.01	46.50
cpi	240	96.93	4.71	78.33	93.22	100.00	104.48
GDP	240	9.50	0.56	8.41	9.18	9.85	10.41
REER	240	398.34	16.25	354.69	389.57	407.19	466.73
DEF	240	−13.547	15.462	−128.200	−20.550	−3.475	16.9

3.5.1 Estimation Methodology

The structural index exercise provides us with a quarterly index of persistence for each country for a ten year period. In order to avoid issues with seasonality and volatility owing to higher frequency data, the index is averaged annually. We are now left with an annual series for the ten year period.

The dataset has 24 panels across 10 years. In order to account for

any unobserved differences between the countries that are time-invariant such as distance and institutional structure, a fixed-effects estimation is adopted for.

$$y_{it} - \hat{y}_t = \beta(X_{it} - X_{it-1}) + \varepsilon_{it} \tag{3.7}$$

Where y_{it} is the dependent variable for panel i at time t. X is a matrix of the independent variables. As the data is time-series and is likely to have a trend , time effects are accounted for in the estimation in order to ensure that data are stationary. Owing to the small t of the data-set with only ten values per panel, lags are not included in the estimation. A panel approach allows for greater accuracy owing to the use of a larger dataset, it allows possible contagion effects between the countries.

In total, four separate models are run on the data. The four model specifications are the following:

Model 1 - Openness

$$\text{Persistence}_{it} = \beta_1\text{Trade Openness}_{it}+\beta_2\text{Capital Flows}_{it}+\beta_3\text{Euro Index}_{it}+\beta_4\text{REER}_{it}+\varepsilon_{it} \tag{3.8}$$

Model 2 - Financial

$$\text{Persistence}_{it} = \beta_4\text{Interbank}_{it} + \beta_5\text{Government Deficit}_{it} + \varepsilon_{it} \tag{3.9}$$

Model 3 - Labour

$$\text{Persistence}_{it} = \beta_6\text{Labour}_{it} + \beta_7\text{Productivity}_{it} + \varepsilon_{it} \tag{3.10}$$

Model 4 - All

$$\text{Persistence}_{it} = \beta_1\text{Trade Openness}_{it}+\beta_8\text{Capital Flows}_{it}+\beta 9\text{Euro Index}_{it}+\beta_{10}\text{REER}_{it}+\varepsilon_{it} \tag{3.11}$$

3.6 Results

Tables 3.4, 3.5 and 3.6 display the results for the estimation of the determinants of the persistence index, deviation of the persistence index from the EU average and the deviation of the persistence index from Germany respectively. The results table shows the coefficients of the variables in each of the three determinants blocks. Table 3.4 shows the results of the first estimation where the dependent variable is the persistence index itself. The model predicts the persistence index with relative success. The R^2 shows that in total, the dependent variables explain about 12% of the variation. The variables that remain significant both in their individual blocks and the estimation that includes all of the blocks together are, the openness (Trade) block and the flexibility (Labour productivity) block. Trade has a positive impact on the level of Persistence. The block that in isolation explains the highest amount of variation is the openness block with an R^2 of 10%. The openness block has all four variables showing up as significant. Trade has a positive effect on the persistence index. The adoption of the euro has a positive effect on the the index. The coefficient of the real exchange rate is negative. As the real exchange rate falls, countries become more competitive. This increased competitiveness is likely to result in a higher responsiveness of demand to supply and therefore this result is somewhat to be expected. The financial block has both variables as very significant and have a positive coefficient on the Persistence index. As the 3 month inter-bank rate increases, the Persistence index also increases. As the three month inter-bank rate is a cyclical measure, it implies that markets are more flexible in cycle upturns than cycle downturns. The positive coefficient of the government deficit coefficient is a little harder to interpret. One possible explanation could be again the cyclicality of the government deficit which is typically higher in cycle upturns than downturns.

Finally, the results of the labour market block are discussed. The effect of the unemployment rate is the weakest of all the variables in the estimation, with it showing no significance at all. Unit labour cost has a

negative coefficient, which implies that the more competitive the cost of labour, the more symmetrical supply and demand is. The estimation that uses all of the variables sees the financial block fall out of significance. This could suggest that the real macroeconomic variables are bigger drivers of persistence than financial variables. The scale of the coefficients of all the variables reduce slightly. Of the individual blocks , the block with the least explanatory power is the financial block, so it is unsurprising that these variables fall out of significance in the total estimation.

Table 3.4: Determinants of the Persistence Index

	Dependent variable:			
	Persistence			
	(1)	(2)	(3)	(4)
Trade	0.04***			0.02*
	(0.01)			(0.01)
CapitalFlows	−0.09**			−0.07
	(0.04)			(0.05)
EuroIndex	0.04*			0.03
	(0.02)			(0.03)
REER	0.001			−0.001
	(0.003)			(0.003)
interbank		−0.01		−0.01
		(0.01)		(0.01)
labour rates			−0.01**	−0.004
			(0.002)	(0.003)
Unit Labour Cost			−0.51**	−0.39*
			(0.20)	(0.20)
GovernmentDef		−0.0000***	−0.0000***	−0.0000
		(0.0000)	(0.0000)	(0.0000)
Observations	240	240	240	240
R^2	0.10	0.07	0.10	0.13
Adjusted R^2	0.05	0.03	0.05	0.06
F Statistic	6.34*** (df = 4; 226)	8.72*** (df = 2; 228)	8.59*** (df = 3; 227)	4.05*** (df = 8; 222)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 3.5: Estimation with dependent Variable of deviations from the EU Average

	Dependent variable:			
	Persistence			
	(1)	(2)	(3)	(4)
Trade	0.99^{***}			0.53^{***}
	(0.06)			(0.07)
CapitalFlows	-0.63^{**}			0.93^{***}
	(0.26)			(0.28)
EuroIndex	0.26^{*}			0.10
	(0.14)			(0.12)
REER	0.04^{**}			0.02
	(0.02)			(0.02)
interbank		0.05^{***}		0.01
		(0.01)		(0.01)
labour rates			-0.07^{***}	-0.03^{**}
			(0.01)	(0.01)
Unit Labour Cost			-3.26^{***}	-1.25
			(1.25)	(1.02)
GovernmentDef		-0.0000^{***}	-0.0000^{***}	-0.0000^{***}
		(0.0000)	(0.0000)	(0.0000)
Observations	240	240	240	240
R^2	0.59	0.54	0.57	0.74
Adjusted R^2	0.57	0.52	0.55	0.72
F Statistic	82.61^{***} (df = 4; 226)	134.65^{***} (df = 2; 228)	100.30^{***} (df = 3; 227)	77.95^{***} (df = 8; 222)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 3.6: Estimation with dependent Variable of deviations from Germany

	Dependent variable:			
	Persistence			
	(1)	(2)	(3)	(4)
Trade	0.20^{***}			0.05^{***}
	(0.02)			(0.02)
CapitalFlows	-0.53^{***}			0.02
	(0.09)			(0.07)
EuroIndex	0.08^{**}			0.03
	(0.04)			(0.03)
REER	0.002			-0.003
	(0.01)			(0.004)
interbank		0.01		0.01
		(0.01)		(0.01)
labour rates			-0.01^{***}	-0.01^{***}
			(0.003)	(0.003)
Unit Labour Cost			-0.46^{**}	-0.32
			(0.23)	(0.23)
GovernmentDef		-0.0000^{***}	-0.0000^{***}	-0.0000^{***}
		(0.0000)	(0.0000)	(0.0000)
Observations	230	230	230	230
R^2	0.53	0.74	0.76	0.78
Adjusted R^2	0.51	0.73	0.75	0.76
F Statistic	62.01^{***} (df = 4; 216)	310.02^{***} (df = 2; 218)	230.69^{***} (df = 3; 217)	94.18^{***} (df = 8; 212)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 3.5 shows the results from the estimation where the dependent variable is the Persistence index expressed as country deviations from the EU average. This estimation can be interpreted as a more direct estimation of convergence within the EU. As the dependent variable is simply the ratio of each country to the EU average, it is unsurprising that the main tenets of the result do not change. The significance and signs of the co-efficient remain broadly the same but change in scale. The coefficient of the labour rates increases in significance from $\rho = 0.05$ to $\rho = 0.01$. It also increases in scale from a value of 0.01 to 0.07. As unemployment decreases, there is a greater amount of convergence that can be amongst the economies of the EU. The R^2 for the estimation with EU average deviations and ratio against Germany's index are quite a lot higher than the R^2 for the Persistence index itself. This could be taken to mean that the group of variables identified by the OCA literature are better at explaining determinants of convergence as oppose to determinants of the symmetry of supply and demand responses themselves. However, such an interpretation should be taken with caution because the persistence levels contain a lot more variation in levels than the deviations from EU averages and ratio against Germany's index.

Table 3.6 shows the coefficients for the final estimation where the dependent variable is the Persistence index expressed as country level deviations from Germany's Persistence index. This approach is more similar to other approaches in the literature in that there is an anchor country that is being used to measure convergence (Bayoumi & Eichengreen 1992, Campos & Macchiarelli 2016). Again there is not a big difference in the main tenets of the results from the previous results tables presented. The signs of the coefficient remain unchanged from the previous estimation. The financial and flexibility blocks have a higher R^2 which are 74% and 76% respectively, which is higher than the R^2 for Table 3.5 where the R^2 is 54% and 57% respectively. The 3 month interbank rate and the real exchange rate both become insignificant in this estimation. Further investigation would be needed to understand the mechanisms as to why these results become insignificant when estimation the

ratio against Germany's index.

In order to check the diagnostics of the model, a the Pesaran test for cross-sectional dependence is run on the model. The test results suggest the rejection of cross-sectional dependence of panels. The next test that is run is the Breusch-Pagan test for heteroskedasticity. The test results suggest that there is no heteroskedasticity present in the results[8].

3.7 Conclusion

One of the key components identified as successful for an optimal currency area is symmetry. The OCA literature has identified at least two other components that are important to stabilizing currency unions, which are flexibility and integration. This study has two aims. The first is a methodological contribution which develops a scalar index that measures the symmetry of demand and supply. The index is developed by measuring the persistence of the demand-side response to a supply-side shock. The index builds on previous approaches aimed at measuring symmetry but expands on them by explicitly measuring the speed of adjustment to a supply side shock through measuring the demand-side persistence. The index on its own provides a picture of how the economies of the EU have changed over the past ten years. It can be argued that the EU economies have increased in their internal macroeconomic symmetry over the past 10 years as the average value of the persistence index over the EU28 has increased, thus suggesting that the different economies of the EU have increased similarity of the demand-side response to a supply-side shock. Furthermore, the index also shows that EU markets have become more symmetrical over the past ten years as the average persistence has increased marginally over the past ten years.

The second aim of the research is to empirically investigate whether

[8]Pesaran Cross sectional dependence and Breusch Pagan test results are in the appendix.

the other components identified by the OCA literature can help to reinforce symmetry. Determinants of symmetry are identified from the OCA literature and are empirically tested using a panel OLS to see if they can be influential in promoting symmetry. The determinants are grouped in to three main blocks. These are a openness, financial integration and labour markets.

One of the main conclusions drawn from the results is that trade is significant and positive in increasing persistence and therefore symmetry. These results match the consensus of previous empirical studies , particularly those done with respect to the Eurozone (Rose 2008). Of the three different blocks of variables estimated, trade seems to have the most explanatory power over the variation in the persistence index. The results show that labour markets also affect symmetry as unit labour costs and the persistence index have a significantly inverse relationship. These results would imply that as labour markets become more competitive through reduced unit costs, symmetry of the demand side response to a supply-shock increases.

3.8 Appendix

3.8.1 Data

- GDP - Real quarterly GDP , measured in millions of euros with a base year of 2010. Sourced from Eurostat.
- Trade - Imports and Exports in goods and services. Measured in millions of euros in real terms with a base year of 2010. Sourced from Eurostat.
- GDP-Deflator - Calculated by dividing the nominal GDP series by the raw GDP series. Nominal and raw GDP series obtained on a quarterly level from Eurostat. Sourced from Eurostat.
- Government Deficit - Net lending and borrowing , measured in millions of euros . Sourced from Eurostat.
- 3 month Interbank rate - The money market rates shown are reference rate for short-term interest rates on the financial market for loans or deposits. Most of the series shown are interbank rates. Sourced from Eurostat.
- Unit Labour Cost - Is an index and measures real labour productivity per person. Sourced from Eurostat.
- Capital Flows - Is the net lending/borrowing that the countries have with the rest of the world. Measured in nominal terms is denominated in millions of euros. The series is from IMF's Balance of Payments statistics.
- CPI - Harmonized index of consumer prices including all item. Obtained on a monthly basis from Eurostat.
- Labour rates- Unemployment rates calculated as the percentage of unemployed between the ages of 15-74. Sourced from Eurostat.

- Real Exchange Rate - Real effective exchange rate using the deflator of 42 industrial countries that are trading partners.

Table 3.7: NORD and Persistence Index for the years 2008-2015

NORD	2008	2009	2010	2011	2012	2013	2014	2015
BE	0.42	0.61	0.83	0.81	0.83	0.81	0.8	0.9
DE	0.57	0.73	0.92	0.86	0.83	0.81	0.78	0.88
DK	0.32	0.17	0.25	0.28	0.38	0.47	0.4	0.4
ES	0.1	0.13	0.3	0.29	0.41	0.31	0.34	0.25
FR	0.34	0.31	0.33	0.35	0.51	0.45	0.61	0.52
GR	0.37	0.16	0.23	0.22	0.24	0.27	0.22	0.19
IE	0.11	0.14	0.14	0.14	0.12	0.08	0.16	0.09
IT	0.83	0.47	0.79	0.69	0.85	0.79	0.78	0.79
NL	0.59	0.69	0.42	0.53	0.59	0.76	0.78	0.76
PT	0.14	0.05	0.03	0.07	0.12	0.08	0.12	0.09
UK	0.51	0.2	0.21	0.29	0.34	0.36	0.46	0.52

Persistence Index	2008	2009	2010	2011	2012	2013	2014	2015
BE	0.63	0.65	0.71	0.68	0.65	0.51	0.55	0.66
DE	0.54	0.80	0.78	0.83	0.85	0.84	0.81	0.82
DK	0.88	0.85	0.83	0.84	0.82	0.83	0.83	0.84
ES	0.70	0.64	0.70	0.78	0.73	0.76	0.91	0.92
FR	0.96	0.93	0.94	0.94	0.94	0.95	0.95	0.95
GR	0.13	0.13	0.02	0.22	0.29	0.49	0.52	0.54
IE	0.62	0.81	0.87	0.86	0.88	0.85	0.88	0.68
IT	0.59	0.72	0.72	0.79	0.84	0.81	0.83	0.82
NL	0.94	0.92	0.92	0.92	0.91	0.91	0.91	0.91
PT	0.81	0.81	0.90	0.97	0.86	0.37	0.43	0.30
UK	0.63	0.78	0.78	0.79	0.83	0.81	0.80	0.82

Table 3.8: Pesaran CD test for cross-sectional dependence in panels

	Statistic	pvalue
Openness	1.760	0.080
Financial	1.570	0.120
labour rates	1.550	0.120
All	1.580	0.110

Table 3.9: Breusch Pagan Test Results

	Statistic	pvalue
Openness	6.730	0.150
Financial	2.030	0.360
labour rates	2.890	0.240
All	12.960	0.110

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